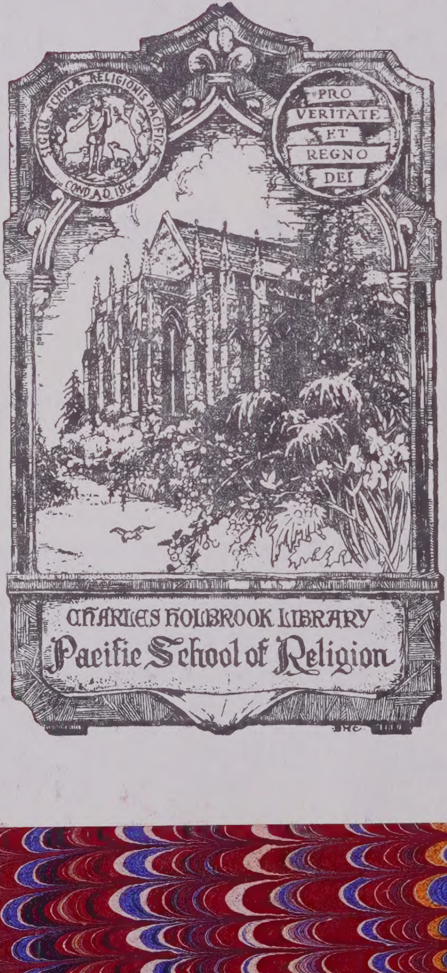
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THE

ENCYCLOPÆDIA BRITANNICA.

A

DICTIONARY

OF

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ENCYCLOPÆDIA BRITANNICA.

G

G REPRESENTS the sound of Gamma, the third letter of the Greek alphabet; but in the Latin alphabet, and in the alphabets derived from the Latin (including our own), it holds the place which Z held in the different Greek alphabets. The history of this remarkable change is well known. It has been already stated (see letter C) that in the 5th century before our era, the distinction between the *k*-sound and the *g*-sound became lost at Rome: apparently the surviving sound was *g*; but, at all events, the symbol K went out of use, being retained only in a few familiar abbreviations, and C (which was the Latinized form of the Greek Γ) remained. Thus in the column of Duillius we find C representing the original surd in *castreis, cepet*, etc., but the sonant in *macistratos, leciones, ceset* (*i.e., gessit*), etc. When, in the 3d century, the two sounds were again distinguished, two symbols were again required; but the K was not taken again to represent the surd; C, the old symbol for the sonant, was put to that use. A new symbol was therefore necessary for the sonant *g*-sound, and it was found by modifying C into G. This G should then have replaced C as the third letter of the alphabet, where it would have stood, as before, between B and D, the sonants of the labial and dental classes respectively. But this was not done. The symbol C was left in its old place with its new value of *k*. The new symbol G was set in the seventh place of the alphabet, which had been vacated by Z, the representative of a sound not used by the Romans of that day. G is found for the first time in the inscription on the tomb of Scipio Barbatus. Its invention is attributed to Spurius Carvilius.

There can be no doubt that the sound of G in Latin, as of Γ in Greek, was always the sonant guttural—which we hear in *gate*, etc. It was not the sonant palatal, which it represents in *gem* or *gin*. This sound began to supplant it about the 6th century of our era, but only when it preceded *e* or *i*—the two vowels which require a position of the tongue nearer to the palatal than to the guttural consonants. We find this change of sound in French and in Italian. In the Latin part of our vocabulary there is naturally the same weakening; whereas, in words of English origin, the original guttural is generally preserved, even before *e* or *i*, as in *get* and *give*. Sometimes it has been weakened at the end of a word, as in *bridge* and *ridge*, which were originally *brigg* and *rigg*, and are still so in the north of England.

It is noteworthy how a *g*-sound made its appearance in French at the beginning of words which originally began with the *w*-sound. An example is *guerre*, a borrowed word from the Teutonic; we see it in Old High German as *werra*, a quarrel. The Gauls apparently found a difficulty in producing the initial German sound, and (there being no difference in the position of the back of the mouth for *g* and *w*, except that the passage between the back-palate and the tongue is entirely closed for *g*, but left slightly open for *w*) they did not keep the *w* pure, but sounded a *g* before it by unintentionally closing the oral passage for a moment. The same thing is seen in *guérir*, which corresponds to Gothic *varjan;* in *garant*, which we have in English *warrant; garnir* corresponds to Anglo-Saxon *warnian*. In a few instances the word so modified seems to have been originally Latin, as *gaine*, a sheath, the Latin *vagina*.

This French change has led to a curious result in England. Many words were introduced by the Normans into England in their French form, which were already existent there in their Teutonic form. Thus we have such pairs as *wile* and *guile, wise* and *guise, warranty* and *guarantee, wager* and *gage*, and many others. It is strange that in so many cases each of the pair of words should have remained in use, and with so little change of meaning.

GABELENTZ, HANS CONON VON DER (1807–1874), a distinguished linguist and ethnologist, born at Altenburg, October 13, 1807, was the only son of Hans Karl Leopold von der Gabelentz, chancellor and privy-councillor of the duchy of Altenburg. From 1821 to 1825 he attended the gymnasium of his native town, where he had Matthiæ (the eminent Grecist) for teacher, and Hermann Brockhaus and Julius Löbe for schoolfellows. Here, in addition to ordinary school-work, he carried on the private study of Arabic and Chinese; and the latter language continued especially to engage his attention during his undergraduate course, from 1825 to 1828, at the universities of Leipsic and Göttingen. In 1830 he entered the public service of the duchy of Altenburg, where he attained to the rank of privy-councillor in 1843. Four years later he was chosen to fill the post of "landmarschall" in the grand-duchy of Weimar, and in 1848 he attended the Frankfort parliament, and represented the Saxon duchies on the commission for drafting an imperial constitution for Germany. In November of the same year he became president of the Altenburg ministry, but he resigned office in the following August. From 1851 to 1868 he was president of the second chamber of the duchy of Altenburg; but in the latter year he withdrew entirely from public life, that he might give undivided attention to his learned researches. He died on his estate of Lemnitz, in Saxe-Weimar, on the 3d of September, 1874. In the course of his life he is said to have learned no fewer than eighty languages, thirty of which he spoke with fluency and elegance. But he was less remarkable for his power of acquisition than for the higher talent which enabled him to turn his knowledge to the genuine advancement of linguistic science. Immediately after quitting the university, he followed up his Chinese researches by a study of the Finno-Tataric languages, which resulted in the publication of his *Élémens de la Grammaire Mandchoue* in 1832. In 1837 he became one of the promoters, and a joint-editor, of the *Zeitschrift für die Kunde des Morgenlandes*, and through this medium he gave to the world his *Versuch einer mordwinischen Grammatik* and other valuable contributions. His *Grundzüge der syrjänischen Grammatik* appeared in 1841. In conjunction with his old school friend, Julius Löbe, the Germanist, he brought out a complete edition, with translation, glossary, and grammar, of Ulfilas's Gothic version of the Bible (Leipsic, 1843–46); and from 1847 he began to contribute to the *Zeitschrift der deutschen morgenländischen Gesellschaft* the fruits of his researches into the languages of the Suahilis, the Samoyeds, the Hazaras, the Aimaks, the Formosans, and other widely-separated tribes. The *Beiträge zur Sprachenkunde* (Leipsic, 1852) contain Dyak, Dakota, and Kiriri grammars; to these were added in 1857 a *Grammatik u. Wörterbuch der Kassiasprache*, and in 1860 a treatise in universal grammar (*Ueber das Passivum*). In 1864 he edited the Manchou translations of the Chinese Sse-shu, Shu-king, and Shi-king, along with a dictionary; and in 1873 he completed the work which constitutes his most important contribution to philology, *Die melanesischen Sprachen nach ihrem grammatischen Bau und ihrer Verwandschaft unter sich und mit den malaiisch-polynesischen Sprachen untersucht* (Leipsic, 1860–73). It treats of the language of the Fiji Islands, New Hebrides, Loyalty Islands, New Caledonia, etc., and shows their radical affinity with the Polynesian class. He also contributed most of the linguistic articles in Pierer's *Conversations-Lexicon*.

GABII, an old, and at one time important, city of Latium, on the Via Prænestina, or road to Præneste, between 12 and 13 miles E. of Rome. Long before the foundation of Rome, Gabii appears to have been one of the largest of the Latin cities; and, according to an old tradition noticed by Dionysius and Plutarch, Romulus and Remus were educated there. During the greater part of the regal period of Rome Gabii maintained its ground, and it only fell into the hands of Tarquin the Proud through a stratagem contrived by his son Sextus, who was afterwards slain by the inhabitants, when, on the expulsion of his family from Rome, he sought refuge in the town. After this period Gabii always appears in history as the ally or dependant of its more powerful neighbor, and it gradually fell into such a state of decay as to become a proverb of desolation—*Gabiis desertior*. The fame of its cold sulphurous waters gave new life to the place in the reign of Tiberius; and the emperor Hadrian, one of whose favorite residences was not far distant, at Tivoli, appears to have been a very liberal patron, building a town-house (*Curia Ælia Augusta*) and an aqueduct. After the 3d century Gabii practically disappears from history, though its "bishops" continue to be mentioned in ecclesiastical documents till the close of the 9th. The principal relic of the ancient city is a ruined temple (probably of Juno) on a hill now crowned by the ruins of the mediæval fortress of Castiglione. It is a hexastyle structure of uncertain date, uniting the characteristics of Greek and Italian architecture; but the fragments of the pillars are not sufficient to show whether it belonged to the Ionic or the Corinthian order. Its length is about 48 English feet. Since 1792, when explorations were commenced by the Prince Borghese, a large number of minor antiquities have been discovered at Gabii, and the sites of the forum and a theatre have been ascertained. The statues and busts are especially numerous and interesting; besides the deities Venus, Diana, Nemesis, etc., they comprise Marcus Agrippa, Tiberius, Germanicus, Caligula, Claudius, Nero, Trajan and Plotina, Hadrian and Sabina, Aurelius Antoninus, L. Septimius Severus, Septimius Geta, Gordianus Pius, etc. The inscriptions relate mainly to local and municipal matters. In the neighborhood of Gabii were valuable and extensive quarries of an excellent building stone, known as the *lapis Gabinus*, which was largely used by the Romans. It was a hard and compact variety of volcanic tufa, and closely resembled the *lapis Albanus*, to which, however, it was superior. The name of *cinctus Gabinus* was given by the Romans to a peculiar method of girding the toga, with one end thrown over the head and the other fastened round the waist, which was employed by the founder of a new town, or by the consul when he "declared war in the name of the Roman people, or devoted himself to death for his country."

See Ciampini, *Monumenta Vetera* (which contains a plan and elevation of the temple); Gallatti, *Gabii antica città di Sabina scoperta*, 1757; Fea, *Lettere sopra la scoperta delle rovine della città di Gabio*, 1792; Visconti, *Monumenti Gabini della villa Pinciana*, Rome, 1797, new edition, Milan, 1835; Gell, *Rome and its vicinity*; Nibby, *Contorni di Roma*; and Canina, *Storia e topographia di Roma antica*. An interesting comparison of the temple of Juno with the similar building at Aricia was contributed by Abeken to the *Annali dell. instit. di corr. arch.*, Rome, 1841.

GABLER, Georg Andreas (1786–1853), a German philosophical writer of the school of Hegel, was born at Altdorf, in Bavaria, where his father was professor, on the 30th of July, 1786. In 1804, when his father was translated to Jena, he accompanied him to that university, where he completed his studies in philosophy and law, and became one of the most enthusiastic of the hearers and disciples of Hegel. After holding successive educational appointments at Weimar, Nuremberg, and Ansbach, he, in 1817, became one of the masters in the gymnasium at Baireuth. In 1821 he was appointed rector, and in 1830 general superintendent of schools. In 1827 he brought out the first volume of a *Lehrbuch der philosophischen Propädeutik als Einleitung zur Wissenschaft*, in which his design was to give a popular exposition of the Hegelian philosophy, which he himself regarded as fitted to give "absolute satisfaction to the faculties of thinking and knowing." In 1835 he succeeded Hegel in the Berlin chair. His other works were a treatise *De veræ philosophiæ erga religionem Christianam pietate* (1836), and *Die Hegel'sche Philosophie*, a defence of the Hegelian philosophy against Trendelenburg, which was published in 1843. He died at Teplitz, September 13, 1853.

GABLER, Johann Philipp (1753–1826), a learned Protestant theologian of the school of Griesbach and Eichhorn, was born at Frankfort-on-the-Main, June 4, 1753. He had already acquired an extensive acquaintance with the ancient languages and their literatures, as well as with the philosophy of Wolf and the theology of Baumgarten, when, in his nineteenth year, he entered the university of Jena as a divinity student. In 1776 he was on the point of abandoning theological pursuits, when the arrival of Griesbach inspired him with new ardor. After having been successively repetent in Göttingen and teacher in the public schools of Dortmund (Westphalia) and Altdorf (Bavaria), he was, in 1793, appointed second professor of theology in the university of the last-named city, whence he was translated to a chair in Jena in 1804. At Altdorf he published (1791–93) a new edition, with introduction and notes, of Eichhorn's *Urgeschichte*; this was followed, two years afterwards, by a supplement entitled *Neuer Versuch über die mosaische Schöpfungsgeschichte*. He was also the author of several original works which were characterized by much critical acumen, and which had considerable influence on the course of German thought on theological and biblical questions. From 1798 to 1811 he was editor of the *Theologisches Journal*, first conjointly with Hänlein, Ammon, and Paulus, and afterwards unassisted. He died at Jena, February 17, 1826.

GABLONZ, the chief town of a circle in Bohemia, is situated in a hilly country on the river Neisse, about 6½ miles S. E. of Reichenberg. It possesses a Catholic and a Protestant church, a city school, a hospital, and a fine new town-house. Its principal industry is the manufacture of glass, the export of which reaches an annual value of over 6 million guilders. It has also net and cloth factories. The population in 1869 was 6752.

GABOON RIVER, or Rio de Gabâo, called Olo' Mpongwe by the Mpongwe natives, and Aboka by the Fan, is, in reality, not a river but an estuary on the west coast of Africa. It lies immediately north of the equator, disemboguing in 0° 21′ 25″ N. lat. and 9° 21′ 23″ W. long. At the entrance, between Cape Joinville, or Santa Clara, on the N., and Cape Pangara, or Sandy Point on the S., it has a width of about 18 English miles. It maintains a breadth of about 7 miles for a distance of 40 miles inland, when it contracts into what is known more correctly as the Rio Olambo, which is not more than 2 or 3 miles from bank to bank. Two rivers, the Nkomo or Como and the Mbokwa or Bokoe, discharge into the upper portion of the Rio Olambo, both taking their rise in the country of the Sierra dal Crystal. The former, which far exceeds the other in the length of its course, has its head waters, according to M. Genoyer (1862), in that part of the range which is known to the natives as Anenguenpala, or the "Water-jug." Mr. Winwood Reade reached the rapids in 1862, and Mr. R. B. N. Walker, one of the traders in the Gaboon, has ascended for about 30 miles up the river, which had still 2 fathoms of water. Captain Burton, who in 1870 sailed up the Mbokwa as far as Tippet Town or Mayyan, a little way beyond the confluence of the Londo, found it there "some 50 feet broad," with a tidal rise of nearly 7 feet. There are a great number of other streams that fall into the Gaboon, but only two are worthy of special mention,—the Remboa, which, rising like the Nkomo and Mbokwa in the Sierra dal Crystal, enters the estuary at its south-east corner, and the Eko or Cohit, which is the largest of the right hand affluents. Though the whole estuary is studded with islands, reefs, and shoals, none of the islands are of great extent except Coniquet, or King's Isle, at the mouth of the Cohit, and Embeneh, or Parrot Island, in the middle of the channel.

The four principal tribes in the country of the Gaboon are the Mpongwa, the Fan, the Bakalai, and the Boulous. The first of these tribes, usually called *Gabons* or *Gabonese* by French writers, is distributed along both banks of the "river," occupying the villages of Kringer, Quaben, Louis, Libreville, and Glass on the right side, and those of George Town and Denis on the left. According to Captain Burton, they are now one of the most civilized of African tribes, displaying a keen interest in trade, and great ease and urbanity of manner. There are three grades or quasi-castes among them—1st, those of pure blood, who rejoice in the title of Ongwá Ntye or "sons of the soil;" 2d, the children of freemen by slaves; and, 3d, the slaves themselves. Marriage is by purchase, and polygamy is the rule, but the women hold a position of considerable social influence, and maintain a secret society of their own. The men are excellent makers of canoes, and, within the present generation, they have learned to build boats of considerable size after the European model. From childhood both sexes are habitual smokers of tobacco or hemp—the tobacco being imported from America, although it might be readily cultivated in the country. A baptismal rite, almost identical with the Christian ceremony, is administered to the new-born child. The language of the Mpongwa has been reduced to writing by the American missionaries. As early as 1847 they published a grammar and vocabulary at New York; and in 1859 the American Bible Society brought out a Mpongwa translation of the books of Proverbs, Genesis, part of Exodus, and the Acts. The language belongs to the same family as the Sechwana, the Zulu, etc., and is characterized, says Captain Burton, by inflexion, by systematic prefixes, a complex alliteration, and the almost unparalleled flexibility of the verb, which can be modified in several hundred different ways. M. Catteloup describes it as "riche, criard, imagé, et compliqué." It has been adopted by the Pahouins, the Bakalai, and the Boulous as a kind of commercial *lingua franca*, and bids fair to become the dominant language of the coast, if it does not give way before English or French, which have both become familiar in a corrupted form to a large number of the maritime population.

The Fan, whose name appears under the various forms of Fanwe, Panwe, Phaouin, and Paouen, are new comers to the Gaboon district, having, it is said, appeared there for the first time in 1842. They are described as of mean height, chocolate complexion, and remarkably regular features. Their reputation as cannibals is evidently well founded; but they seem to partake of human flesh rather as a ceremonial observance than as an ordinary means of nourishment, and both Winwood Reade and Captain Burton speak in favorable terms of their general characteristics. They are skilful workers in iron, and manufacture cross-bows which discharge poisoned darts 40 or 50 yards. Tattooing is practised by both sexes, and the women often stain the whole body red or yellow. The tribe has come very little into contact with Europeans, but it is moving towards the coast, and will probably before long be the dominant race in the Gaboon.

The Gaboon was early visited by the Portuguese explorers, and it became one of the chief seats of the slave trade. It was not, however, till well on in the present century that Europeans made any more permanent settlement than was absolutely necessary for the maintenance of their commerce. In 1839 Captain Bouet of the "Malouine" obtained for France the right of residence on the left bank, and in 1842 he secured better positions at Louis and Quaben on the right bank. The chief establishment, called Le Plateau, at Libreville, was founded in 1845, and gradually acquired considerable importance. In 1867 the troops numbered about 1000, and the civil population about 5000, while the official reports about the same date claimed for the whole colony an area of 8000 square miles, and a population of 186,000. A large building with arcades at Libreville served as Government house, and there were pretty extensive warehouses, a hospital, and a small dockyard, as well as gardens, and a nursery for coffee plants and fruit trees. At some little distance off a convent was founded in 1844 by Mgr. Bessieux. In consequence of the war with Germany the colony was practically abandoned in 1871, and the establishment at Libreville is now maintained only as a coaling depôt. There are numerous English trading ports along the shores of the estuary, as at Glass Town and Olemi; and even when the French influence was at its greatest almost the whole commerce of the Gaboon was in English hands. The chief articles of export are ivory and beeswax; to which may be added caoutchouc, ebony, and camwood. Mission stations are maintained by French, English, American, German, and Portuguese societies.

See Bowditch, *Mission from Cape Coast Castle to Ashantee*, etc., 1819; E. Bouet-Willaumez, *Descr. nautiques des côtes de l'Afrique Occidentale*, 1846; Pigeard, "Rapport addressé a M. Montagnies de la Roque," in *Annales maritimes*, 1847; J. L. Wilson, *Western Africa*, 1856; Winwood Reade, *Savage Africa*, 1863; *Annales des Voyages*, 1866; Du Chaillu, *Journey to Ashangoland*, 1867; "Notice d'une Carte," in *Bull. de la soc. géog.*, 1869; Catteloup, in *Revue maritime et coloniale*, 1874; Burton, *Two Trips to Gorilla Land*, 1876; Coello's map in *Boletin de la soc. geogr. de Madrid*, 1878.

GABRIEL (גַּבְרִיאֵל, *i.e.*, man of God, Γαβριήλ) is the name of the heavenly messenger (see ANGEL) who was sent to Daniel to explain the vision of the ram and the he-goat, and to communicate the prediction of the Seventy Weeks (Dan. viii. 16; ix. 21). He was also employed to announce the birth of John the Baptist to Zechariah, and that of the Messiah to the Virgin Mary (Luke i. 19, 26). Both Jewish and Christian writers generally speak of him as an archangel—a habit which is readily accounted for when Luke i. 19 is compared with Rev. viii. 2, and also with Tobit xii. 15. In the apocryphal *Book of Enoch* (c. ix.) he is spoken of as one of "the four great archangels," Michael, Uriel, and Suriel or Raphael being the other three. His name frequently occurs in the Jewish literature of the later post-Biblical period. Thus, according to the Chaldee paraphrase of Pseudo-Jonathan, the man who showed the way to Joseph (Gen. xxxvii. 15) was no other than Gabriel in human form; and in Deut. xxxiv. 6 it is affirmed that he, along with Michael, Uriel, Jophiel, Jephephiah, and the Metatron, buried the body of Moses. In the Targum on 2 Chr. xxxii. 21 he is named as the angel who destroyed the host of Sennacherib; and in similar writings of a still later period he is spoken of as the spirit who presides over fire, thunder, the ripening of the fruits of the earth, and similar processes. In the Koran great prominence is given to his function as the medium of divine revelation, and, according to the Mahometan interpreters, he it is who is referred to by the appellations "Holy Spirit" and "Spirit of Truth." He is specially commemorated in the calendars of the Greek, Coptic, and Armenian churches.

GAD (גָּד) in Hebrew and Chaldee means "luck;" hence, in the Phœnician and Babylonian cultus, the god of luck, who is mentioned in Isa. lxv. 11 (where for "that troop" should be read "Gad"), and whose name appears in several names of places, such as Baal-Gad (Josh. xi. 17, xii. 7); possibly also in Dibon-Gad, Migdol-Gad, and Nahal-Gad. Gad was the name given by Leah, the wife of Jacob, to the patriarch's seventh son, the first-born of Zilpah, her maid; see Gen. xxx. 11, where the Hebrew K'tib is בְּגָד, and the K'ri בָּא גָד. The former is adopted by the LXX., and rightly rendered ἐν τύχῃ (Vulgate *feliciter*); the latter reading is adopted in the Targums and Peshito, which translate "luck is come," and by the Samaritan and Ven., which interpret the expression as meaning "a troop (or army) is come." This last rendering has doubtless been influenced by Gen. xlix. 19, where the name is played on as if it were גְּדוּד, "a plundering troop;" "Gad, a plundering troop shall plunder him, but he shall plunder at their heels." Of the personal history of Gad nothing is related. According to Gen. xlvi. 16, he had seven sons when he went down to Egypt along with Jacob; and in Num. xxvi. 15 these appear as seven families, one of the names, however, being changed (Ozni for Ezbon). At the Exodus the tribe numbered 45,650 fighting men (Num. i. 25); but they declined to 40,500 during the forty years' wandering in the wilderness (Num. xxvi. 18). During the subsequent period the fortunes of this tribe were very closely connected with those of the tribe of Reuben. At the division of the country a portion in the trans-Jordanic territory was, at their special request, allotted to them by Moses (Num. xxxii. 33), and this arrangement was carried out by Joshua; but considerable difficulty arises when the attempt is made to define the precise limits of the district thus assigned. It is certain that Gad never extended farther west than the Jordan; but in different passages we find its northern, eastern, and southern boundaries stretched as far as to the sea of Galilee, Salkah in the desert, and the river Arnon respectively. In the book of Numbers (xxxii. 34) the cities of Gad appear to lie chiefly to the south of Heshbon; in Joshua xiii. 24–28 they lie almost wholly to the north; while other texts present discrepancies that are not easily reconciled with either passage. That Gad, at one time at least, held territory as far south as Pisgah and Nebo would follow from Deut. xxxiii. 21, if the rendering of the Targums, revived by Ewald and Diestel, were to be accepted—"and he looked out the first part for himself, because there was the portion of the buried lawgiver;" it is certain, however, that, at a late period, this tribe was localized chiefly in Gilead, in the district which now goes by the name of Jebel Jilad. Possibly some cities were common to both Reuben and Gad, and perhaps others more than once changed hands. Both tribes were pastoral and warlike; but the latter seems to have excelled in bravery and force of character, and indeed there are indications that the tribe of Reuben had been absorbed, or become extinct, at a somewhat early date. David's men of Gad (1 Chr. xii. 8) are famous, and Jephthah and Elijah seem to have belonged to that tribe. It followed Jeroboam in the great revolt against the house of David; and a genealogy, as at the time of Jeroboam II., is given in 1 Chr. v. 11–16, where the names are in every case different from those in Numbers. The tribe was "carried into captivity" by Tiglath-Pileser in the 8th century B. C. (1 Chr. v. 26; comp. 2 Kings xv. 29), and at this point it wholly disappears from history.

GAD is also the name of a "prophet" or "seer," who was probably a pupil of Samuel at Naioth, and a companion of David, to whom he early attached himself. It is not known to which tribe he belonged. He is first mentioned in 1 Sam. xxii. 5 as having joined David while he was "in the hold;" and he afterwards became a member of his regal court, where he seems to have held an official position, being occasionally designated as "the king's seer." He assisted in organizing the musical service of the "house of God" (2 Chr. xxix. 25), and also wrote a "book of the acts of David," which is referred to in 1 Chr. xxix. 29.

GADÂMES, GHADÂMES, or RHADÂMES, the chief town of an oasis of the same name, in that part of the Sahara which belongs to the regency of Tripoli, not far from the frontier of Algeria. According to Dr. Rohlfs, the last form of the word more correctly represents the Arabic pronunciation; but the other forms are more usual in European books. The whole oasis is surrounded by a dilapidated wall varying in height from 12 to 20 feet, and it requires about an hour and a half to make the circuit of the enclosure at an ordinary walking pace. In the town proper the streets are narrow and tortuous, and they are usually covered in overhead to keep out the heat. Its public buildings comprise six mosques and seven schools; and it is worthy of note that all the inhabitants can read and write, and that those who cannot pay for their children are allowed to send them to school free of charge. The Gadamsi merchants have been known for centuries as keen and adventurous traders, and their commercial establishments are to be found in many of the more important cities of northern and central Africa, such as Kano, Katsema, Timbuctoo. Gadames itself is the centre of a large number of caravan routes, and it is calculated that, on an average, about 30,000 laden camels enter its markets every year. At the time of Richardson's visit in 1845 the total population was estimated at 3000, of whom about 500 were slaves and strangers, and upwards of 1200 children; but it now amounts in round numbers to 7000 or even 10,000. The natives are mainly of Berber descent, although their blood has from generation to generation been mingled with that of Negro slaves from various parts of Africa. It is evident, from the remains that are still extant, that the oasis of Gadames was formerly inhabited by people whose architecture was of Roman origin; and it is not unlikely that the Romans themselves may have been attracted to the spot by the presence of the warm springs which still rise in the heart of the town, and spread fertility in the surrounding gardens. An identification has been made with Cydamus, a town mentioned by Pliny. See Largeau in *Bull. de la soc. géogr. de Paris*, 1877.

GADARA, an ancient city of Syria, in the Decapolis, about 6 miles S. E. of the Sea of Galilee, on the banks of the Hieromax. The site, now called Um Keis, is marked by extensive ruins, which are quite in keeping with the statements of Josephus and Polybius that Gadara was the capital of Peræa, and one of the most strongly fortified places in the country. The walls can still be traced in a circuit of about 2 miles; one of the principal streets—a *via recta*, or straight street—has evidently been bordered on both sides by colonnades; and two theatres are the most noticeable of the ruined edifices. The cliffs round the town are full of tombs excavated in the limestone rock, and by a curious irony of fate these chambers of the dead are the only places where a living inhabitant of Gadara is to be found. According to Josephus, Gadara was a Greek city, and it appears at least not improbable that it was a foreign settlement. The name does not occur in the Scriptures; but in the New Testament, the phrase "the country of the Gadarenes" is used more than once, and there is no reason to doubt that the vicinity of the town was the scene of the healing of the demoniacs by the Saviour, recorded in Matt. viii., Mark v., and Luke viii. Josephus informs us that Gadara was captured by Antiochus in 218 B. C., and, about 20 years afterwards, stood a ten months' siege by Alexander Jannæus. It was twice taken by Vespasian, though, on the first occasion, the Jewish inhabitants offered a stout resistance. At a later period it recovered from the injuries he inflicted, and was one of the most beautiful and flourishing cities of Syria, and it was not till after the Mahometan conquest that it fell again into decay. Its archæon or prefecture is mentioned in the Midrash Rabba (*circa* 278) and other Jewish writings. According to Dr. O. Blau the town was also known as the Arabian Antioch. To the literary student it is interesting as the birthplace of Meleager the anthologist.

See Porter in *Journ. of Sacred Literature*, vol. vi.; *Journ. Asiatique*, 1867, p. 191; *Zeitsch. d. D. Morg. Ges.*, 1869.

GADDI. Four painters of the early Florentine school—father, son, and two grandsons—bore this name.

1. GADDO GADDI (1239 to about 1312) was, according to Vasari, an intimate friend of Cimabue, and afterwards of Giotto. He was a painter and mosaist, is said to have executed the great mosaic inside the portal of the cathedral of Florence, representing the coronation of the Virgin, and may with more certainty be credited with the mosaics inside the portico of the basilica of St. Maria Maggiore, Rome, relating to the legend of the foundation of that church; their date is probably 1308. In the original cathedral of St. Peter in Rome, he also executed the mosaics of the choir, and those of the front, representing on a colossal scale God the Father, with many other figures; likewise an altarpiece in the church of St. Maria Novella, Florence; these works no longer exist. It is ordinarily held that no picture (as distinct from mosaics) by Gaddo Gaddi is now extant. Messrs. Crowe & Cavalcaselle, however, consider that the mosaics of St. Maria Maggiore bear so strong a resemblance in style to four of the frescoes in the upper church of Assisi, representing incidents in the life of St. Francis (frescoes 2, 3, 4, and especially 5, which shows Francis stripping himself, and protected by the bishop), that those frescoes likewise may, with considerable confidence, be ascribed to Gaddi. Some other extant mosaics are attributed to him, but without full authentication. This artist laid the foundation of a very large fortune, which continued increasing, and placed his progeny in a highly distinguished worldly position.

2. TADDEO GADDI (about 1300–1366, or later), son of Gaddo, was born in Florence, and became one of Giotto's most industrious assistants for a period (as usually stated) of 24 years. This can hardly be other than an exaggeration; it is probable that he began painting on his own account towards 1330, when Giotto went to Naples. Taddeo also traded as a merchant, and had a branch establishment in Venice. He was a painter, mosaist, and architect. He executed in fresco in the Baroncelli (now Giugni) chapel, in the Florentine church of St. Croce, the Virgin and Child between Four Prophets, on the funeral monument at the entrance, and on the walls various incidents in the legend of the Virgin, from the Expulsion of Joachim from the Temple up to the Nativity. In the subject of the Presentation of the Virgin in the Temple are the two heads traditionally accepted as portraits of Gaddo Gaddi and Andrea Tafi; they cannot, at any rate, be portraits of those artists from the life. On the ceiling of the same chapel are the Eight Virtues. In the museum of Berlin is an altar-piece by Taddeo, the Virgin and Child and some other subjects, dated 1334; in the Naples Gallery, a triptych, dated 1336, of the Virgin enthroned along with Four Saints, the Baptism of Jesus, and his Deposition from the Cross; in the sacristy of St. Pietro a Megognano, near Poggibonsi, an altarpiece dated 1355, the Virgin and Child enthroned amid Angels. A series of paintings, partly from the life of St. Francis, which Taddeo executed for the presses in St. Croce, are now divided between the Florentine Academy and the Berlin Museum; the compositions are taken from or founded on Giotto, to whom, indeed, the Berlin authorities have ascribed their examples. Taddeo also painted some frescoes still extant in Pisa, besides many in St. Croce and other Florentine buildings, which have perished. He deservedly ranks as one of the most eminent successors of Giotto; it may be said that he continued working up the

material furnished by that great painter, with comparatively feeble inspiration of his own. His figures are vehement in action, long and slender in form; his execution rapid and somewhat conventional. To Taddeo are generally ascribed the celebrated frescoes,—those of the ceiling and left or western wall,—in the Cappella degli Spagnuoli, in the church of St. Maria Novella, Florence; this is, however open to considerable doubt, although it may perhaps be conceded that the designs for the ceiling were furnished by Taddeo. Dubious also are the three pictures ascribed to him in the London National Gallery. As a mosaist, he has left some work in the baptistery of Florence. As an architect, he supplied in 1336 the plans for the present Ponte Vecchio, and those for the original (not the present) Ponte St. Trinita; in 1337 he was engaged on the church of Orsan-Michele; and he carried on after Giotto's death the work of the unrivalled Campanile.

3. Agnolo Gaddi, born in Florence, was the son of Taddeo; the date of his birth has been given as 1326, but possibly 1350 is nearer the mark. He was a painter and mosaist, trained by his father, and a merchant as well; in middle age he settled down to commercial life in Venice, and he added greatly to the family wealth. He died in October, 1396. His paintings show much early promise, hardly sustained as he advanced in life. One of the earliest, at St. Jacopo tra' Fossi, Florence, represents the Resurrection of Lazarus. Another probably youthful performance is the series of frescoes of the Pieve di Prato,—legends of the Virgin and of her Sacred Girdle, bestowed upon St. Thomas, and brought to Prato in the 11th century by Michele dei Dagomari; the Marriage of Mary is one of the best of this series, the later compositions in which have suffered much by renewals. In St. Croce he painted, in eight frescoes, the legend of the Cross, beginning with the Archangel Michael giving Seth a branch from the tree of knowledge, and ending with the Emperor Heraclius carrying the Cross as he enters Jerusalem; in this picture is a portrait of the painter himself. Agnolo composed his subjects better than Taddeo; he had more dignity and individuality in the figures, and was a clear and bold colorist; the general effect is laudably decorative, but the drawing is poor, and the works show best from a distance. Various other productions of this master exist, and many have perished. Cennino Cennini, the author of the celebrated treatise on painting, was one of his pupils.

4. Giovanni Gaddi, brother of Agnolo, was also a painter of promise. He died young. (W. M. R.)

GADIATCH, a town of Russia, at the head of a district in the government of Poltava, situated on the elevated banks of the Grun and the Psel, 73 miles N.N.W. of Poltava, in 50° 22′ N. lat. and 34° 0′ E. long. It is a plain, wood-built town, with four Greek churches and two synagogues, deriving its main importance from its four annual fairs, one of which, lasting for three weeks, was, up to 1857, held at the Hermitage of the Transfiguration (*Skeet Preobrazhenski*). In 1860 the population was 7263, 1213 of the number being Jews. According to W. Struve's *Calendar* for 1878, it was 8425. Gadiatch was the place where the assembly was convoked by the hetman Vigofski in 1658, for the publication of the treaty contracted between the Ukrainians and the Poles. During the hetmanate it had fortifications of which traces are still extant, ranked as a garrison town, and was the residence of the hetman. At first it was included in the military district of Luben, but after 1650 in the district to which it gave its name. Along with 13 large villages it was bestowed by the Empress Elizabeth on Count Razumofski, but it was afterwards purchased from him by the Empress Catharine II. In 1771 the town and district were incorporated with the province of Kieff, and in 1802 they obtained their present position in the government of Pultowa.

GADWALL, a word of obscure origin,[1] the common English name of the Duck called by Linnæus *Anas strepera*, but considered by many modern ornithologists to require removal from the genus *Anas* to that of *Chaulelasmus* or *Ctenorhynchus*, of either of which it is not only the typical but the sole species. Its geographical distribution is almost identical with that of the common Wild Duck or Mallard (see Duck, vol. vii. p. 436), since it is found over the greater part of the Northern Hemisphere; but, save in India, where it is said to be perhaps the most plentiful species of Duck during the cold weather, it is hardly anywhere so numerous, and both in the eastern parts of the United States and in the British Islands it is rather rare than otherwise. Its habits also, so far as they have been observed, greatly resemble those of the Wild Duck; but its appearance on the water is very different, its small head, flat back, elongated form, and elevated stern rendering it recognizable by the fowler even at such a distance as hinders him from seeing its very distinct plumage. In coloration the two sexes agree much more than is the case with any of the European Freshwater Ducks (*Anatinæ*)—one only, the *Anas marmorata*, excepted; but on closer inspection the drake exhibits a delicate, ash-colored breast, and upper wing-coverts of a deep chestnut, which are wholly wanting in his soberly clad partner. She, however, has, in common with him, some of the secondary quills of a pure white, presenting a patch of that color which forms one of the most readily-perceived distinctive characters of the species. The Gadwall is a bird of some interest, since it is one of the few that have been induced, by the protection afforded them in certain localities, to resume the indigenous position they once filled, but had, through the draining and reclaiming of marshy lands, long since abandoned. In regard to the present species, this fact is due to the efforts of the late Mr. Andrew Fountaine, on whose property, in West Norfolk and its immediate neighborhood, the Gadwall has now, for nearly thirty years, annually bred in constantly increasing numbers, so that it may again be accounted, in the fullest sense of the word, an inhabitant of England; and, as it has been always esteemed one of the best of wild fowl for the table, the satisfactory result of its encouragement by this gentleman is not to be despised. (A. N.)

GAELIC LANGUAGE AND LITERATURE. Until recently there was doubt as to the family of languages to which the Gaelic belonged; indeed, with many scholars the impression existed that it belonged to the Semitic branch, and that its relations must all be traced among some one or other of its varieties. This view arose very much from the neglect with which the language had been treated by scientific men. Comparative philology is itself a modern subject of study. Naturally, in its progress, the more prominent languages came first, while the more obscure were passed over as of comparatively subordinate importance. The study is one so comprehensive, and requiring so large an amount of acquirement of various kinds, that it is no real reproach to modern scholarship that the study of such languages as the latter should have been postponed in favor of that of languages more generally known. Their turn, however, gradually came, and no one can complain now that they have not received the attention of very competent scholars. It is doubtful whether a higher class of scholarship has been nurtured anywhere than in the study of the Celtic languages, as exhibited by such men as Zeuss, Dieffenbach, Ebel, Whitley Stokes, the Chevalier Nigra, Henri Gaidoz, and others who have devoted their strength to their exposition. The result has been the complete establishment of the fact that this class of languages belongs to the Indo-European or Aryan stock, and is closely related to the classical branch of those tongues.

The first who brought real scholarship to bear upon the question of the family to which the Celtic dialects belonged was Dr. Cowles Pritchard. His *Eastern Origin of the Celtic Nations* is a work of the highest value, distinguished by its erudition, and the sound judgment it displays. He was one of the most remarkable men whom Britain has produced in the field of comparative philology. No doubt it is with the Welsh he chiefly dealt, but, in discussing such questions as he had to deal with, it mattered little which of the Celtic tongues was made use of. Many writers followed Dr. Pritchard, and there is now, as has been said, no question about the Aryan source of the Celtic languages. It is not that the words are to a large extent analogous, but the grammatical structure and the idioms correspond to such an extent that the question is put beyond a doubt; while, with the exception of a few common vocables, there is little that is analogous between the Celtic and the Semitic languages.

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[1] Webster gives the etymology *gad well* = go about well. Dr. R. G. Latham suggests that it is taken from the syllables *quedul*, of the Latin *querquedula*, a Teal. The spelling "Gadwall" seems to be first found in Willughby in 1676, and has been generally adopted by later writers; but Merrett, in 1667, has "Gaddel" (*Pinax Rerum naturalium Britannicarum*, p. 180), saying that it was so called by bird-dealers. The synonym "Gray," given by Willughby and Ray, is doubtless derived from the general color of the species, and has its analogue in the Icelandic *Gráönd*, applied almost indifferently, or with some distinguishing epithet, to the female of any of the Freshwater Ducks, and especially to both sexes of the present, in which, as stated in the text, there is comparatively little difference of plumage in Drake and Duck.

The territory once occupied by the Celtic race is a question of much interest. Now they are confined within well-known limits. On the European continent they occupy that part of France usually called Brittany, the most westerly portion of the country terminating in Cape Finisterre. They occupied this territory so early as the days of Julius Cæsar, although it has been said that they were emigrants from Britain at a later period. The topographical terms given by Cæsar in describing the Roman invasion all indicate that the language of the natives of Brittany used then, and for a long time before, was as much Celtic as it is now. Opposite to Brittany lies British Cornwall, a region with a Celtic tongue until about 100 years ago. The two Cornwalls—one in Britain and the other in France—terminated, one on each side, the territory occupied by the Celt. The dialects spoken in these stood in the closest relationship. To the north of this lies the greatest of all the modern sections of the Cimbrian Celts. Wales, occupied by about a million inhabitants, is nearly Celtic, and uses the ancient tongue of Wales, Cumbria, and Strathclyde. Across the sea from Wales lies the Isle of Man, where the Gaelic branch of the Celtic held sway, and does to some extent still. In Ireland the Gaelic also prevailed, and is still spoken by about a million people. And lastly, in the Scottish Highlands about 300,000 people still use, less or more, the old Gaelic tongue of Scotland. Thus Brittany, Wales, Man, western Ireland, and the Scottish Highlands are now the territory of the Celtic languages. That they once occupied a wider sphere is beyond a doubt. There are traces of the tongue, in one form or other, to be found all along southern Europe. Topography is a valuable source of evidence, and one that will be made to serve purposes it has never served as yet; and it furnishes us—in Italy, France, Switzerland, Spain, and Portugal—with relics which, like animal fossils dug from the depths of the earth, speak unmistakably of what formerly existed there. How far the Gaelic form of Celtic speech prevailed it is difficult to say, or whether it existed alongside of the Cimbric on the continent of Europe. But the name Gallia is significant as applied to France; and it is a suggestive fact that to this day, the Bretons call France Gaul, as distinguished from their own country, and in like manner call the French language Gallic, as distinguished from the Breton. In Scotland the Gaelic and Cimbric races long dwelt together, distinct and yet nearly related. When they separated, either as to race or language, is not easily settled. There are indications on the Continent which rather throw doubt on the idea maintained by some writers that the divergence took place after the settlement of the race in Britain, and further inquiry as to these indications is essential ere a satisfactory conclusion can be reached. But within the historic period the two races existed side by side in Scotland, the Cimbric occupying the region called Strathclyde, with their separate government and laws, and the Gael at least occupying the Dalriadic kingdom of Argyll. The people called by the Romans Picts occupied the north and east of Scotland. That these were the same people with the Dalriadic Scots is somewhat questionable. That they were closely related to them is beyond doubt, but that they had linguistic and other peculiarities is manifest. Their topography proves it, being different from that of either Ireland or Argyll, and, so far as the historic relations of both are concerned, they indicate a state of chronic war. For centuries there were mutual raids of Scots on Picts, and Picts on Scots, until finally, under Kenneth MacAlpine, king of Dalriada, the Picts were overcome in the year 843, and they and the Scots became united under one monarchy. The tradition is that the Picts were annihilated,—meaning, in all likelihood, their power,—and there arose one great united kingdom. The united people are the ancestors of the present Scottish Highlanders, and the Gaelic language has come down from them to us, influenced as to structure by the dialect spoken and written by the victors.

The Gaelic language, as now in use in Scotland, resembles closely in its structure both the Irish and the Manx. They form one family, and yet it has its own distinctive features. Irish scholars maintain that it is a modern and corrupt offshoot of the Irish, and account in this way for these peculiarities. They say, for example, that the absence of the present tense in the Gaelic verb is a mere instance of decay, and proves the modern character of the dialect. But the Welsh is no modern and corrupt form of Irish, but an ancient distinct tongue, so far back as history carries us. And yet it wants the present tense, indicating that this peculiarity is distinctive of some of the Celtic tongues, and that what is cited as a proof of recency may in reality be a proof of priority. The present tense may be called an Irish addition made to the verb in the process of culture. At the same time it must be allowed that there is a difficulty in proving from any literary remains existing that the present Scottish form of the language is of great antiquity. All the literary relics that have come down to us are written in what is usually called the Irish dialect. The present tense is in universal use, as well by Scottish as by Irish writers. This arose from the identity of the Irish and Scottish churches. The dialect in which all theological treatises were written was one, and this dialect extended from the clergy to bards, and sennachies, and medical men. There is not a page of Gaelic written in any other dialect before the middle of last century. But as in other countries there was both a spoken and a written dialect in use, so in both Scotland and Ireland there appears to have been a dialect in use among the people as their common speech, and another used by their scholars,—the former varying according to locality, and the latter being identical throughout. Some of the features that distinguish the Gaelic language, partly in common with the other Celtic tongues, and partly not, are the following:—

1. The aspiration of consonants. This is accomplished by the change of *m* into *v*, of *b* into *v*, of *d* into *y*, of *g* into a broad *y*, of *p* into *f*, and *s* and *t* into *h*. As appearing in the initial articulations this presents a peculiar difficulty to the learner of Gaelic. He has been accustomed, in learning other tongues, to observe the changes required by inflexion, and other requirements of correct grammatical structure. But he has not been familiar with changes in the initial letters of words. In English these letters never undergo any change; but in Gaelic he meets with such changes at once. He finds *mac*, a son, becoming in certain circumstances *vac*, and he is ready to doubt whether both forms belong to the same word. To make the difficulty as little formidable as possible to the reader, the authors of the Gaelic orthography fell upon the method of using the letter *h*, which, though hardly a letter in Gaelic, and never used to begin a word, is now used more than any other letter. The Irish use a dot. The use of the *h* serves to preserve to the reader the original form of the word. Hence *mac* becomes by aspiration, or *adoucissement*, as the French call it, *mhac*, pronounced *vac*. These initial changes of certain consonants are made for the purpose of euphony, to which Gaelic makes large sacrifices, and also for the purpose of distinguishing gender. An aspiration converts the feminine into the masculine, and *vice versa*. *An ceann* is the head, masculine, *a' chos* the foot, feminine. So *a chos* is his foot, *a cos* is her foot; *a cheann* is his head, *a ceann* is her head, the pronoun undergoing no change, although its gender is indicated by the change. There are other purposes served by aspiration of considerable importance. The Gaelic learner makes a large acquisition when he masters the principles of aspiration, and inquirers into the characters of the language will cease to blame the frequency with which *h* appears in Gaelic writing when they come to see how important a purpose it serves.

2. Another peculiarity of the Gaelic language is to be found, as already said, in the want of a present tense in the verb. The verb "to do" is *dean*, the theme of the verb being in the imperative mood. There is no tense expressing simply I do, the form in use being I am doing, *tha mi a' deanamh*. The Irish say *deanaim*, I do, but that is not the Scottish form of the expression. In this Gaelic is not only at one with several of the Celtic branches, but with some of the Semitic tongues. And it has this further in common with these last, that the future is used to express present time. This occurs frequently in the Gaelic version of the Bible, where we have *an ti a chreideas anns a' Mhac*, he that will believe in the Son, for he that believeth. And yet occasionally a true present tense appears in Gaelic:—*an cluinn thu sin?* Do you hear that? *cluinnidh*, I do hear it; *am faic thu sin?* Do you see that? *chi*, I do see it. In these cases and some others there is no doubt a distinct present tense. The cases are, however, few, and occur in peculiar circumstances.

3. Another feature peculiar to Gaelic is that there is no real infinitive in the verb. The infinitive in use is a noun which may appear either in the form of a participle or an infinitive, according to the effect of the preceding preposition. I am going to strike, *tha mi 'dol do bhualadh*, I am going to striking; I am striking, *tha mi a' bualadh*, I am at striking,—the preposition *do*, to, in the one case giving the noun the force of an infinitive, and the preposition *ag* or *a'*, at, giving the same noun the force of a participle. The Gaelic infinitive is thus identical with the

Latin Gerund, and is one of the points where the classical and the Celtic tongues meet and touch.

In the article Celtic Literature reference is made to some of those cases in which the Irish dialect of the Celtic differs from some of the others. It is unnecessary here to go over the same ground again. What is distinctive of the Irish is, for the most part, distinctive of the Scottish Gaelic. The Gaelic retains the hard or *k* sound of *c*. There is not an instance of a purely Gaelic word in which the *c* is pronounced soft. There are dialects of Gaelic, however, in which the *c* becomes aspirated in the middle or at the end of a word. Thus *mac*, a son, is pronounced *machd; peacadh*, sin, is pronounced *peachdadh*. This peculiarity does not exist in the counties of Sutherland and Caithness, where the hard sound of *c* is retained. The Scottish Gaelic, in like manner, in common with Sanskrit, Latin, German, and Slavonian, retains the sibilant *s*, where other dialects have discarded it. Many words beginning in Gaelic with *s* have *h* as the initial letter in Welsh. It is worthy of observation, however, that, in the aspirated form of the *s* used in inflexion or as indicative of gender, the *s* assumes the sound of *h* in Gaelic. In like manner, words in Gaelic, as in Irish, can end in *s*, *r*, and *n*. The instances of these are numerous. So also does the Gaelic, like Irish, retain a harder form of the articulation than the British, but not to the same extent; for *huvel*, low, in Irish *humal*, is in Gaelic *umhal*, approaching in this, as in many other cases, nearer to the British form. So the Gaelic preserves letters where the British loses them, but not to the same extent as the Irish. For when the Irish has *tech*, a house, and the British *ti*, the Gaelic has both *teach* and *tigh*, and for the most part uses the latter. In addition to this, the Gaelic, like the Irish, has preserved the declension of its noun, which cannot be said of the British. Four of the cases are in constant use, the nominative, the genitive, the dative, and the vocative in both numbers, the dative plural alone having almost disappeared from common speech. In the singular number these cases are distinctly marked—*cos*, a foot, gen. *coise*, dat. *cois*, voc. *a chos*. Wherever the language is well spoken these cases are in daily use, and are lost only when the language is far on in the process of decay.

Difference between Gaelic and Irish.—The differences between the Gaelic and the Irish are considerable, and, though Irish writers maintain the contrary, are not to be taken as indications of the modern origin of the former. Without entering on that question, we find a marked distinction in the use by the Irish of what is called eclipsis,—that is, the use of other and softer articulations to eclipse the harder in the beginning of a word, in some cases, as, for instance, in the genitive plural of nouns. The object aimed at would seem to be euphony, and in seeking this object the Irish and the Scottish ear did not altogether correspond. In Irish, the law as given by O'Donovan is that *m* eclipses *b*, as *ar m-bo*, our cow; *g* eclipses *c*, as *ar g-ceart*, our right; *n* eclipses *d*, *bh* eclipses *f*, *n* eclipses *g*, *b* eclipses *p*, *d* eclipses *t*, *t* eclipses *s*. This system of eclipsing runs through the nouns and verbs. It is unknown in Gaelic, if we except the eclipsing of *s* by *t*, as *an t-sùil*, the eye, *an t-slat*, the rod, and certain words which, in some districts of the Highlands, suffer eclipse. In Skye the expression for the number of men is *àireamh nan n-daoine*, the *n* eclipsing the *d*. Other instances may be found along the west coast of Scotland. But eclipsis is, for the most part, distinctive of the Irish dialect. The Gaelic is further marked by a greater tendency to aspiration than the Irish. The sentence *cionnas ta tu?* how art thou? in Irish, is in Gaelic *cionnus tha thu?* the verb and the pronoun being both aspirated. Other differences might be referred to, but one is prominent, the difference of accent or emphasis. The tendency of the Irish is to emphasize the final syllable, that of the Gaelic to emphasize the penultimate. Thus *salàch*, dirty, in Irish, is in Gaelic *salăch; Oisìn*, Ossian, is in Gaelic *Oisiăn*. This makes a striking difference in the spoken tongues, and occasions one of the main difficulties Irish and Scottish Celts have in understanding each other's speech.

Advantages and Defects of Gaelic—The Gaelic language, as now existing, has its advantages and its corresponding defects. It is admirably adapted for the purposes of the poet. In descriptive poetry few languages excel it. There are some pieces of ancient, authentic, Ossianic poetry existing that are equal in power and beauty to the compositions of any age or country. Such are the description of Cuchullin's chariot and horses, and the description of the swords of the Ossianic heroes. The same is true of more modern poetic compositions. Macintyre of Glenorchy's *Beinn Douran* and *Coire Cheathaich* are fine specimens of descriptive poetry—poetical in conception throughout, couched in the choicest language, and with rhythm of unfailing accuracy. The same may be said of Macdonald's *Oran an t-samhraidh*, or Ode to Summer, which is a remarkable specimen of what the Gaelic is capable of when used for the description of nature. Other lyrical compositions are also of a high order of merit. Love-songs and boat-songs abound, and are in many cases full of life and force; and the numerous songs expressive of clan affections and animosities display the same characteristics. No language is more capable of expressing both love and hate, and there seems to have been ample scope for both in the past history of the Highland clans. Within certin limits then, Gaelic is the language of poetry, extending from the epic of the Ossianic bards down to the lyric or less aspiring efforts of lesser bards.

The language is also admirably fitted for the communication of religious knowledge. It is in its structure metaphorical and emotional, and renders with wonderful precision and effect the statements of Scripture. The saying attributed to one of the dukes of Argyll is well known, that if addressing his sovereign he would choose English, if addressing the lady of his affections he would choose French, but if he was addressing his God he would choose Gaelic. Few of those whose calling it is to teach religious truth, and who know how to handle the language with effect, have failed to feel and own that it is incomparable for conveying the knowledge of the truth with power. Perhaps no preachers have surpassed the Welsh in real eloquence, and yet some of the Gaelic preachers have not been behind them. The language has served a great purpose in the Highlands in connection with the religious life of the people.

The defects of the language are to be found chiefly in the departments of philosophy, science, and art. There it has either to be rejected or to be supplied from foreign sources. Indeed in this field it seems to have deteriorated during the course of several centuries. There are MSS. of the 14th and 15th centuries in existence, in which terms are employed in connection with discussions in philosophy, theology, and medicine that could not now be understood. The philosophy of Aristotle is well rendered, as are also the theology of the fathers and the medical disquisitions of the Arabic writers on medicine. But when modern science and philosophy, and even theology in some of its departments, have to be dealt with, the lack of terms renders the task a difficult one. It is here that, in the progress of education, the difficulty of preserving the language lies. The effect of this want is traceable in common speech, when English words have of necessity to be used in connection with objects of every day use. Steamer, train, boiler, engine, railway, quay, etc., have just to be introduced from the Saxon, and presented with a little of the Gaelic tone in them to suit the Celtic ear. Some writers and speakers do try to invent Gaelic terms to represent all these and similar objects, but popular usage rejects them and prefers the foreign words.

Gaelic Literature.—The literature of the Scottish Highlands may be divided into several branches. The following outline comprehends more perhaps than is usually included under that term; in particular, it appears necessary to give here some account of topographical and personal names.

Mythology.—We have first the mythology of the race. Little of this now exists, and it is difficult to piece the scattered fragments together. We find the mythology of the older faith or faiths interwoven in some cases with the mythology of the Northmen. The mythology of the East appears at some points, and we have giants, fairies, and witches, some of them firmly believed in to the present day. Adamnan, in his life of Columba, refers to the magi who were in the palace of the Pictish king whom the missionary sought to convert. Who these were, and what was their creed, is not clearly stated, but all we read of that early faith, and all that tradition brings down to us, would seem to indicate that their worship was a form of sun worship. The words applied to the cardinal points of the compass convey this impression, the fear shown in many ways of going against the course of the sun, and certain festivals in which fire was and is used, would seem to confirm it. The bodies of the dead are in some cases carried sunwise round certain objects on their way to the burial ground; in fact, words and practices crop up in several parts of the country serving to show that the sun was worshipped. *Rath*, a circle, is used in Gaelic to express good fortune:—*cha-n'eil rath air*, there is no circle on him,—he is not fortunate,—referring, no doubt, to the course of the sun. There was a Gaelic mythology connected with the Fingalian heroes. Whether they themselves were mythical or not is debated, but there was a mythology connected with them. Fingal had a sword that never required to be used twice; the Vulcan of the race could cross a glen with a stride; Manannan, son of Lir, from whom the Isle of Man is named, could clothe himself in a fog, and so hide himself from his enemy. The story of Diarmad and the boar and the story of Fraoch and the beast are mythological, the former being the Celtic story of Achilles, and the latter the Celtic version of the Garden of the Hesperides. Then there were giants called *Na Fiantaichean*, men of colossal mould. *Dun Fhian*, the giant's castle, is a common topographical term. Here is the description (with English translation) of one of these heroes:—

> "Tambull mòr, mac sheann Tamhuil,
> Cha ruigeadh a' mhuir mhòr a ruinnse,
> Cha thàradh e mach, 's cha thàradh e steach
> 'Us 'n uair a bhitheadh e 's a bheul fodha,
> Bhitheadh a dhruim a' sgriobadh an athar."
>
> Great Taval, son of old Taval,
> The great sea wouldn't reach his middle;
> He couldn't get out and he couldn't get in;
> And when he lay down on his face,
> His back would be scratching the sky.

Some of these tales of the giants attribute to them a great age. There is one tale in which five generations in succession are said to exist at the same time, and the youngest of them a very aged man. The traditional tales taken down by Mr. J. F. Campbell, from oral tradition, in the Highlands are full of mythology. Animals in these play an important part, and are endowed with remarkable powers. How far this mythology is original, or is borrowed from the East, is an interesting question. In some of the Western Isles, the Scandinavian god Odin enters into the popular mythology, a relic, no doubt, of the Norse occupation of the territory. Fairies, or the *daoine sìthe* or *sìthichean*, fill an important place in the mythology of the Highlands. The name of these imaginary beings is derived from their supposed habits. *Sìth* is a common name in Gaelic for a hill of a peculiar form. As a diminutive it is *sìthean*, the word used for green hillocks, which abound throughout the Highlands. These hills are supposed to be the abodes of fairies, who, in consequence, are called *daoine sìthe*, or the men of the hillocks. *Sìth*, peace, has no part in forming the designation, although often said to have. These beings were the very opposite of peaceful in the popular belief. It is impossible here to give an account of the common belief in the Highlands regarding fairies, but there is a great deal of popular literature taken up with descriptions of it, and with stories regarding these mischievous and meddling beings. They were fond of carrying away young children, and substituting young fairies in their place, to the grief and harassment of the mother. Nor did they confine their assaults to children, but sometimes carried men and women to their underground abodes, where they passed through extraordinary scenes. The Rev. Robert Kirke of Balquhidder wrote an account of the fairies which awakened their anger, and they spirited him away to fairyland. He was able to appear in the room at the baptism of a child born after his removal, when it was arranged that for his deliverance a knife was to be thrown over his head at a certain moment. The hour came, but through some infatuation the party entrusted with the duty failed in the performance. Mr. Kirke was not delivered, and is believed to be in fairyland to this day. Similar stories are without number, and show how widely extended the belief in fairies was.

Witchcraft had a large place in the popular beliefs, and has not lost it altogether at the present day. It was supposed possible for a person endowed with this power to inflict great damage upon an adversary. Milk could be abstracted from the cows of a neighbor and brought to swell the produce of the party abstracting it. This belief has been the source of much animosity and strife among neighbors down to the present time. Clay bodies stuck over with pins could be formed representing an adversary, and could be laid in a stream, and as the clay wasted, the body of the man represented pined until he died. This afforded ample room for the exhibition of party or personal hatred, and is not altogether unknown now. The literature of witchcraft is of considerable extent, and consists in tales and forms of exorcism which are very various, and some of them very curious. The forms are all in rhyme, and do not display much of the genius of poetry; they are usually made up of appeals to saints and apostles, with the occasional introduction of the Virgin Mary. Several of these have been handed down by tradition, and are scattered through various works devoted to Highland lore. Near the valley of the Spey there recently lived a noted wizard, who possessed a charmed bridle which exercised a most powerful influence over all forms of bewitchment. A clergyman, not far from the residence of this man, was on one occasion much disturbed by the state of his cows, which had suddenly ceased to give milk. The neighbors assured the minister that it was witchcraft, and that he ought to send for the man with the charmed bridle, which, very much against his will, he was induced to do. The wizard came, and was told by the clergyman that he had no faith in his witchcraft, but he should very much like to have his counsel as a man of skill. The so-called wizard, understanding with whom he had to deal, at once laid aside all pretension to superhuman power, and asked the minister where his cows usually fed, saying that they would go and take a look at the grass. They did so, when the wizard pointed out a plant, then in flower, which he said was, in that condition, most injurious to cows yielding milk. He advised the minister to keep the cows away from that piece of pasture for a fortnight. This was done, and the cows recovered. The wizard got his fee and a promise that nothing should be said to affect the public confidence in his power. This is the kind of witchcraft that has existed all along, and which has cost many poor helpless creatures their lives at the stake.

Topography.—In dealing with the literature of the Highlands we cannot overlook the topography of the country. It is to be regretted that in Scotland we have no such MS. remains, containing topographical terms with their origin, as are to be found in Ireland, nor have we any work on the subject of topography possessed of the slightest authority. But we have numerous ancient charters containing names of places, and we have what are called the *retours*, connected with the succession to property throughout the country, and these contain extensive lists with the spelling adopted for the names at different periods. These names belong to different languages. There is apparently an original language, if not more than one, which is now lost. Without this assumption there is no accounting for many of the names applied to natural objects. Then there is the old Norse and the Anglo-Saxon, the one using *wick* for a bay, as in Caithness, and the other for a town, as in Roxburghshire; then there is the British, as in the old Strathclyde territory, and the Gaelic. The Gaelic, in its topographical distribution, does not occupy the same field with that occupied by it as a spoken tongue. The spoken language and the topography of Galloway are quite at variance; so with Lewis and others of the Western Isles. The spoken language of Galloway is Scottish, the topography is almost wholly Gaelic. The spoken language of Lewis, Harris, Skye, etc., is Gaelic, the topography is almost wholly old Norse. But one thing is manifest, that Gaelic names are distributed over the whole surface of Scotland, although not in equal proportions. These names contain a history, could it be evolved. They speak of races distinct and successive, although their testimony as to dates is difficult to read. The county names of Scotland in Gaelic are suggestive:—

Shetland.....	*Sialtuinn.*	Fife................	*Fiu.*
Orkney	*Arcaibh.*	Stirling...........	*Sruileadh.*
Caithness	*Gallthaobh.*	Galloway.........	*Gallthaobh.*
Sutherland....	*Cataobh.*	Dumfries..........	*Dunphris.*
Ross............	*Ros.*	Lanark...	*Lanerch.*
Cromarty......	*Crombadh.*	Argyll.............	*Araghael.*
Inverness......	*Inbhearnaoise.*	Dumbarton	*Dunbhreatuinn.*
Nairn	*Inbhearnarunn.*	Bute	*Boite.*
Moray..........	*Morthaobh.*	Linlithgow.......	*Lanneuthaich.*
Banff........ ..	*Banabh.*	Lothian. M. & E.	*Loudaidh.*
Aberdeen......	*Abaireadhain.*	Renfrew	*Renfreudh.*
Kincardine...	*Cinnechardainn.*	Ayr.............	*Siorramachd Adhar.*
Forfar	*Farfair.*		
Perth	*Peart.*	Kirkcudbright..	*Cilleehuibeirt.*

This list does not include Peebles (which is probably Celtic), Selkirk, Roxburgh, and Berwick, as there are no Gaelic terms for them, but in the other cases it will be seen to what an extent the county names are really Gaelic. The same is true of names of parishes, which are, to a large extent, Gaelic both in the north and in the south.

It is to be observed that the Gaelic topography of Scotland differs widely from that of Ireland. The Irish *sliabh*, for a mountain, rarely occurs in Scotland, where the word in use chiefly is *beinn*. It does occur, but the instances are few, while the Scottish *ben* is as rare in Ireland. *Baile*, a township, is sufficiently frequent in Scotland, but not so much so as the Irish *bally*. The word *strath*, for a great valley, occurs but rarely in Ireland; in Scotland it abounds over the whole kingdom. The *abers* and *pits* and *invers* of Scotland are rare in Ireland, or altogether unknown, while there is little resemblance in the names of rivers. These two systems of topography may have originated with the same people, but in one of the sections there were influences manifestly at work which were unknown in the other. Even in the Dalriadic kingdom of Argyll there are features which indicate a marked distinction between the topography and that of Ireland. The study of this subject is full of interest, and is capable of producing important results both linguistic and historical. The field is as yet unoccupied, and affords much to encourage the judicious and painstaking student.

Names of Persons.—The literature of the Highlands may be held further to include the names of persons as well as those of places. Indeed some of the older MSS. are filled with pedigrees, sometimes of kings, sometimes of lesser persons. Many of these ascend up to Noah, and even to Adam, showing at least that they date since the conversion of the Gael to Christianity. There are several interesting genealogical lists in the volume of transactions published by the Iona Club, and there are MSS. in the Advocates' Library, Edinburgh, which contain several lists of a similar kind. The descent of family representatives is in these traced up to the original source, which in many cases is found among the ancient Scottish kings. The preparing and continuing of these pedigrees was one of the duties of the ancient bards and sennachies, who transmitted their knowledge of family history from generation to generation. It may be believed that these officials would have a measure of bias in favor of their own patrons, and this may have, in some cases, influenced their accounts of family history; but, upon the whole, there seems to be a large amount of truth in what they have transmitted to us, back to a certain date. The rest is pure fiction. A specimen may be given, extracted from the genealogy of the family of Argyll.

> Genelach mac Cailin Gillespic mac Cailin anann mac Gillespic mac Donch anagha mac Cailin mac Gillespic ruoidh mac Cailin oig mac Neill mac Cailin moir mac Gillespic mac Dubgaill, etc., and so on through King Arthur up to Seth, the son of Adam, the son of God. In English this is—The genealogy of MacCailin: Gillespick, son of Colin, son of Gillespick, son of Duncan the fortunate, son of Colin, son of Gillespick the red, son of Colin the young, son of Neil, son of Colin the great, son of Gillespick, son of Dougal, etc. So far the genealogy corresponds nearly with the usual genealogies of the family historians of the house of Argyll. Similar pedigrees are furnished of most of the Highland clans.

The names of persons among the Gaelic races are for the most part patronymic.

The first name in its earlier form is usually descriptive, as *Donnghal, Dubhghal, Donnachadh, Gillespuig,*—Donald, Dougal, Duncan, Gillespick,—the brown man, the black man, the brown-faced man, the servant of the bishop; often it is taken from the Scriptures, as *Eoin* John, *Seumas* James, *Tomas* or *Tabhas* Thomas, *Peadar* Peter, etc.; some of the names come from the Norse, as *Torcuil* Torquil, *Tormaid* Norman, *Aulaidh* Olave, *Leod* Leod, and some are borrowed from the Normans, as *Uilleam* William, *Eanraic* Henry, etc. The surnames are for the most part patronymics, as *Eoin Mac Neill,* John the son of Neil; and in case there should be another John M'Neil, another step is introduced, as *Eoin Mac Neill mhic Dhomhnaill,* and perhaps a third until the person is thoroughly identified. Sometimes there is a reduplication of the sonship, as *Mac Mhic Alasdair, Mac Mhic Ailein,* the son of the son of Alexander or Allan, names of important Highland chiefs. In other cases the surname is descriptive, as *Dubh* black, *Eoin dubh* Black John, *Beag* little, *Mor* big, *Buidh* yellow, *Crom* bent, *Ruadh* red, etc., whence many well known English names are derived. A large number of Highland names and surnames are ecclesiastical, as those derived from St. John, St. Columba, St. Cattan, St. Bridget, and others, and thus become helps to historical inquiry. One thing is somewhat remarkable, that there is not an *O'*, in accordance with Irish nomenclature, among the Scottish Celts. The old O'Duinn of Argyle is lost, and the patronymic of the Celt is marked by the uniform use of *mac*, representing a son, as *O'* does a grandson. The age of fixed family names seems no older than the age of charters. Previous to that patronymics universally prevailed, but when charters were taken fixed names were essential to their value.

Proverbs.—From names of persons we may pass to proverbs as a part, and a very curious part, of Gaelic literature. Few languages so abound in proverbs, and proverbs of a very clever and popular caste. A Highlander seldom gives expression to an important sentiment without backing it with a proverb, and these give force and pungency to what he says. A collection of these proverbs was made, in the year 1819, by the Rev. Donald Mackintosh, and, to form some idea of the number of them, it is only necessary to observe that, under the letter "I" alone, they reach the number of 382 in the first edition of the book. A large number of these proverbial sayings escaped the notice of Mr. Mackintosh, and additions were made in the second edition, while some of the very best are not recorded even yet. Proverbial sayings in English are represented by sayings of a different kind in Gaelic, having the same meaning. "There is many a slip between the cup and the lip" is represented by *Is le duine an ni a shluigeas e, ach cha leis an ni a chagaineas e,* "What a man swallows is his own, but not what he chews." "It never rains but it pours" is represented by *An uair a theid a' chailleach 'n a ruith, theid i 'n a deann-ruith,* "When the old woman takes to running, she runs with a will." "Sour grapes"—*Mionnan a 'bhaird ris a' chaisteal, cha téid mi fhéin do'n chaisteal bhreun, cha teid, cha leig iad ann mi,* "The bard's oath to the castle, 'I won't go to the vile castle; no, they won't let me in.'" The Gaelic proverbs are full of interest, and add much to the power of either speech or writing when skilfully used.

Sgeulachdan, or Tales of Fiction.—These at one time abounded in the Highlands, and had much in common with the tales collected and published by Grimm and Dasent, from the German and the Norse. Until lately, these tales were entirely oral, and were little known beyond certain portions of the West Highlands. Recently they have been collected, translated, and edited, with peculiar care and skill, by Mr. J. F. Campbell, in four 8vo volumes. This is a real addition to Gaelic literature, and Mr. Campbell has laid every friend of that literature under obligation. One real service it has done in preserving for us admirable specimens of the most idiomatic and popular forms of the Gaelic language. We have it there as used by the tellers of popular tales among the people for generations. Whence many of these tales have come it is hard to say, but tales have been collected in the small islands south of Barra, where the people seldom tread the soil of even their main island, containing ideas and forms of thought which never could have originated there, and the preservation of which, in such a locality, is a remarkable fact. Are they relics of a higher civilization existing in ages long gone by? It is remarkable that the Thomas the Rhymer of Lowland tradition is well known in the traditions of the Highlands, and that stories of him related on the borders in broad Scotch are related in the Highlands in Gaelic as tales of great antiquity.

Clan History.—A portion of the literature of the Gaelic Celt consists of clan history. The clan system does not seem to be very ancient. In all probability it dates from the period when the Gaelic kingdom of Scotland ceased to exist. It has been already said to date from the era of charters. But the two eras are pretty nearly identical. Down to the reign of Malcolm III. the Gaelic kingdom appears to have been to a large extent homogeneous. There were no elements in it but what were Celtic, as it never really embraced within it the Scandinavian sections. Then the land was governed by its *maormors* and *toiseachs,* men who represented the central governing power. It would seem that when, in the reign of David I., the kingdom became largely Anglo-Saxon and Anglo-Norman, the Gaelic people became estranged from their native kings, and gathered themselves in sections under the sway of their own chiefs; and hence came chiefs and clans, instead of a king and his subjects forming a united nation. The change was a serious one for the Gaelic people, as they never became again what they had been before. Clan names appear at an early period, and in some form or other must have existed before the time of the Saxonized kings; but not one of the great clans of Highland history—the Macdonalds, the Macleans, the Campbells, the Macleods, the Mackenzies, the Mackintoshes, or others—appears at all. In the book of Deer, supposed to be of the 11th or 12th century, the names of two clans—the clan Morgan and the clan Canan—appear; but it is very questionable whether these represent any clan existing now, although clan Morgan is said to be the old name of the Mackays of Strathnaver. But the names in that interesting record are for the most part purely patronymic, and do not indicate any connection with existing clans. The fact is that, till very recently, the clan name was confined to the chief, as records of old deeds and processes at law serve to show.

The Gaelic historical literature of one kind or another is of considerable extent, and consists of relics, written and traditional, of the old sennachies or family historians. In certain sections of the country the local traditions are full of the stories of old feuds, and, though not to be implicitly relied on, contain usually an element of truth. In Sutherland the feuds of the Sutherlands and the Mackays, in Lewis those of the Mackenzies and Macleods, in Skye the feuds of the M'Leods and the Macdonalds, in eastern Inverness-shire those of the Mackintoshes and Cummings, in Lochaber those of the Mackintoshes and the Camerons, in Perthshire those of the Campbells and the Macgregors, and others in other quarters are largely related. Native accounts of the clans were sometimes committed to writing, a specimen of which appears in the transactions of the Iona Club. For a good deal of what is historical regarding the Highlands, recourse must be had to the Irish Annals, which occasionally refer to events occurring in Scotland.

MS. Literature.—The written Gaelic literature was at its earlier period so mixed up with that of Ireland that it is not easy in every instance to distinguish them. The early church of both countries was one, and the early literature was the offspring of the early church. The very first notices we have of the church, whether among the mission institutes of Ireland or in Iona, indicate the existence and extensive cultivation of a native literature. The transcription or translation of portions of the Scriptures is shown to have been one of the frequent exercises of the early missionaries, and they all learned to write the same dialect and make use of the same letters. Many of the MSS. written in Iona may be credited to Ireland, and *vice versa;* and writings found in Continental libraries may be presumed to have been the work of Scottish as truly as of Irish writers. The early treatises, and glosses upon Latin treatises, on theological and other subjects still existing in the early Gaelic dialect are numerous, and have afforded materials for the acute and masterly criticism of Zeuss, De Nigra, Stokes, and others; and these are accompanied by treatises on grammar, history, medicine, astrology, metaphysics, poetry, and similar subjects, which are of much interest. Most of these remains are found in the collections in Trinity College, Dublin, and in the library of the Irish Royal Academy; but there are numerous remains in the Edinburgh Advocates' Library, which prove at least that there were in Scotland persons who valued and collected this literature. There can be no doubt that there were many contributors to it as well.

The earliest specimen of Gaelic writing, which can be pronounced to be Scottish beyond any question, is the *Book of Deer*, said already to be a work of the 11th or 12th century. The book itself consists of portions of the New Testament written in Latin. The Gaelic portion consists of historical references, with notices of grants of land bestowed on the old monastery of Deer, in Aberdeenshire. These references and notices are, for the most part, written on the margin. They show that, at the time the book was written, the Gaelic language was used, both for speaking and writing, in the district around Deer, where it is now unknown except in the topography. There is not a shade of difference between the language of the *Book of Deer* and the language of the Irish writings of the same age. The following specimen of the notices of grants of land may be interesting:—*Donchad mac mec bead mec híded dorat achad madchor docrist acus drostan acusdocholuimcille insóre gobrád malechí acuscómgell acusgille crist mac fingúni innáienasi intestes*, etc. "Duncan, son of MacBeth, son of Idid, gave Achad Madchor to Christ, and to Drostan, and to Columcille, in freedom for ever; Malechi, and Comgall, and Gilchrist, son of Fingon, witnesses in proof of it." The notices of grants continue in similar form, being records kept within the monastery of what had been given. The *Book of Deer* is a work of much interest to the Gaelic scholar, and his best thanks are due to the Spalding Club and the late Dr. John Stuart for the excellent volume they have published, containing all that is interesting in the original, with a full and learned account of it.

Of the period immediately after the *Book of Deer* there are several MS. remains of Scottish Gaelic writing in existence. There is the Glenmasan MS. in the Edinburgh Advocates' Library, inscribed with the date 1238, and containing several interesting fragments. Here we find the famous lay of Deirdre or Darthula, connected with the story of the sons of Usnoth. The whole character of this MS. is identical with that of the Irish MSS., and yet it is manifestly a Scottish work. There are lives of saints preserved; one of these, in the Advocates' Library, is the life of St. Findchua. Mr. Skene, in his *Chronicles of the Picts and Scots*, gives transcripts of several important MSS., as the Duan Albanach, or poetical accounts of the Scottish kings, recited by the royal bard at the coronation of Malcolm Kenmore. This was copied from an Irish MS., but is manifestly a Scottish composition. The bards of both Ireland and Scotland often crossed the Irish Channel, and their works were well known on both sides of it.

The 14th and 15th centuries were a period of revival of literature over the whole continent of Europe, and the Celts of Great Britain and Ireland felt the impulse. This was a period of much writing both in Ireland and in Scotland. The remains that exist are of a varied kind, and are numerous, especially those of the 15th century. Of this century is the only Gaelic charter that we possess, which is printed, with a translation, in the *National Records of Scotland.* Of this age also are numerous medical MSS. Some of these belonged to the famous family of Beatons, hereditary physicians to the Lords of the Isles, and contain accounts of such remedies as were believed at the time to have efficacy in the cure of disease. Others are metaphysical treatises, while others deal with what were looked upon as the great and important mysteries of astrology. Of this period also are most of the written genealogies that remain. The remarkable thing is the extent to which the Gaelic language bears the marks of cultivation at the time. In both medicine and metaphysics words are found to express the most abstract ideas, which could not be understood by the modern Highlander. As has already been said, some of these writings are translations from Arabic writers, as Averroes, Avicenna, Iacobus de Forlivio, and others. The state of learning at the time in the Highlands was not behind that in the rest of the kingdom. The clergy and the physicians, and even the bards, were possessed of real learning, and have left evidence of it.

The 16th century was the period of two important additions to Gaelic literature. The first of these was what is called "The Dean of Lismore's book," a collection of poetical pieces, and an obituary, chiefly of the M'Gregor chiefs, made about the year 1512. The work has recently been transcribed, translated, and edited, with notes by the Rev. Dr. M'Lauchlan, and an introduction and additional notes by Mr. W. F. Skene. The work is one which has helped to settle several interesting questions connected with Gaelic literature. It makes clear that, down to the period of the dean of Lismore of 1512, there was much in common between the Celtic scholars and bards of Ireland any those of Scotland, while the latter were striking out a course for themselves, in laying aside the Irish letter and orthography, and in using the Saxon letter and an orthography almost purely phonetic. The dean of Lismore's book is a substantial addition to the literature of the Gael. The same century furnished us with another important addition in the translation of the prayer-book usually called "John Knox's Liturgy" into Gaelic, by John Carswell, the bishop of the Isles. This is the first Gaelic book that ever was printed, and bears the date of 1567. There was till very recently only one complete copy of this work in existence, that in the library of the duke of Argyll; but now the book has been reprinted, edited by Dr. M'Lauchlan, who has given an English translation, and such notices of the life of Carswell as very scanty materials would permit. This book is printed in the Roman letter. The publication of Carswell's Gaelic prayer-book would seem to indicate that at the time of its publication the Highlanders could read Gaelic, and that they were familiar with the dialect then in use among scholars both in Scotland and Ireland.

Of the 17th century not many remains exist. Calvin's *Catechism* was published about the beginning of the century, probably translated by Carswell, and published long after his death. A copy is now hardly to be found. But two important contributions were made towards the close of the century. The one of these was the metrical translation of the Gaelic Psalms, executed both by the synod of Argyll and the Rev. Robert Kirke of Balquhidder; and the other was an edition, in the Roman letter, of Bedell's Irish Bible for the use of the Highlanders of Scotland. The first fifty of the psalms by the synod were published in 1659, and the whole psalter was completed in 1694. Kirke published his version in 1684. Both are highly creditable performances, and Kirke is entitled to special commendation, inasmuch as the Gaelic language was acquired by him after he was settled in the Highlands. Kirke's version of the Irish Bible for the use of the Highlanders was published in 1690. The New Testament is that of O'Donnell. This work is accompanied by a glossary including the words in the Irish Bible not generally in use in the Highlands. The book was for a time used in Highland churches, but the Irish Bible, in the Irish letter, was well known and read in the Highlands—both in churches and in families.

The 18th century was productive of large additions to Gaelic literature, partly due to an awakening of religious life, partly to the Jacobite rising, and partly to the progress of literary culture. In the beginning of the century Lhuyd produced his *Vocabulary*, accompanied by a few interesting Gaelic compositions from the Highlands. About the same time, the synod of Argyll executed a translation of the Confession of Faith and Larger and Shorter Catechisms. These were published in 1725. M'Donald's *Vocabulary* appeared in the year 1741. It is the first attempt at anything like a vocabulary of the Gaelic. It is of little value except as being the first book in which the orthography approached to that of the modern Gaelic. During this century several famous Gaelic bards flourished. M'Donald, the author of the *Vocabulary*, filled the country with Jacobite and other songs. The former are of a violent character, indicating keen partisanship with the exiled Stuarts. M'Intyre, of Glenorchy, commonly called Duncan Ban, flourished about the same period, and, though he was a Jacobite at first, this appeared less in his compositions than in M'Donald's. His hunting and other descriptive songs are admirable. M'Kay or Calder, usually called Rob Donn, the Reay bard, flourished about the same time, and has left numerous admirable pieces of Gaelic poetry. Others were also successful composers, such as William Ross of Gairloch, and the religious poet of the Highlands, Dougal Buchanan. And towards the close of the century was published Gillies's *Collection of Gaelic Poetry*, one of the best collections we possess, containing, as it does, many authentic pieces of Ossianic poetry taken down when the old clan system was still in force in the Highlands to a larger extent than now. But the 18th century was distinguished by two works of special interest, in different departments. The first of these was the Gaelic translation of the Bible, and the second was Macpherson's *Ossian*. The former was executed chiefly by the Rev. James Stewart, of Killin, and his son the Rev. Dr. John Stewart, of Luss,—two eminent scholars, who had all the soundness of judgment necessary for such a work. This translation of the Bible has been most popular in the Highlands and throughout the British Colonies where the Gaelic is still spoken. The Gaelic learner cannot do better at the outset than master the Gaelic Bible. Macpherson's *Ossian* appeared about the same time, but not in Gaelic. It appeared first in English dress. This was the only mode of making the general public acquainted with it. Macpherson's first small volume of fragments appeared altogether in English; it would have been well if both the original and the translation had been published simultaneously. The only part of the Gaelic that was published before 1818 was what is called a "Specimen of the original of Temora," given with the other poems in English in 1762. The opinions with regard to the authenticity of Macpherson's *Ossian* are as various as ever, and yet considerable progress has been made in the discovery of truth, which all parties are prepared to acknowledge. It has been established that poems ascribed to Ossian have been known and written down in the Highlands for 300 years, that many of them have been handed down by tradition, that these were fragments referring to certain important events in the history of the Gaelic race, and that there was nothing to make it improbable that such poems as those translated by Macpherson could have existed. Further, it is clear that the Highlanders at once, whether they knew the pieces or not as given by Macpherson, recognized them as in a style familiar to them, and as relating to persons and events with which they were familiar. That Macpherson found materials for his work in the Highlands is beyond a doubt, and it seems quite as manifest that he used very considerable liberties with them in order to serve his object of producing a great Gaelic epic poem or poems. In 1818 the full Gaelic version was printed, long after the death of James Macpherson. *The Poems of Ossian*, as collected, and translated, and edited by Macpherson, are a valuable and interesting addition to Gaelic literature, and enter largely into the history of the modern literature of Europe. The Saxon may have his doubts about Ossian, and may have little scruple or delicacy in stating them, but the Gael knows more about Ossian than he does about Milton, and is more familiar with his heroes than with those of Homer.

The 19th century has seen many large contributions to the literature of the Gaelic Celt. It has shared in the general progress of learning, and with this it has risen in the estimation of the scholars of Europe. Grammars and dictionaries have been compiled; magazines of various kinds have been started and carried on for a time with much vigor; collections, such as Mackenzie's *Beauties of Gaelic Poetry*, have been made; and such provisions have been laid up for the future as to secure an ample supply of materials for the scholars of a coming age. That appears to be the special work laid upon the scholars of the present time. They have to collect materials and commit them to writing, and to describe the peculiarities that are distinctive of a living language, for the use of those who hereafter can only study it as existing in books, where emphasis, and tone, and accent are altogether unknown, and where the comments and expositions of living men, familiar with the language and the literature from their childhood, are altogether awanting. For that the Gaelic language is in a state of decay is manifest to the most ordinary observer. And the decay is twofold, being both within and without. Within, the vocabulary is waning, and English words are coming into use. Gaelic idioms are in like manner disappearing, and English idioms replacing them; while from without, under the influence of education, immigration, steamboats, railways, and other modern devices, English is rapidly finding its way into the land, and pushing the ancient tongue out of it. When this process is completed, a change will befall the people too, for there is no doubt that there is a close relation between the character of a language and the character of the people who use it; so that, when the Gaelic disappears, many of the features distinctive of the Highland character will disappear along with it. In some respects this will be cause of regret; in others perhaps it will not.

At the close of the article CELTIC LITERATURE a list is given of the existing MS. remains of Gaelic literature. It may interest readers and aid students of Gaelic to furnish here a list of some of the more important printed books in the language. They are as follows:—

Fragments in *Report of Highland Society on Ossian*; Fragments in *Chronicles of Picts and Scots*; *The Book of Deer*; *The Book of the Dean of Lismore*; Carswell's Prayer Book; Bedell's and O'Donnell's Bible; The Gaelic Psalter, various editions; The Confession of Faith, and Catechisms; Lhuyd's *Vocabulary*; M'Donald's *Vocabulary*; *Ossian's Poems*; Smith's *Sean Dana*; Gillies's *Collection of Poems*; Macdonald's *Poems*; M'Intyre's *Poems*; Rob Donn's *Poems*; Dougal Buchanan's *Hymns*; M'Callum's *Collection of Poetry*; The Gaelic Bible; Stewart's *Collection of Poems*; Turner's *Collection of Poems*; *Sacred Poetry of the North*, edited by Rose; *The Beauties of Gaelic Poetry*, M'Kenzie; Grant's *Hymns*; M'Intosh's *Gaelic Proverbs*; Stewart's *Gaelic Grammar*; Munro's *Gaelic Grammar*; Highland Society's *Gaelic Dictionary*; Armstrong's *Gaelic Dictionary*; M'Alpin's *Gaelic Dictionary*; *Highland Tales*, collected and edited by J. F. Campbell; *Leabhar na Feinn*, by J. F. Campbell; *An Duanaire*, by D. C. M'Pherson; *An Teachdaire Gaelach*, by Rev. Dr. M'Leod; *An Fhianuis*, by Rev. Dr. Mackay; *An Gaidheal*, a magazine; numerous translations from the English, chiefly religious works; Connell's *Astronomy*; M'Kenzie's *History of Scotland*; besides many others. (T. M'L.)

GAETA, at one time the "Gibraltar of Italy," a strongly-fortified seaport town in the province of Caserta, at the extremity of a peninsula forming the N. W. boundary of the Gulf of Gaeta, with a station on the railway 40 miles N.W. of Naples. The citadel occupies the heights of the peninsula, and the town stretches below in a long thin line. To the east lies the harbor, one of the safest on the whole coast, with a depth of about 15 feet. The principal buildings are the cathedral, the churches, the conventual buildings (of which the most noteworthy are those of the Franciscans and the Benedictines), the hospital, and the foundling asylum. In the cathedral, which was founded, or partially built, by Barbarossa, are several objects of historical interest:—the body of St. Erasmus (the St. Ermo or Elmo, whose "fires" are familiar to the Mediterranean sailor); the standard presented by Pope Pius V. to Don John of Austria, the hero of the battle of Lepanto; and a baptismal font from the ruins of Formiæ, which had formerly been an altar to Bacchus, and still bears the Greek inscription Σαλπίων Αθηναῖος ἐποίησε. Among the larger remains of Roman Gaeta are a temple and an aqueduct; and the circular *Torre d' Orlando*, which crowns the height above the citadel, is, in reality, the sepulchre of L. Munatius Plancus, as is distinctly proved by a well-preserved inscription. The suburbs of Gaeta, called Castellona, Mola di Gaeta, and Del Borgo, are larger than the town itself, and form a separate commune under the name of Formia (see FORMIA). The population of the town in 1871 was 7193, and of the commune, which includes Anatola, 18,385.

Gaeta is identified with Caieta, a town of great antiquity, about whose origin and name very different accounts are offered by the various Greek and Roman writers. Virgil makes it the burial-place of Caieta the nurse of Æneas, while Strabo connects the name with a Laconian word signifying a cavern. In Cicero's time the harbor of Caieta was a *portus celeberrimus et plenissimus navium*, and it was afterwards greatly improved by Antoninus Pius. As a town, the Roman Caieta does not appear to have attained to any great development or importance. On the fall of the Western empire it became a republic, or free town, under the Byzantine government, and it was also the residence of the imperial prætor for Sicily. A considerable increase of its population and power resulted from the destruction of the neighboring town of Formiæ by the Arabs, in 850. In the 9th century Pope John VIII. bestowed the fief on Pandolf, count of Capua; but in 877 Duke Docibilis called in the assistance of the Arabs against the Capuans, and in the course of the 11th century we find the people of Gaeta exercising their rights for the election of their dukes. At a later period the fief became an apanage of the princes of the successive dynasties of Naples. The capture of the town by Pedro, brother of the king of Aragon, in 1435, was followed by the erection of the fortress to which so much of its subsequent importance was due. Ferdinand the Catholic and Charles V. both added to the strength of its defences. In 1707 the citadel was taken by storm by the Austrian general Daun, after a three months' siege; and in 1734 it was forced to capitulate, after a five months' siege, by the allied army under Charles, afterwards king of Naples. In 1806 it was brilliantly defended against the French, under Masséna, by Prince Louis of Hessen-Philippsthal, who was, however, severely wounded and obliged to leave the fortress to its fate. Pope Pius IX. found an asylum in the governor's palace at Gaeta in 1848, and remained there till September, 1849. In 1861 it afforded a last point of defence for Francis II. of Naples, who capitulated to the Piedmontese on 13th February. Gaeta has given the name of Gaetani to a famous Italian family, about whose original connection with the town there are, however, various accounts; and Antonio di Gaeta, one of the great Benedictine missionaries to Africa in the 17th century, bears the mark of his origin.

See Rosetto, *Breve descrizione delle cose più notabili di Gaeta*, reprinted by Antonio Bulifone, at Naples, in 1690; "Geschichte von Gaeta," in *Oester. milit. Zeitschrift*, 1823.

GÆTULIA, or the land of the Gætuli, an ancient district of somewhat uncertain limits in northern Africa. It may be roughly said to have been bounded on the N. by Mauretania and Numidia, E. by the country of the Garamantes, S. by the basin of the Niger, and W. by the Atlantic; but the frontiers must have been of a very uncertain and shifting character. The Gætulians, who, according to a tradition mentioned by Sallust, were one of the two great aboriginal races of northern Africa, appear to have retreated inland before the encroachments of the Numidians and Mauretanians, but continued to make incursions over a wide stretch of country. Ethnographically, they were quite distinct from the negro races, and indeed probably belonged to the great Berber race, which still forms so important an element in the population of North Africa. Their southern tribes having mingled with negro tribes, acquired the distinctive title of Melano-Gætuli or Black Gætulians. A warlike, roving people, they bestowed great attention on the rearing of horses, and, according to Strabo, had 100,000 foals in the course of a year. They were clad in skins, lived on flesh and the milk of their cows, mares, and camels, and took almost no advantage of the valuable productions of their country. It was not till the Jugurthine war that they became familiar to the Romans; but afterwards their name occurs with great frequency in Latin poetical literature, and, indeed, the adjective Gætulian became little more than a synecdoche for African. Allusions are more particularly made to Gætulian purple, which was obtained from the murex of the African coast. In the Jugurthine war some of the Gætulian tribes assisted the Numidian king with a contingent of horse; but during the civil war Cæsar found among them very serviceable allies in his contest with Juba. Augustus, having made Numidia a Roman province, affected to assign a portion of the Gætulian territory to Juba as a compensation; but the Gætulians rose in revolt and massacred the Roman residents, and it was not till a severe defeat had been inflicted on them by Cossius Lentulus that they consented to recognize their gratuitous sovereign. By his victory Lentulus acquired the title of Gætulicus. Ibn Said in the middle of the 13th century, Ibn Khaldun at the end of the 14th, Leo Africanus in the beginning of the 16th, and Marmol about sixty years later, are all quoted by M. Vivien de St. Martin in his *Le Nord de l'Afrique*, 1863, as mentioning a mountainous country called Gozulé, Gutzula, or Guézula in the south of Morocco. He is disposed further to identify the Gætulians with the Godâla, who, according to Ibn Said, occupied the maritime portion of the great desert, and are referred to by other Arabian geographers as the Djoddala; and it is even possible, he thinks, that their name survives in that of the Ghedala between Cape Blanco and the Lower Senegal on the one hand, and that of the Beni Guechtula in the Algerian province of Bougie on the other.

GAGE, THOMAS (1720–1787), governor of Massachusetts, second son of the first Viscount Gage, was born in England in 1720. He entered the army at an early age, became lieutenant-colonel of the 44th regiment of foot in 1750, was made major-general and governor of Montreal in 1761, and in 1763 succeeded Amherst in the command of the British forces in America. In 1774 he was appointed governor of Massachusetts, and in that capacity was entrusted with carrying into effect the Boston Port Act. In this political crisis, by his hesitancy in adopting measures against the leaders of the insurrectionary party, and contenting himself with fortifying Boston, he enabled the Americans to mature their plans in comparative security. The battle at Lexington, in which a detachment sent by him, on the 18th April, 1775, to destroy the cannon and ammunition at Concord was defeated, inaugurated the American revolutionary war. On the 12th June he proclaimed martial law, and proscribed Samuel Adams and John Hancock, offering pardon to all the other rebels who should return to their allegiance; but the result of these measures was at once to exasperate and encourage the Americans. Although Gage gained the nominal victory of Bunker's Hill (June 17), he was unable to raise the siege of Boston; and being shortly afterwards superseded by General Howe, he sailed for England. He died in 1787.

GAGERN, HANS CHRISTOPH ERNST, BARON VON (1766–1852), a German statesman and political writer, was born at Kleinniederheim, near Worms, January 25, 1766. After completing his studies at the universities of Leipsic and Göttingen, he entered the service of the prince of Orange-Nassau, whom in 1791 he represented at the imperial diet. He was afterwards appointed ambassador to Paris, where he remained till the decree of Napoleon, forbidding all persons born on the left side of the Rhine to serve any other power than France, compelled him to resign his office. He then retired to Vienna, and in 1812 he endeavored to promote insurrection against Napoleon in Tyrol. On the failure of this attempt he left Austria and joined the headquarters of the Prussian army. When the prince of Orange became king of the Netherlands, Baron Gagern was appointed his prime minister, and in 1815 he represented him at the congress of Vienna, and succeeded in obtaining for the Netherlands a considerable aggrandizement of territory. From 1816 to 1818 he continued to be Netherland ambassador at the German diet, where, while endeavoring to promote German unity, he also advocated the adoption of measures which should secure the independence of the individual states. In 1820 he retired with a pension to his estate of Hornau, in Hesse-Darmstadt; but, as a member of the first chamber of the states of the grand duchy, he continued to take an active share in the promotion of measures for the welfare of his country. He retired from public life in 1848, and died at Hornau, 22d October, 1852. Three of the sons of Baron Gagern have attained considerable eminence—one as a soldier, and two, who are still living (1879), as politicians.

His principal works are—*Die Resultate der Sittengeschichte*, 6 vols., 1808–1822; *Die Nationalgeschichte der Deutschen*, Vienna, 1812; 2d ed. in 2 vols., Frankfort, 1825–26; *Mein Antheil an der Politik*, 4 vols., Stuttgart, 1823–33; *Kritik des Völkerrechts*, Leipsic, 1840; and *Civilization*, Leipsic, 1847.

GAILLAC, the capital of an arrondissement in the department of Tarn, France, is situated on the right bank of the Tarn, 12 miles W. of Albi. It possesses two churches of the 13th century, a communal college, a hospital, a theatre, and a military prison. Its industries include the manufacture of wine casks, leather, brandy, bricks, and various kinds of coarse cloth; and it has a considerable trade in corn, vegetables, dried plums, and wine, the white and red wines of the arrondissement having a high reputation. Gaillac was in existence in the 7th century. It was captured by the English in 1280, and its archives were taken to London. Even at that time it was famed for its wines, which, under the name of *Vin du Coq*, were exported to England and Holland. The population in 1876 was 6099.

GAILLARD, Gabriel Henri (1726–1806), a French historian, was born at Ostel, Picardy, in 1726. He was educated for the bar, but after finishing his studies adopted the literary profession, ultimately devoting his chief attention to history. In 1801 he was chosen a member of the French Academy, and he was also one of the original members of the Institute. For forty years he was the intimate friend of the minister Malesherbes. He died at St. Firmin, near Chantilly, 13th February, 1806. Gaillard is painstaking and impartial in his statement of facts, and his style is correct and elegant, but the unity of his narrative is somewhat destroyed by digressions, and by his method of treating war, politics, civil administration, and ecclesiastical affairs under separate heads.

His most important work is his *Histoire de la rivalité de la France et de l'Angleterre*, in 11 vols., 1771–1777; and among his other works may be mentioned *Essai de rhétorique française, à l'usage des jeunes demoiselles*, 1745, often reprinted, and in 1822 with a life of the author; *Histoire de Marie de Bourgogne*, 1757; *Histoire de François I.*, 7 vols., 1776–1779; *Histoire des grandes querelles entre Charles V. et François I.*, 2 vols., 1777; *Histoire de Charlemagne*, 2 vols., 1782; *Histoire de la rivalité de la France et de l'Espagne*, 8 vols., 1801; *Dictionnaire historique*, 6 vols., 1789–1804, making part of the *Encyclopédie méthodique*; and *Mélanges littéraires*, containing *éloges* on Charles V., Henry IV., Descartes, Corneille, La Fontaine, Malesherbes, and others.

GAINSBOROUGH, a market-town and port of Lincolnshire, is situated on the right bank of the Trent, 21 miles above its junction with the estuary of the Humber, and 16 miles N. W. of Lincoln. It consists chiefly of one long well-paved street running parallel to the river, which is here crossed by a fine stone bridge of three arches. The parish church, a fine building in the Grecian style, was rebuilt in 1748, with the exception of the old tower, which belongs to the 12th century. Holy Trinity church, built in 1843, has annexed to it an ecclesiastical district taken out of the old parish of Gainsborough. The old hall, supposed to have been partly built by John of Gaunt, is a curious oak-timber framed building, forming three sides of a quadrangle, and having a tower 78 feet high. It has been restored, and part of it converted into a corn exchange and assembly rooms. Gainsborough possesses a grammar school (founded in 1589 by a charter of Queen Elizabeth) and other schools, a town-hall, a county court-house, a literary institute, a temperance hall, a savings-bank, and a provident dispensary. Ship-building is carried on, and there are manufactories of linseed cake, ropes, malt, and tobacco, with breweries and iron and brass foundries. Vessels of 200 tons burden can come up to the town. The population in 1871 was 7564, and since that date has been rapidly increasing.

GAINSBOROUGH, Thomas (1727–1788), a painter famous for the truth and elegance of his portraits, and for the simple beauty of his landscapes, was born at Sudbury, Suffolk, in the year 1727. His father, who carried on the business of a woollen crape-maker in that town, was of a respectable character and family, and was noted for his skill in fencing; his mother excelled in flower-painting, and encouraged her son in the use of the pencil. There were nine children of the marriage. At ten years old, Gainsborough had sketched every fine tree and picturesque cottage near Sudbury, and at fifteen, having filled his task-books with caricatures of his schoolmaster, forged his father's handwriting to get a holiday, and sketched the portrait of a man whom he had detected in the act of robbing his father's orchard, he was allowed to follow the bent of his genius in London, under such advantages as Hayman, the historical painter, and the academy in St. Martin's Lane, could afford. Three years of study in the metropolis were succeeded by two years of idleness in the country. Here he fell in love with Margaret Burr, a young lady of many charms, including an annuity of £200, married her after a short courtship, and, at the age of twenty, became a householder in Ipswich, his rent being £6 a year. The annuity was reported to come from Margaret's real (not her putative) father, who was one of the exiled Stuart princes, or else the duke of Bedford. At Ipswich, Gainsborough tells us, he was "chiefly in the face-way," though his sitters were not so numerous as to prevent him from often rambling with his friend Joshua Kirby (president of the Society of Artists) on the banks of the Orwell, from painting many landscapes with an attention to details which his later works never exhibited, or from joining a musical club, and entertaining himself and his fellow-townsmen by giving concerts. But as he advanced in years he became ambitious of advancing in reputation. Bath was then the general resort of wealth and fashion, and to that city, towards the close of the year 1759, he removed with his wife and two daughters, the only issue of their marriage. His studio in the circus was soon thronged with visitors; he gradually raised his price for a half-length portrait from 5 to 40 guineas, and for a whole-length from 8 to 100 guineas. Among his sitters at this period were the authors Sterne and Richardson, and the actors Quin, Henderson, and Garrick. Meanwhile he contributed both portraits and landscapes to the annual exhibitions in London. He indulged his taste for music by learning to play the viol-di-gamba, the harp, the hautboy, the violoncello. His house harbored Italian, German, French, and English musicians. He haunted the green-room of Palmer's theatre, and painted gratuitously the portraits of many of the actors. He gave away his sketches and landscapes to any one who had taste or assurance enough to ask for them; and in the summer of 1774, having already attained a position of great prosperity, he took his departure for the metropolis, and fixed his residence at Schomberg House, Pall Mall, a noble mansion still standing, for which the artist paid £300 a year.

Gainsborough had not been many months in London ere he received a summons to the palace, and to the end of his career he divided with West the favor of the court, and with Reynolds the favor of the town. Sheridan, Burke, Clive, Blackstone, Hurd, were among the number of those who sat to him. But in London as in Bath his landscapes were exhibited, were commended, won the good opinion of Walpole the fastidious and Wolcot the surly, and were year after year returned to him, "till they stood," says Sir William Beechey, "ranged in long lines from his hall to his painting-room." Gainsborough was a member of the Royal Academy, but in 1784, being dissatisfied with the position assigned on the exhibition-walls to his portrait of the three princesses, he withdrew that and his other pictures, and he never afterwards exhibited there. In February, 1788, while witnessing the trial of Warren Hastings, he felt an extraordinary chill at the back of his neck; this was the beginning of a cancer (or, as some say, a malignant wen) which proved fatal on 2d August of the same year.

Gainsborough was tall, fair, and handsome, generous, impulsive to the point of capriciousness, easily irritated, not of bookish likings. The property which he left at his death was not large. One of his daughters, Mary, had married contrary to his wishes, and was subject to fits of mental aberration.

Gainsborough and Reynolds rank side by side as the greatest portrait painters of the English school. It is difficult to say which stands the higher of the two, although Reynolds may claim to have worked with a nearer approach to even and demonstrable excellence. In grace, spirit, and lightness of insight and of touch, Gainsborough is peculiarly eminent. His handling was slight for the most part, and somewhat arbitrary, but in a high degree masterly; and his landscapes and rustic compositions are not less gifted than his portraits. Among his finest works are the likenesses of Lady Ligonier, the duchess of Devonshire, Master Buttall (the Blue Boy), Mrs. Sheridan and Mrs. Tickell, Orpin the parish-clerk (National Gallery), the Hon. Mrs. Graham (Scottish National Gallery), his own portrait (Royal Academy), Mrs. Siddons (National Gallery); also the Cottage Door, the Market Cart, the Return from Harvest, the Woodman and his Dog in a Storm (destroyed by fire), and Wagon and Horses passing a Brook (National Gallery). He made a vast number of drawings and sketches.

In 1788 Philip Thicknesse, lieut.-governor of Landguard Fort, who had been active in promoting Gainsborough's fortunes at starting, but was not on good terms with him when he left Bath, gave to the world *A Sketch of the Life and Paintings of Thomas Gainsborough*; in 1829 Allan Cunningham published a memoir of him in his *Lives of the Painters*; and in 1856 there appeared *A Life of Thomas Gainsborough, R. A.*, by G. W. Fulcher.

GAISSIN, **GAICYN**, or **HAISCIN**, a town of Russia, at the head of a district in Podolia, 178 miles E. of Kamenetz Podolski or Podolian Kamenetz, in 48° 39′ N. lat. and 29° 23′ E. long., near the river Sop, a tributary of the Bug. With few exceptions, the houses are built of wood, and the inhabitants are mainly supported by agriculture. Among the public buildings are an orthodox church, a synagogue and four Jewish chapels, and a town hospital. In 1860 the population was 10,106, of whom 1863 were Jews. In the *St. Petersburg Calendar* for 1878 the total is given as 9417. Gaissin dates from about 1600: in one of the acts of 1615 it is stated that Heyszyn or Gaissin was founded with royal privilege by the ban Swierski about 15 years before. In 1659 King John Casimir, of Poland, bestowed it on Maximus Buliga, the Zaporogian chief. It obtained Magdeburg rights in 1744 or 1745; and in 1796, after the incorporation of Podolia with Russia, it was made a district town.

GAIUS, a celebrated Roman jurist. Of his personal history very little is known. It is impossible to discover even his full name, Gaius or Caius being merely a personal name (prænomen) very common in Rome. From internal evidence in his works it may be gathered that he flourished in the reigns of the emperors Hadrian, Antoninus Pius, Marcus Aurelius, and Commodus. His works were thus composed between the years 130 and 180, at the time when the Roman empire was most prosperous, and its government the best. Most probably Gaius lived in some provincial town, and hence we find no contemporary notices of his life or works. After his death, however, his writings were recognized as of great authority, and the emperor Valentinian named him, along with Papinian, Ulpian, Modestin, and Paulus, as one of the five jurists whose opinions were to be followed by judicial officers in deciding cases. The works of these jurists accordingly became most important sources of Roman law.

Besides the *Institutes*, which are a complete exposition of the elements of Roman law, Gaius was the author of a treatise on the *Edicts of the Magistrates*, of *Commentaries on the Twelve Tables*, and on the important *Lex Papia Poppæa*, and several other works. His interest in the antiquities of Roman law is apparent, and for this reason his work is most valuable to the historian of early institutions. In the disputes between the two schools of Roman jurists he generally attached himself to that of the Sabinians, who were said to be followers of Ateius Capito, of whose life we have some account in the *Annals* of Tacitus, and to advocate a strict adherence as far as possible to ancient rules, and to resist innovation. Many quotations from the works of Gaius occur in the *Digest* of Justinian, and so acquired a permanent place in the system of Roman law; while a comparison of the *Institutes* of Justinian with those of Gaius shows that the whole method and arrangement of the later work were copied from that of the earlier, and very numerous passages are word for word the same. Probably, for the greater part of the period of three centuries which elapsed between Gaius and Justinian, the *Institutes* of the former had been the familiar text-book of all students of Roman law.

Unfortunately the work was lost to modern scholars, until, in 1816, a manuscript was discovered by Niebuhr at Verona, in which certain of the works of St. Jerome were written over some earlier writings, which proved to be the lost work of Gaius. The greater part of the palimpsest has, however, been deciphered by various German scholars, and the text is now fairly complete.

This discovery has thrown a flood of light on portions of the history of Roman law which had previously been most obscure. Much of the historical information given by Gaius is wanting in the compilations of Justinian, and, in particular, the account of the ancient forms of procedure in actions. In these forms can be traced "survivals" from the most primitive times, which provide the science of comparative law with valuable illustrations, which may explain the strange forms of legal procedure found in other early systems. Another circumstance which renders the work of Gaius more interesting to the historical student than that of Justinian, is that Gaius lived at a time when actions were tried by the system of formulæ, or formal directions given by the prætor before whom the case first came, to the judex to whom he referred it. Without a knowledge of the terms of these formulæ it is impossible to solve the most interesting question in the history of Roman law, and show how the rigid rules peculiar to the ancient law of Rome were modified by what has been called the equitable jurisdiction of the prætors, and made applicable to new conditions, and brought into harmony with the notions and the needs of a more developed society. It is clear from evidence of Gaius that this result was obtained, not by an independent set of courts administering, as in England until recently, a system different from that of the ordinary courts, but by the manipulation of the formulæ. In the time of Justinian the work was complete, and the formulary system had disappeared.

The *Institutes* of Gaius are divided into four books—the first treating of persons and the differences of the status they may occupy in the eye of the law; the second of things, and the modes in which rights over them may be acquired, including the law relating to wills; the third of intestate succession and of obligations; the fourth of actions and their forms.

There are several carefully prepared editions of the *Institutes*; the first was that of Göschen, published in 1820. During the next fifty years more than twenty new editions appeared. A list of these, and of the various treatises on Gaius, is given in the preface to Böcking's edition. The most complete English edition is that of Mr. Poste, which includes besides the text an English translation and copious commentary. A comparison of the early forms of actions mentioned by Gaius with those used by other primitive societies will be found in Sir H. Maine's *Early Institutions*, cap. 9. For further information see M. Glasson, *Étude sur Gaius et sur le jus respondendi.*

GALABAT, **GALLABAT**, or **METEMME**, a town in the frontier district of Egypt and Abyssinia, near one of the western sub-tributaries of the Atbara, about 100 miles W. of Gondar, in 13° N. lat. and 36° E. long. Most of the houses are built in the Abyssinian style, with conical roofs of grass, and the place would be of little importance if it were not the staple market for the exportation of Abyssinian produce across the Egyptian frontier. Beeswax, coffee, cotton, and hides are the principal articles of legitimate trade; but as recently at least as 1873 the traffic in slaves was quite as important a department of its commerce. The town and district form a small ethnographical island, being peopled by a colony of Tokrooris from Darfur, who, finding the spot a convenient resting-place for their fellow-pilgrims on their way to Mecca and back, obtained permission from the king of Abyssinia to make a permanent settlement. They are an industrious race, and grow a considerable quantity of cotton. When Sir Samuel Baker was at Galabat in 1862, the sheikh refused to recognize the authority of the viceroy of Egypt; but when De Cosson passed through in 1873, the Egyptians had a camp, with a strong stone wall, on the top of a hill commanding the town, and acted as masters of the place. The population of the town and district, which have an area of about 40 square miles, is estimated at 20,000. Galabat is the proper name, and Metemme is really the native word for a capital.

GALANGAL, formerly written "galingale," and sometimes "garingal," *rhizoma galangæ* (Arabian, *Kholínjan*;[1] German, *Galgantwurzel*; French, *Racine de Galanga*), is an aromatic stimulant drug. Lesser galangal root, *radix galangæ minoris*, the ordinary galangal of commerce, is the dried rhizome of *Alpinia officinarum*, Hance, a plant of the natural order *Zingiberaceæ*, growing in the Chinese island of Hainan, where it is cultivated, and probably also in the woods of the southern provinces of China. The plant is regarded by Dr. Hance as closely allied to, but as perfectly distinct from, the *Alpinia calcarata* of Roscoe, the rhizome of which is sold in the bazaars of some parts of India as a sort of galangal. Its stems attain a length of about 4 feet, and its leaves are slender, lanceolate, and light green, and have a hot taste; the flowers are ebracteate, white with red veins, and in simple racemes; the roots form dense masses, sometimes more than a foot in diameter; and the rhizomes grow horizontally, and are $\frac{3}{4}$ inch or less in thickness. The drug occurs in short, cylindrical, or somewhat tuberous, often forked pieces, which have a fibrous structure, and externally are reddish-brown, and marked with fine longitudinal striations, and with transverse rings showing the points of attachment of scales or leaves, and internally are of a light-brown, becoming darker at the centre. It has a warm, aromatic taste, resembling that of mingled ginger and pepper. On analysis it yields, among other constituents, much starch, an essential oil of the composition $C_{10}H_{16},H_2O$ (Vogel), and a crystalline body, *kämpferid* (Brandes). Greater or Java galangal, *radix galangæ majoris* (French, *Galanga de l'Inde*), the rhizome of *Alpinia Galanga*, Willd., is a drug rarely now imported into Europe. It is mentioned by Marco Polo (ed. Yule, ii. p. 217) and Garcias da Horta as a product of Java, and the latter distinguishes it from the Chinese or lesser galangal, from which it is known by its larger size, orange-brown exterior, and feebler and less aromatic odor. The seed-capsules of *Alpinia Galanga* are believed to be what are termed "galanga cardamoms," which have the properties of cardamoms and ginger combined, and in China are used for various medicinal purposes. (See Hanbury, *Science Papers*, pp. 107–9, and 252, 253, 1876; and F. P. Smith, *op. cit.*) Galangal seems to have been unknown to the ancient Greeks and Romans, and to have been first introduced into Europe by Arabian physicians. It is mentioned in the writings of Ibn Khurdádbah, an Arabian geographer who flourished in the latter half of the 9th century, and "gallengar" (galingale or galangal) is one of the ingredients in an Anglo-Saxon receipt for a "wen salve" (see O. Cockayne, *Saxon Leechdoms*, vol. iii. p. 13). In the Middle Ages, as at present in Livonia, Esthonia, and Central Russia, galangal was in esteem in Europe both as a medicine and a spice, and in China it is still employed as a therapeutic agent. Its chief consumption is in Russia, where it is used as a cattle medicine, and as a flavoring for liqueurs. By the Tartars it is taken with tea (see Hanbury, *op. cit.*, p. 374). The exports of galangal from Shanghai, in China, amounted in 1869 to 370,000 ℔, value £3046, 16s. 9d. Chinese or lesser galangal was in past times commonly known as "Cyperus Babylonicus," from its resemblance to the tubers of plants of the genus *Cyperus*, which apparently served as a substitute for it[1] (*cf.* Fuchs, *Op. Didactica*, pars ii. p. 28, 1604, fol.; and Avicenna, ed. Plempii, lib. ii. p. 297, 1658, fol.). Gerarde (*The Herball*, p. 28, 1597) terms the species *Cyperus longus*, "English galingale."

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[1] Apparently derived from the Chinese *Kau-liang-Kiang*, *i. e.* Kau-liang ginger, the term applied by the Chinese to galangal, after the prefecture Kau-chau-fu in Canton province, formerly called Kau-liang (see F. Porter Smith, *Contrib. to the Materia Medica . . . of China*, p. 9, 1871).

See *Pharm. Journ.*, ser. i., vol. xiv. p. 241, and ser. iii., vol. ii. p. 248; Pereira, *Materia Medica*, ii., pt. i., p. 257, 4th ed., 1857; O. Berg, *Anatomischer Atlas zur Pharmazeutischen Waarenkunde*, p. 37, taf. xix., Berlin, 1865; H. Yule, *The Book of Ser Marco Polo*, vol. ii. pp. 181, 182, etc., 1871; H. F. Hance, "On the Source of the *Radix Galangæ minoris* of Pharmacologists," *Journ. Linn. Soc.*, Botany, vol. xiii., 1873, p. 1; Flückiger and Hanbury, *Pharmacographia*, 1874, and the above quoted *Science Papers* of the latter author, pp. 370–375; Bentley and Trimen, *Medicinal Plants*, pt. xxxi., tab. 271; and *Histoire des Drogues*, vol. ii., 7th ed., 1876.

GALAPAGOS ISLANDS, an archipelago of five larger and ten smaller islands, situated in the Pacific Ocean exactly under the equator, about 500 or 600 miles west of Ecuador. They were discovered about the beginning of the 16th century by the Spaniards, who gave them their present name from the numerous *galápago* or giant tortoises they found there. The larger members of the group, several of them attaining an elevation of 3000 to 4000 feet, are Albemarle (75 miles long and 15 broad), Narborough, Indefatigable, Chatham, and James Islands. The total area is estimated at 2250 square miles.

The extraordinary number of craters, a few of them still active, "in size from mere spiracles to huge caldrons several miles in circumference," to be found throughout the islands, gives evidence that the archipelago has been the result of volcanic action. It stands in very deep water, and Mr. Darwin thinks that it has never been nearer to the mainland than it is now, nor have its members been at any time closer together. None of the islands are inhabited, with the exception of Charles, Chatham, and Albemarle, which, since 1829, have been used by the Government of Ecuador as a penal settlement for political offenders, who find an easy subsistence on the bananas, Indian corn, and sweet potatoes which readily grow in the black fertile mud of the higher parts, and on the large herds, now become wild, of cattle, swine, and goats. The principal settlement, founded by General Vilamil in 1832, is situated in Charles Island, and bears the name of La Floreana, in honor of Floris, the president of Ecuador. At one time it contained 200 or 300 inhabitants; but when the United States steamer "Hassler" visited the Galapagos in 1871, there were little more than a dozen. In 1872 about 2000 cattle had perished in the island. The archipelago was formerly a frequent resort of vessels in quest of turtle; and it is still visited by parties from Guayaquil in quest of a species of moss, which is sent to the English market under the name of *orchilla*.

Though the islands are under the equator, the climate is not intensely hot, as it is tempered by cold currents from the Antarctic Sea, which, having followed the barren coast of Peru as far as Cape Blanco, bear off to the N. W. towards and through the Galapagos. Very little rain falls, except during the short season from November to January. The clouds indeed hang low, and the nights are misty, but this benefits those districts only which attain a height of over 800 or 1000 feet and enter the moist upper air; so that there alone, and chiefly on the side from which the winds oftenest blow, is there anything like a luxuriant vegetation. The low grounds are entirely parched and rocky, presenting merely a few thickets of Peruvian cactus and stunted shrubs, and a shore as uninviting as it well can be.

The greatest interest attaches to the study of all the oceanic islands, for the elucidation of the origin and development of their fauna and flora has an important bearing on the question of the genesis of species. The Galapagos archipelago possesses in this respect a rare advantage from its isolated situation, and from the fact that its history has never been interfered with by any aborigines of the human race, and that it is only very lately that the operations of man or of animals introduced by his means have disturbed, and that to a very limited extent only, the indigenous life. Many of the more remarkable animal and vegetable forms are confined to one islet of the group, and are represented on the others by allied but different species. Of the indigenous gigantic tortoises there are five species at present known, each of which is an inhabitant of a different island, and it is believed that many others have become extinct. There are two species, one terrestrial, the other marine, of a peculiar genus of lizard. Nearly all the land birds are peculiar to the archipelago, and of these more than half belong to peculiar genera. The flora of the Galapagos is most remarkable; it differs by upwards of one-half of its species from that of the rest of the globe. Both the fauna and flora indicate affinity with the South American continent, and the peculiarities of their distribution can be explained only by the supposition that species were transported to the islands by some accident at very rare and remote intervals, and have become changed through natural selection under the new conditions to which they have been exposed. That there should be so few species common to the different islands is accounted for by their separation from each other by deep channels, scoured by rapid currents, the direction of which, and of the winds, rarely violent in this region, does not favor inter-migration. Many of the islands are yet but imperfectly known.

For more detailed information the following works may be consulted:—Darwin, *Voyage of the Beagle*; O. Salvin, "On the avifauna of the Galapagos Archip.," *Trans. Zool. Soc.*, part ix., 1876, p. 447; Sir J. D. Hooker, "On the Vegetation of the Gal. Arch.," *Trans. Lin. Soc.*, vol. xx. p. 235; Dr. A. Günther, "Description of the living and extinct races of Gigantic

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[1] Alexander Neckam, an English author (1157–1217), says of "cyperus," in his poem *De Laudibus Divinæ Sapientiæ* (see Wright's edition of his works, p. 478, London, 1863)—

> "Hydropicus laudat cyperum, vulnus, stomachusque,
> Humor siccandus, calculus, atque lien."

Tortoises of the Galapagos Islands," *Phil. Trans.*, vol. clxv. p. 251; A. R. Wallace, *Geographical Distribution of Animals*; Villavicencio, *Geografia de la Rep. del Ecuador*, 1858.

GALASHIELS, a parliamentary burgh and manufacturing town of Scotland, built on both sides of the river Gala, about a mile above its confluence with the Tweed, and 33 miles south of Edinburgh. It is situated partly in Roxburghshire and partly in Selkirkshire, but for all judicial purposes it is held, by special Act of Parliament passed in 1867, as entirely within the county of Selkirk. The "forest-steading of Galashiels" is first mentioned in history shortly after the beginning of the 15th century, when it was the occasional residence of the Douglases, who at that time held the office of keeper of Ettrick forest. In 1599 it was erected into a burgh of barony, when it contained 400 inhabitants. For the next 200 years Galashiels remained a mere village, as the population in 1778 had only grown to 600. At that time, however, we find its inhabitants engaged—though in a limited way—in those manufactures by which it has since so greatly prospered. There were 30 looms and 3 waulk (or fulling) mills; and the cloth manufactured was a coarse woollen texture which sold at from 1s. 6d. to 2s. a yard. In 1790 the quantity of wool used annually was 2916 stones, and the value of goods manufactured was about £1000. In the same year the first factory was erected, and advantage taken of the Gala water as a motive power; and from this time forward the woollen trade in Galashiels underwent steady progress, until, in 1879, the town contains about 20 factories with 100 sets of carding engines, using annually 220,000 stones of wool, and producing goods to the value of £750,000.

The wool chiefly used is imported from Australia and the Cape of Good Hope. The manufacture was at one time of a more diversified character than now, and embraced tweeds, shawls, tartans, etc., but it is now almost exclusively devoted to the production of tweeds. The Galashiels manufacturers have long been united in a corporation called by their name, which was instituted in 1777, and of which the minutes during the whole intervening period are still preserved. In addition to its woollen trade Galashiels has also a large skinnery, capable of manufacturing into leather 35,000 skins per week. In recent years the external aspect of the town has been very much improved by the erection of several handsome public buildings, and the introduction of a better style of architecture for shops and dwelling-houses. It was made a parliamentary burgh in 1868, and unites with Hawick and Selkirk in returning a member to parliament. Municipally, it is governed by a provost, four bailies, and ten councillors. In 1876 an Act was passed for the extension of the burgh and the introduction (since effected) of a water supply. As significant of the rapid growth of Galashiels it may be mentioned that, while in 1851 the population was only 5921, in 1871 it was 9678, and that of the extended burgh is now estimated to be nearly 15,000; while the annual assessable rental, which in 1864 was £21,000, is now £49,000.

GALATIA, afterwards called also GALLO-GRÆCIA, in ancient geography, an inland division of Asia Minor, bounded on the N. by Bithynia and Paphlagonia, E. by Pontus, S. by Cappadocia and Lycaonia, W. by Phrygia. These boundaries, however, varied at different periods in the history of Galatia. The river Halys flowed in a northerly direction through the centre of the province, the eastern half of which was watered by tributaries of that stream, while the Sangarius and its affluents traversed the western half.

Galatia originally formed a part of the extensive province of Phrygia; after its separation it was occupied by three Gallic tribes, who still continued distinct in the time of Strabo—the Trocmi, who dwelt in the east, the Tectosages in the centre, and the Tolistobogii in the west. Each of these tribes was subdivided into four parts, and these were ruled over each by a tetrarch of its own. The power of the tetrarchs was limited by a senate of 300, before which also all capital cases were tried. Minor offences came under the cognizance of the tetrarchs and special judges appointed by them. The three tribes all spoke the same tongue; and though in course of time they became Hellenized, their original language was still in use among them as late as the time of Jerome.

The physical characters of Galatia are in great measure similar to those of the adjoining provinces of Phrygia and Lycaonia, the whole region being an elevated plateau or table-land, no part of which is less than 2000 feet above the sea, while the greater part exceeds 3000 feet in elevation. The southern portion, towards Lycaonia, is the most level, and is an almost perfect plain, passing gradually into the expanse of salt desert which occupies the frontier lands of the two provinces. The rest of the country consists for the most part of vast undulating downs, affording excellent pasture for sheep and goats, and capable of producing good crops of corn, though at present in great part uncultivated, and almost wholly devoid of wood. Towards the frontiers of Bithynia it becomes more broken, and is intersected by numerous valleys, as well as by several detached ranges of hills, none of them, however, attaining to any considerable height or importance. The lofty range of the Ala-dagh (6000–7000 feet), though frequently termed the Galatian Olympus, is not properly included within the limits of the province, but forms in part the natural boundary which separates it from Bithynia. From its elevated position, the climate of Galatia is naturally one of considerable extremes of heat and cold; and while the summers are burning hot, the winters at Angora are more severe than at Paris, and the snow often lies on the ground for a month together.

The only towns of importance in Galatia were Tavium, the capital of the Trocmi, a small town which speedily fell into decay; Ancyra, the capital of the Tectosages, which under the Romans became the capital of the country, and has ever since retained its importance as one of the principal cities of Asia Minor (see ANGORA); and Pessinus, the chief town of the Tolistobogii, where a splendid temple was consecrated to Agdistis, the mother of the gods, the divinity who was worshipped at Rome under the title of Rhea Cybele.

Galatia took its name from a body of Gauls who invaded Asia Minor about the year 277 B. C. They had formed part of the army which invaded Greece under Brennus, but having quarrelled with that commander, had left his standard, and marching into Thrace under generals of their own choice, advanced to Byzantium, whence they were invited by Nicomedes, king of Bithynia, to cross into Asia, and help him in his struggle against his brother Zipætes. After performing the required services, they turned their arms against their employer, and ravaged the western half of Asia Minor. Their success allured other hordes of their countrymen, who readily took service with the Asiatic kings in their wars against each other. No Oriental prince was found able to check them, until Attalus, king of Pergamus, defeated them in a great battle, 239 B. C., and compelled them to settle in that part of the country which after them was called Galatia. They still remained independent, however, and proved a formidable foe to the Romans in their wars with Antiochus. It was found necessary to direct a special army against them under Cn. Manlius, and the result of the campaign (189 B. C.) was their complete subjugation to the power of Rome. Galatia was not at this time reduced to a Roman province, but the Gauls were still allowed to retain their own government under their tetrarchs. This system, however, gradually gave way, and the whole country passed under the authority of one ruler. The first of these sole tetrarchs was Deiotarus, a contemporary of Cicero and Cæsar, who, in return for the assistance which he gave the Romans in their wars against Mithridates, was rewarded with a part of Pontus and Armenia Minor, and was styled king by the senate. It was afterwards united with Lycaonia, Isauria, and several adjoining districts, under a king named Amyntas, at whose death, in 25 B. C., Galatia became a Roman province. Theodosius the Great subdivided it for purposes of government into Galatia Prima, of which Ancyra was the capital, and Galatia Secunda, with Pessinus for its chief town.

The antiquities of Galatia have in recent times been made the subject of special investigation by a French commission composed of MM. Perrot, Guillaume, and Delbet, and the result of their labors published in 2 vols. fol., Paris, 1872; but with the exception of those of Angora, they are not of much general interest.

GALATIANS, EPISTLE TO THE. *Origin.*—Although "Galatia," as a united kingdom under Amyntas, included Pisidia, as well as portions of Lycaonia and Pamphylia, and when constituted a Roman province was further enlarged so that it extended from Taurus to the Euxine (Ptol., v. 1), it may with safety be taken for granted that the name is never used in the New Testament except in its older colloquial sense as equivalent to "Gallogræcia" or "Eastern Gaul" (Γαλλία ἡ ἑῴα, Appian, *De Bell. Civ.*, ii. 49), the country of those Galli (Γλῆτες, Γαλάται, Κέλται) whose migrations and final territorial limits have already been indicated in the preceding article.[1] On this assumption, the history of the formation of the Christian "churches of Galatia" is very obscure. It is obvious enough, from the epistle itself, that they had been planted by Paul; but when, or under what circumstances, we are nowhere explicitly informed. In the Acts of the Apostles we read that, accompanied by Silas, he set out on what is generally known as his second missionary journey soon after the council of Jerusalem, which may be dated approximately as having occurred about the year 52 A.D.[1] After having traversed "Syria" and "Cilicia," strengthening the churches, they "passed through Phrygia and the region of Galatia (*τὴν Γαλατικὴν χώραν*), being forbidden of the Holy Ghost to preach the word in Asia; and after they were come to Mysia, they assayed to go into Bithynia, but the Spirit of Jesus suffered them not."[2] The language here employed, even if, as Wieseler argues, it implies that preaching was engaged in, can hardly be said to suggest of itself that churches had been formed on the route, but rather appears to hint at a forced and rapid march. Acts xviii. 23, however, indicates that "disciples" at least had been made, and it is well known that in the narrative of the Acts many important passages in the eventful public life of the apostle have been passed with even less explicit allusion. Combining, then, the meagre facts which that narrative in this instance affords with inferences derived from incidental expressions made use of in the epistle itself, we conjecture the apostle to have been detained by ill-health (see Gal. iv. 13, "because of bodily weakness"), probably in the western district of Galatia (that of the Tolistobogii), though not at the capital Pessinus itself, but nearer the borders of Asia and Mysia; and there, in the *προσευχαί* or synagogues, to have addressed his message to Jews,[3] proselytes, and as many of the native pagan population as could be induced to hear. The Galatians, although in their intercourse with one another they still continued to make use of their ancient dialect, were quite able to understand the then almost universally diffused Greek;[4] and some of them, both Jews and Gentiles,[5] almost immediately began to receive Paul's doctrine with favor and even with enthusiasm (Gal. iv. 14). How long this visit continued we are not told; but most of the chronological evidence goes to show that it cannot have lasted more than six months, and that it probably came to an end within a much shorter interval. Resuming the journey by Mysia and the Troad, Paul and his companion proceeded to "Macedonia" and "Achaia," spending in the latter province at least eighteen months, and finding no opportunity of revisiting Galatia for a space of at least three years. During this interval several causes must have been quietly but constantly working with a tendency to alienate the Galatian converts from the new "gospel of the uncircumcision" (*εὐαγγέλιον τῆς ἀκροβυστίας*, ii. 7), and induce them to that conformity with certain parts of Jewish ceremonial which was even at that time described by the word "Judaizing" (*ἰουδαΐζειν*, Gal. ii. 14). Even among those whose leanings were towards the spiritual religion of the Old Testament, Jewish habits of thinking and feeling could never fail to assert themselves with considerable strength; and there were also elements peculiar to the old pagan religion of the district which were fitted to predispose even the heathen mind towards that ceremonialism and "making a fair show in the flesh" (*εὐπροσωπῆσαι ἐν σαρκί*) which the apostle deprecated.[6] How or when these tendencies had first begun to manifest themselves in the way of deliberate rebellion against the teachings which Paul had left behind him, can only be a matter of pure conjecture; but it would appear that, even if the revolt had been originated by Palestinian Jews, it had at least been fomented by other agitators who were Gentiles by birth (v. 12; vi. 13); nor does it seem improbable that they had begun their work very soon after the time of the apostle's first visit. The second visit, mentioned in Acts xviii. 23, which must have taken place about 55 A. D., and have occupied very little time, appears to have been on the whole a pleasant one; the apostle was still received with due respect (iv. 12, 18), and may well have left Galatia with the impression that the disciples had been "strengthened" by him, and that they "were running well" (v. 7). But shortly after his departure tidings reached him that, though the influence of the Judaizers had for the time been neutralized by his presence, it had begun to reassert itself with greater force than ever almost immediately after he had gone, and that his disciples had been so "bewitched" that, after "having begun in the spirit," they were now endeavoring to be "made perfect by the flesh." He also learned that the reactionary doctrines had been supported by a suggestion that he himself was no teacher of independent authority, but merely a subordinate, and that a treacherous one, of the original apostles and pillars of the church, whose "gospel" was emphatically "of the circumcision." Immediately on receipt of this intelligence, he wrote the present epistle.

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[1] See Strabo, xii. p. 566 (where the words are τὴν νῦν Γαλατίαν καὶ Γαλλογραικίαν λεγομένην); and compare Pliny (*H. N.*, v. 25), who

Contents.—It consists of three parts, in which the personal, the doctrinal, and the practical elements respectively predominate. (1.) After an expression of surprise at the instability displayed by his Galatian converts, the author proceeds to establish the divineness of his message by an historical proof of the wholly divine character of his commission to be its messenger. He urges that he had received his apostleship directly from God; and that, far from proceeding from men, it had been tardily, and so far reluctantly, acknowledged by them only after it had become an altogether patent and undeniable fact. His first visit to Jerusalem had been three years after his conversion. If it had not resulted in his recognition as on a footing of equality with the apostles, it at least had not led to his taking any position of subordination; while on his second visit to Jerusalem he had met the apostles and deliberated with them on terms of undisputed parity. On the third occasion of his coming into contact with an apostolic person so distinguished as Peter, he had openly withstood him and vanquished him in argument, thereby even establishing a superiority. (2.) He proceeds to state and defend the doctrine of justification by faith in the crucified Christ. After alluding to it as a truth already established in their Christian consciousness (iii. 1–5), he proceeds to show that the same truth had been embedded in the whole Old Testament revelation, and was capable of being deduced from the entire course of the past history of the church. The religion of Abraham had been a religion of faith, and his justification had not been a justification by works (iii. 6–18). The law which came later is misunderstood if it be regarded as superseding the promise which had been the foundation of the religion of the patriarch. Its relation to the promise was manifestly of a subordinate and temporary kind. To regard it as having been otherwise would be as absurd as to suppose that a Hagar and an Ishmael could ever have taken that place in the family which belonged of inalienable right to Sarah and to Isaac (iii. 19–iv. 31). (3.) He exhorts to a continuance in the life of faith which is also the life of freedom, and warns against any relapse under the yoke of Judaism (v. 1–12). He explains that Christian freedom is a freedom conditioned by morality (v. 13–vi. 10), and concludes with a recapitulation and the benediction.

Genuineness, Date, and Place.—The genuineness of this epistle has never been disputed. The external evidence is

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continues to distinguish Lycaonia from Galatia. The later historian Memnon also incidentally mentions that the Galatæ had taken possession of *τὴν νῦν Γαλατιαν καλουμένην*. Renan (*Saint Paul*, p. 48) and latterly, Hausrath (*NTliche Zeitgeschichte*, ii. 258), however, uphold the theory that Paul when he uses the word Galatia intends the Roman province, and that by the Galatians we are to understand chiefly the Christians of Antioch, Iconium, Derbe, and Lystra. Their arguments are drawn from the ordinary *usus loquendi* of Paul (by Asia, Macedonia, Achaia he invariably means the provinces bearing these names); from the analogy of 1 Pet. i. 1, where all the districts mentioned happen to be "provinces;" from such considerations as the inaccessibility of Galatia proper; from inferences based on Acts xviii. 23, Gal. ii. 5, and other texts; and from the admittedly perplexing fact that unless the churches of Derbe, Lystra, etc., be regarded as Galatian, we are left in ignorance of the names, localities, and histories of the churches addressed. But, as has been seen, the ancient *usus loquendi* appears on the whole to have disregarded the Roman division of provinces in this case at least; moreover, Iconium was never a part of the Roman Galatia; and in any case there would have been an inappropriateness in addressing Lycaonians and Pisidians by a title so rich in ethnological and historical suggestion as that of "Galatians" is.

[1] The full consideration of the chronology of this period of sacred history must be postponed to the article PAUL.

[2] So Acts xvi. 6, 7, according to the oldest texts. See Lachmann, Tischendorf, Tregelles.

[3] For the fact of the prevalence of Jews in Galatia reference may be made to the Monumentum Ancyranum (Joseph., *Ant.*, xvi. 6, 2; *cf.* xii. 3, 4); compare 1 Pet. i. 1.

[4] See Jerome's often-quoted *Prol. in Epist. Gal.* "Galatos, excepto sermone Græco quod omnis oriens loquitur, propriam linguam eandem habere quam Treviros." Philologists have hardly any doubt of the essentially Celtic character of this dialect; though many German theologians still maintain it to have been Teutonic. See Lightfoot (*Galatians*), and Grimm in the *Studien u. Kritiken* for 1876.

[5] That there were any Jews among Paul's converts here has sometimes been doubted, but unreasonably. See Gal. iii. 23, 25; iv. 3. It seems probable, however, that the Gentiles were in the majority.

[6] Galatia, and particularly Pessinus, was famed for its worship of Cybele. See Livy, xxxviii. 18; Strabo, xii. p. 567.

remarkably clear and continuous, while the internal has been such as to satisfy even the most negative school of modern criticism.[1] Its autographic character, also, is inferred by many, including Hilgenfeld, Holzmann, and other moderns, from the expression used in vi. 11; but it is at least possible that the word ἔγραψα may refer only to vi. 11–18. The question as to its date has given occasion for considerable diversity of opinion. It has been seen that the apostle wrote immediately after he had heard of the change that had come over the Galatian churches, and that this change occurred "soon" (ταχέως) after his second visit. These facts favor a date not much later than 55 A. D. Further, a comparison of the epistle to the Galatians with those to the Romans and Corinthians results, on the whole, in favor of the opinion that it was the earliest of the four, or at all events not much later than the latest, in other words, not later than 59 A. D. It is probably idle to attempt to fix the date much more precisely. The reference in 1 Cor. xvi. 1, which may mean either that friendly relations with the Galatians had been until then uninterrupted, or that they had been already restored, have determined the critics, according to the interpretation adopted, in placing it either early in the Ephesian sojourn or late in the Corinthian. The majority of the moderns is in favor of the former date (55–57 A. D.), but the latter still continues to find supporters. Reference has already been made to the theory of Renan and Hausrath, which leads them to assign this epistle to the period of the second missionary journey. Apart from the considerations which have been indicated in a preceding note, this view is open to the objection that it raises new and gratuitous difficulties in connection with the history and chronology of the Acts; it has accordingly met with comparatively little acceptance. According to some older writers, such as Michaelis, Koppe, Borger, the supposed absence of any reference to the council of Jerusalem implies a very early date; English readers, on the other hand, are familiar with the statement derived from some of the later Greek MSS., and supported by the Syriac and Arabic versions, as well as by the weighty authority of Eusebius, Jerome, and Theodoret, that the epistle was "written from Rome." This view has been advocated in modern times also by C. Schrader; but the general verdict will probably continue to be, as it has for some time been, adverse to a theory which would group this among the letters of the captivity rather than among those of an earlier period.

On the relation of Galatians to the book of the Acts of the Apostles, see vol. i. p. 116.

Literature—For an interesting and detailed account of the patristic commentaries on this epistle reference may be made to an excursus by Bishop Lightfoot (*Saint Paul's Epistle to the Galatians*, 1865, 2d ed. 1874). Those belonging to the Reformation period are sufficiently well known, particularly Luther's, Calvin's, and Beza's. Of modern English commentaries the most exhaustive is that of Dr. Lightfoot, already referred to; but those of Ellicott (1854), Jowett (1855), and Alford (1857) are also of great value. In Germany one of the latest is that of Wieseler (*Commentar über den Galaterbrief*, 1859); and among those who preceded him in this field, Winer (*Pauli ad Galatas Epistola lat. versa et perpetua annotatione illustrata*, 1829, 4th ed. 1859), Usteri (*Comm. ü. d. Galaterbrief*, 1833), Rückert (1833), Olshausen (1840), De Wette (1845, 3d ed. 1864), Meyer (1851, 5th ed. 1870), Hilgenfeld (1852), and Ewald (*Die Sendschreiben des Apostels Paulus übersezt und erklärt*, 1857) are all worthy of particular mention. Windischmann's *Commentar* (1843) is an able and learned exposition from the Roman Catholic point of view. See also Holsten (*Inhalt u. Gedankengang des Br. a. d. Galater*, 1859), Hofmann (*Die heilige Schrift Neuen Testaments zusammenhängend ausgelegt*, 1863), Brandes (*D. Ap. P. Sendschreiben a. d. Galater*, 1869), Sanday (in vol. iii. of the *Speaker's Commentary*), and Venn (*On the Epistle to the Galatians*, 1878). Much help in the interpretation of the epistle is to be derived from the various works on the apostle Paul and the apostolic period of church history; also from those on New Testament Introduction, such as Hilgenfeld's (*Einl.*, 1875) and Bleek's (*Einl.*, 1875). (J. S. BL.)

GALATINA, a town of Italy, in the province and circondario of Lecce, on the road from Otranto to Taranto. It still preserves its ancient walls and towers, and possesses an interesting Franciscan church and monastery (St. Catharine's), founded in the 14th century by Raimondo Orsini del Balzo, prince of Taranto. The frescoes with which the church is richly decorated are of no small historical value. For a long time the inhabitants were attached to the Greek Church. In 1871 they numbered 7873.

GALATZ, or Galacz, a town and port of Roumania, principality of Moldavia, chief town of the district of Covurlin, on the left bank of the Danube (there 2000 feet wide), between the mouths of the Pruth and Sereth, about 85 miles from the Sulina mouth of the Danube, and 130 miles N. E. of Bucharest, with which it is connected by rail, lat. 45° 26′ 12″ N., long. 28° 3′ E. Galatz is said to have got its name from a colony of the same Galatians who invaded Asia Minor in 278 B. C., though this seems doubtful. The town stands on a level plateau, and consists of two portions, an old and a new. The former, which is nearest to the river, is irregularly and badly built, with crooked streets paved with wood, some of them being regular sewers. This part of the town is liable to be flooded, and, as in the greater part of Roumania, the sanitary conditions are bad. The new town, which has rapidly extended during the past few years, is built on the rising ground towards the north-west. It is partly paved, is much more open and comfortable than the old town, and contains most of the public buildings, consulates, etc. Galatz is now to a considerable extent lighted with gas, and some time ago a regular system of water-works was commenced to supply the town with purified and filtered water. There are several Roman Catholic and Greek churches, educational institutions, a hospital, a quarantine building, etc. In the church of St. Mary is the tomb of Mazeppa, said, however, to have been rifled of its contents by the Russians. Galatz is the seat of the international commission instituted by the treaty of Paris, 1856, to insure the free navigation of the mouths of the Danube; and by the treaty of Berlin, 1878, Roumania is to be represented on this commission, which exercises its duties as far as Galatz independently of all territorial rights. Galatz has been a favorite place for crossing the Danube with military expeditions since the time of the Roman emperors, though during the war of 1877–78 the Russians did not adopt it except for parties of reconnaissance. There are very few strictly Roumanian industries carried on at Galatz. There are several flour-mills, saw-mills, and breweries, extensive cooperage works, and soap and candle manufactories to a small extent; light wines are also made. Galatz is an important free port, and shares with Ibraila most of the trade of the lower Danube. The navigation of the Sulina mouth of the river has so improved that steamers of 850 tons can sail up to Galatz. There are French, Austrian, Russian, and British steamboat companies that carry on a regular trade with Galatz, and attempts have been made by the municipality to construct solid stone wharfs. For the traffic generally much inconvenience is felt from want of adequate quay and warehouse accommodation; but now that Roumania is an independent state, improvements may be made in this and other directions. A considerable proportion of ships unload at Sulina and send their cargoes up to Galatz in lighters. The river is generally frozen over for a few weeks during winter.

The staple article of export from Galatz is grain of various kinds, of which large quantities are grown in all the districts situated on the Danube. In 1876, 281 sailing ships, 157 steamers, and 873 lighters, of an aggregate tonnage of 258,391 tons, cleared from the port of Galatz. The lighters had a total of 102,564 tons, while of the remainder 13 sailing ships and 70 steamers of 49,779 tons were British. In the same year the principal articles of export were—wheat, 313,673 qrs.; maize, 423,775 qrs.; barley, 160,443 qrs.; oats, 421,457 qrs.; rye, 167,840 qrs.; flour, 391,657 cwt.; fir planks, 766,869; besides considerable quantities of linseed, rape seed, beans, and small quantities of millet, wool, hides, cheese, and dried prunes. Of wheat 8000 qrs. went to Britain and 19,549 to Holland; maize, 71,500 qrs. to Britain, 21,000 to Malta: rye, 58,485 qrs. to Holland; barley, 37,347 qrs. to Britain. The total value of exports from Galatz in 1876 was £1,215,621, being a considerable increase over 1875. There does not seem to be any return of exports by rail, though Galatz is now connected with the general European railway system. The imports for 1876 were valued roughly at £1,750,000, among which manufactured goods figured at £354,000; sugar, £117,000; coal, £112,000; iron, £80,000; caviare, £66,000; oil, £65,000; rice, £58,000; coffee, £32,000; leather, £28,000; sacking, £29,000; soap, £26,000. Galatz is to cease to be a free port on 13th January, 1880, after which import duties will be imposed. Constant steam communication is maintained between Galatz and Constantinople, and regular lines of steamers sail from London, Liverpool, and Hull. There is a British consulate at Galatz.

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[1] The only dissenting voice has been that of Bauer (1851).

The population in 1873 was estimated at 80,000; if this is correct, it has more than doubled itself in ten years; it was only 8000 in 1835.

GALBA, Servius Sulpicius (3 B. C.–69 A. D.), a Roman emperor. He came of a noble family, being sixth in direct descent from the great orator of the same name, though unconnected either by birth or adoption with the line of the first six Cæsars. He owed his elevation to the growing power of the prætorians and the discontent of the provincials, weary of Nero's rule, and beginning to assert their independence. As Tacitus justly remarks, the death of Nero divulged that secret of the empire, that emperors could be made elsewhere than at Rome. From the little we know of his earlier years he appears as a young man of remarkable gifts and even fascination—a strange contrast to his weak and unlovable old age. His biographer, Suetonius, relates that both Augustus and Tiberius prophesied to him his future rise. The story is improbable, though in part borne out by Tacitus, and rests on the authority of a credulous gossip, who inserts an omen or a prodigy at every turn of his hero's fortunes; but it helps to show, what we learn from other sources, that while still a youth he was regarded as one who was capable of great things. He resisted the solicitations of the empress Agrippina, and refused the rich legacy of Livia Augusta. Rising through the various grades of office to the consulship in 33 A. D., he acquired a high and well-merited reputation both as a general and an administrator in the provinces of Gaul, of Africa, and of Spain, which he successively held. For the first half of Nero's reign he lived in retirement, till, in 61, the emperor bestowed on him the province of Hispania Tarraconensis.

The first years of his rule were marked by rigorous discipline and strict justice, which sometimes degenerated into cruelty. We are told how he nailed the hand of a cheating money-changer to his bench, and how, when a guardian who had murdered his ward appealed to his Roman citizenship, he allowed him the honor of a higher gallows. It is true that during the later period of his administration he was indolent and apathetic, whether it was that he sought to elude the jealousy of Nero, or, as is more probable, felt the growing infirmities of age. Yet his career, taken as a whole, shows the justice of the common judgment, as reported by Tacitus, that all would have pronounced him fit for empire had he not been emperor indeed. In the spring of 68 Galba was holding an assembly at New Carthage when the news reached him of the insurrection in Gaul. The appeal of Vindex urging him to assume the championship of the oppressed human race placed Galba in an awkward dilemma, and his decision was prompted not so much by ambition as by fear of Nero, whom he knew to be plotting his death. The fall and suicide of Vindex renewed his hesitation, when the news that Nymphidius Sabinus, the prefect of the prætorians, had declared in his favor, and by large promises in his name carried the troops with him, revived his spirits. Before, he had only dared to call himself the minister of the senate and Roman people; he now assumed the title of Cæsar, and marched straight for Rome.

At first he was welcomed by the senate and the party of order, but he was never popular with the soldiers or the people, and he soon forfeited the regard even of his few supporters. He was ruined by his virtues no less than by his vices. To the prætorians who claimed their promised largess he replied that he chose his soldiers and would not buy them. The mob was disgusted at the moroseness and niggardliness of a prince who hated all display, and rewarded a popular singer with a paltry present of five denarii. But the respectable classes had graver causes of discontent. They soon found that the government was wholly in the hands of three favorites—two of them officers, and one a freedman who had followed Galba from Spain. Thus the worst abuses of the last reign were revived, without any of its brilliance and gayety.

Galba was first made aware of the general discontent by an outbreak among the legions of Germany. He sought to avert the rising storm by an act which, if better timed and performed in a more popular way, might have saved him. He adopted as his coadjutor and successor Piso Frugi Licinianus, a man in every way worthy of the honor. The speech in which he announced to Piso his election has a genuine ring, and convinces us that his choice was wise and patriotic; but by the populace it was attributed solely to fear, and the prætorians were indignant at it because unaccompanied with the usual donative. When the elements of a revolution are all in train a leader is not far to seek Salvius Otho, a disappointed candidate for the office of Piso, entered into communication with the discontented prætorians, and was by them adopted as their emperor. Two soldiers from the ranks undertook to transfer the empire of Rome, and actually transferred it. Galba, on his way to meet the rebels, was met by a troop of cavalry and butchered near the Lacus Curtius. A common slave severed the bald head from the body, and thrusting it inside his toga presented the bloody offering to Otho. Thus perished, unwept and unpitied, a man who, had he died a proconsul instead of an emperor, would have left as fair a fame as any Roman of the first century.

GALBANUM (Hebrew, *Chelbenah;* Greek, χαλβάνη), a gum-resin, believed to be the product of *Ferula galbaniflua,* Boiss. et. Buhse, and *F. rubricaulis,* Boiss., indigenous to Persia, and perhaps also of other umbelliferous plants. From the stems of these it is said to exude as a milk-white juice, which is rendered yellow by exposure to light and air. It occurs usually in hard or soft, irregular, more or less translucent and shining lumps, composed of agglutinated drops or tears, or occasionally in separate tears, and is of a light-brown, yellowish, or greenish-yellow color, and has a disagreeable bitter taste, a peculiar, somewhat musky odor, and a specific gravity of 1·212. Exposed to cold, it becomes brittle, and may be reduced to powder (Pereira). To separate the vegetable and other impurities commonly present in it, galbanum is melted at 100° C., and strained On analysis 100 parts yield about 65 of resin soluble in ether and alkaline liquids, 20 to 25 of gum, and about 7 of volatile oil. The last furnishes a colorless crystallizable substance, *umbelliferone*, $C_9H_6O_3$, which may be recognized by its formation of a blue color with ammonia, destroyed by acids. Galbanum oil has been shown by J. Kachler (see *Journ. Chem. Soc.*, xxiv., 1871, p. 258) to contain a colorless limpid oil, boiling at 160° to 165° C., and a blue oil, of boiling point 240° to 250° C., varying in quantity with the temperature of distillation, which is isomeric with oil of turpentine, and identical with the oil of *Matricaria Chamomilla*, L. Galbanum is one of the oldest of drugs. In Exodus xxx. 34 it is mentioned as a sweet spice, to be used in the making of a perfume for the tabernacle. Hippocrates employed it in medicine, and Pliny (*Nat. Hist.*, xxiv. 13) ascribes to it extraordinary curative powers, concluding his account of it with the assertion that "the very touch of it mixed with oil of spondylium is sufficient to kill a serpent." By Arabian and Persian authors it was termed *barzud*, the plants producing it being known as *kinneh* and *nafeel* (Royle, *Man. of Mat. Med.*). Avicenna extols the drug for its emmenagogue, diuretic, and various other virtues, and as an antidote "for all poisons." In Chinese writings galbanum, *O-yú*, is not met with as a distinct drug (F. Porter Smith). It is now administered for its antispasmodic, expectorant, and stimulant properties. As an antispasmodic it is considered inferior to asafœtida, but superior to ammoniacum, which, however, is more efficacious as an expectorant in asthma. Galbanum (German, *Mutterharz*) has been supposed to have a stimulating effect upon the uterus, and has been given, combined with salts of iron, in amenorrhœa, and also is recommended in hysteria and neuralgia accompanied by uterine affections. It is an ingredient in the *pilula asafœtidæ composita* of pharmacy, and in a plaster, *emplastrum galbani*, which has been found serviceable in cases of indolent tumors and chronic arthritic swellings. Galbanum is imported to some extent from the Levant, but chiefly from India, through Bombay.

See Waring, *Manual of Practical Therapeutics*, 3d ed., 1871, p. 311; Flückiger and Hanbury, *Pharmacographia*, p. 285, 1874; Bentley and Trimen, *Medicinal Plants*, No. 128.

GALE, Theophilus (1628–1678), a distinguished divine, was born in 1628 at King's Teignmouth, in Devonshire, of which place his father was vicar. In 1647 he was entered at Magdalen College, Oxford, where he took his B.A. degree in 1649, and M.A. in 1652. In 1650 he was made fellow and tutor of his college. He remained five years at Oxford, discharging actively the duties of tutor, and was then appointed to a church at Winchester. After the restoration he refused to submit to the Act of Uniformity, and was ejected from his parish. In 1662 he accepted the post of tutor to the sons of Lord Wharton, whom he accompanied to the college of Caen, in Normandy. He returned to England in 1665, and spent some years in literary work. The latter portion of his life he passed in London as assistant to the Rev. John Rowe, a dissenting minister, who had charge of an important church in Holborn. Gale succeeded Rowe in 1677, and died in the following year.

His principal work, *The Court of the Gentiles*, which appeared in parts in 1669, 1671, and 1676, is a strange storehouse of miscellaneous philosophical learning. It resembles the *Intellectual System* of Cudworth, though very inferior to that work both in general construction and in fundamental idea. Gale's endeavor is to prove that the whole philosophy of the Gentiles is a distorted or mangled reproduction of Biblical truths. Just as Cudworth referred the Democritean doctrine of atoms to Moses as the original author, so Gale tries to show that the various systems of Greek thought may be traced back to Biblical sources. Like most of the learned works of the 17th century, the *Court of the Gentiles* is chaotic and unsystematic, while its erudition is rendered almost valueless by the complete absence of any critical discrimination. The other writings of Gale are—*The Idea of Jansenism*, 1669; *Theophilus, or a Discourse of the Saint's Amity with God in Christ*, 1671; *Anatomy of Infidelity*, 1672; *Idea Theologiæ*, 1673; *Philosophia Generalis*, 1676.

GALE, Thomas (1636–1702), an eminent classical scholar, was born at Scruton, Yorkshire, in 1636. He was educated at Westminster School and at Trinity College, Cambridge, of which he became a fellow. In 1666 he was appointed regius professor of Greek, in 1672 head-master of St. Paul's School, in 1676 a fellow of the Royal Society, and also prebendary of St. Paul's, and in 1697 dean of York. He died at York in 1702. Gale published a collection of *Opuscula Mythologica, Ethica, et Physica*, and editions of several Greek and Latin authors, but his fame rests chiefly on his collection of old works bearing on early English history, entitled *Historiæ Anglicanæ Scriptores* and *Historiæ Britannicæ, Saxonicæ, Anglo-Danicæ, Scriptores XV*. He is the author of the inscription on the London Monument in which the Roman Catholics are accused of having originated the great fire.

GALEN, Christoph Bernhard van (1600–1678), prince-bishop of Münster, was descended from a noble family in Westphalia, and was born 15th October, 1600. After attending the Jesuit College at Münster, and the universities of Cologne, Mainz, Louvain, and Bordeaux, he was engaged in several diplomatic missions. Subsequently he became colonel in the army of the elector Ferdinand of Bavaria, and took part in campaigns against the French and Swiss. On the death of Ferdinand he was chosen prince-bishop of Münster, but scarcely had he succeeded in restoring the internal prosperity of his territories, and freeing them from foreign invaders, when an insurrection arose in the city which he was unable completely to subdue till 1661. In 1664 he was chosen, along with the margrave Frederick of Baden, joint administrator of military affairs of the Rhenish alliance in its war against the Turks. After the peace that followed the victory of St. Gotthard, he concluded an alliance with Charles II. of England against the Netherlands; but through the intervention of Louis XIV. an arrangement was made in 1666 by which the king of the Netherlands vacated all the territories of Galen, with the exception of the town of Borkelo. In 1672, in conjunction with France, Galen renewed hostilities against the Netherlands, but in the same year suffered a severe defeat at Coevorden, and although, along with the French general Turenne, he afterwards obtained several successes, he concluded a peace in 1674, by which he resigned all the advantages he had gained. In the following year he entered into an alliance with the king of Denmark and the elector of Brandenburg against Charles XI. of Sweden, and in 1676 captured Stade, the capital of the duchy of Bremen, after which he took possession of that duchy and of several places in the duchy of Verden. Subsequently he became involved in a war with East Friesland, and only consented to evacuate that territory on payment of a large sum of money. He died at Ahaus, 19th September, 1678.

The *Vie de Christophe Bernard de Galen, évêque de Münster*, was published at Rouen in 1679; J. Ab. Alpen's *De vita et rebus gestis Ch. Bern. de Galen* appeared at Koesfeld in 2 vols. in 1694, an abridgment of this work at Münster in 1790, and a more extended abridgment at Ulm in 1804; and Tucking's *Geschichte des Stifts Münster unter Galen* was published at Münster in 1865.

GALEN, or Galenus, Claudius, called Gallien by Chaucer and other writers of the Middle Ages, the most celebrated of ancient medical writers, was born at Pergamus, in Mysia, about 130 A. D. His father Nicon, from whom he received his early education, is described as remarkable both for excellence of natural disposition, and for mental culture; his mother, on the other hand, appears to have been a second Xanthippe. In 146 Galen commenced the study of medicine, and in about his twentieth year he left Pergamus for Smyrna, in order to place himself under the instruction of the anatomist and physician Pelops, and of the peripatetic philosopher Albinus. He subsequently visited other cities, and in 158 returned from Alexandria to Pergamus. In 164 he went for the first time to Rome. There he healed Eudemus, a celebrated peripatetic philosopher, and other persons of distinction; and ere long, by his learning and unparalleled success as a physician, earned for himself the titles of "Paradoxologus," the wonder-speaker, and "Paradoxopœus," the wonder-worker, thereby incurring the jealousy and envy of his fellow-practitioners. Leaving Rome in 168, he repaired to his native city, whence he was soon sent for to Aquileia, in Venetia, by the emperors Lucius Verus and Marcus Aurelius. In 170 he returned to Rome with the latter, who, on departing thence to conduct the war on the Danube, having with difficulty been persuaded to dispense with his personal attendance, appointed him medical guardian of his son Commodus. In Rome Galen remained for some years, greatly extending his reputation as a physician, and writing some of his most important treatises. It would appear that he eventually betook himself to Pergamus, after spending some time at the island of Lemnos, where he learned the method of preparing a certain popular medicine, the "terra lemnia" or "sigillata." Whether he ever revisited Rome is uncertain, as also are the time and place of his death. According to Suidas, he died at the age of seventy, or in the year 200, in the reign of Septimius Severus. If, however, we are to trust the testimony of Abul-faraj, one of his Arabian biographers, his decease took place in Sicily, when he was in his eightieth year. Galen was one of the most versatile and accomplished writers of his age. He composed, it is said, nearly 500 treatises on various subjects, including logic, ethics, and grammar. Of the published works attributed to him 83 are recognized as genuine, 19 are of doubtful authenticity, 45 are confessedly spurious, 19 are fragments, and 15 are notes on the writings of Hippocrates.

Galen, who in his youth was carefully trained in the Stoic philosophy, was an unusually prolific writer on logic. Of the numerous commentaries and original treatises, a catalogue of which is given in his work *De Propriis Libris*, one only has come down to us, the treatise on Fallacies *in dictione* (*περὶ τῶν κατὰ τὴν λέξιν σοφισμάτων*). Many points of logical theory, however, are discussed in his medical and scientific writings. His name is perhaps best known in the history of logic in connection with the fourth syllogistic figure, the first distinct statement of which was ascribed to him by Averroes. There is no evidence from Galen's own works that he did make this addition to the doctrines of syllogism, and the remarkable passage quoted by M. Minas from a Greek commentator on the *Analytrics*, referring the fourth figure to Galen, clearly shows that the addition did not, as generally supposed, rest on a new principle, but was merely an amplification or alteration of the indirect moods of the first figure already noted by Theophrastus and the earlier Peripatetics.

In 1844 M. Minoides Minas published a work, avowedly from a MS. with the superscription *Galenus*, entitled *Γαληνοῦ Εἰσαγωγὴ Διαλεκτική*. Of this work, which contains no direct intimation of a fourth figure, and which in general exhibits an astonishing mixture of the Aristotelian and Stoic logic, Prantl speaks with the bitterest contempt. He shows demonstratively that it cannot be regarded as a writing of Galen's, and ascribes it to some one or other of the later Greek logicians. A full summary of its contents will be found in the 1st vol. of the *Geschichte der Logik* (591–610), and a notice of the logical theories of the true Galen in the same work, pp. 559–577.

There have been numerous issues of the whole or parts of Galen's works, among the editors or illustrators of which may be mentioned Jo. Bapt. Opizo, N. Leonicenus, L. Fuchs, A. Lacuna, Ant. Musa Brassavolus, Aug. Gadaldinus, Conrad Gesner, Sylvius, Cornarius, Joannes Montanus, Joannes Caius, Thomas Linacre, Theodore Goulston, Caspar Hoffman, René

Chartier, Haller, and Kühn. Of Latin translations Choulant mentions one in the 15th and twenty-two in the following century. The Greek text was edited at Venice, in 1525, 5 vols. fol.; at Basel, in 1538, 5 vols. fol.; at Paris, with Latin version by René Chartier, in 1639, and in 1679, 13 vols. fol.; and at Leipsic, in 1821–33, by C. G. Kühn, considered to be the best, 20 vols. 8vo. An epitome in English of the works of Hippocrates and Galen, by J. R. Coxe, was published at Philadelphia in 1846.

Further details as to the life and an account of the anatomical knowledge of Galen will be found in the art. ANATOMY, vol. i. pp. 704, 705. See also René Chartier's Life, in his edition of Galen's works; N. F. J. Eloy, *Dictionnaire Historique de la Médecine, s. v.* "Galien," tom. i, 1778; F. Adams's "Commentary" in his *Medical Works of Paulus Æyineta*, London and Aberdeen, 1834; J. Kidd, "A Cursory Analysis of the Works of Galen, so far as they relate to Anatomy and Physiology," *Trans. Provincial Med. and Surg. Assoc.*, vi., 1837, pp. 299–336; C. V. Daremberg, *Exposition des Connaissances de Galien sur l'Anatomie, la Physiologie, et la Pathologie du Système Nerveux* (Thèse pour le Doctorat en Médecine), Paris, 1841; and J. R. Gasquet, "The Practical Medicine of Galen and his Time," *The British and Foreign Medico-Chirurgical Rev.*, vol. xi., 1867, pp. 472–488.

GALENA, a city of the United States, the capital of Jo Daviess county, Illinois, is situated on the Fever or Galena river, 6 miles above its junction with the Mississippi, and on the northern division of the Illinois Central Railroad, 180 miles W. N. W. of Chicago. The city winds around the base of rocky limestone bluffs, which spring rather abruptly from the river on both sides, and the streets rise above one another, and are connected by flights of steps. It is the commercial depôt of an extensive and fertile district, but owes its prosperity chiefly to the species of lead from which it takes its name, and the mines of which surround it in all directions, underlying, more or less densely, an area of over 1,500,000 acres. In these mines copper is also found in combination with the galena. In the earlier years the produce of the mines found its way by water to St. Louis, but in 1829 the first load, 3000 ℔, was conveyed overland to Chicago. In 1846 the yield reached its highest point of 50,000,000 ℔; in 1852 it was 40,000,000; and in 1877 only 3,300,000. This diminution is due to the absence of the expensive appliances necessary for deep mining. Meanwhile zinc ore has been discovered, of which 12,000,000 ℔ were mined in 1877. The lumber produce is also considerable, averaging 7,000,000 feet annually. The principal buildings are the German-English normal school, the high school, and the building in which are included the custom-house and post-office. Galena has an iron-foundry, flour-mills, woollen-mills, saw- and planing-mills, besides furnaces and manufactories for lead, zinc, copper, and furniture. Mining commenced in 1820, and in 1822 the United States began to grant leases of the mineral lands. The first street was laid out in 1826; village government was legalized in 1837, and a city charter granted in 1839. Population in 1850, 6004; in 1860, 8196; and in 1870, 7019, of whom 2473 were foreigners.

GALESBURG, a city of the United States, the capital of Knox county, Illinois, is situated at the junction of the Burlington and Peoria branches of the Chicago, Burlington, and Quincy Railroad, 163 miles W. S. W. of Chicago, and is the centre of a farming district of great fertility. It has several extensive manufactories of agricultural implements, besides carriages and wagons, and also contains the machine-shops and car-works of the railroad company. It is the seat of two colleges, Knox College (Congregational), founded in 1841, and Lombard University (Universalist), founded in 1852, to both of which female students are admitted. Population in 1860, 4953; and in 1870, 10,158, of whom 3136 were foreigners.

GALIANI, FERDINANDO (1728–1787), one of the most celebrated, if not one of the soundest, political economists of Italy, was born at Chieti on the 2d of December, 1728. For his early education and opportunities of advancement in life he was less indebted to his parents than to his uncle, Monsignor Celestino Galiani. By his care, and at his expense, Galiani received the best education which Naples and Rome could then furnish, becoming qualified for an ecclesiastical career at a time when a clever abbé might hope to fill with profit and reputation important offices in the state as well as in the church. Galiani gave early promise of distinction as an economist, and even more as a wit. At the age of twenty-two he had produced two works by which his name became widely known far beyond the bounds of his own Naples. His taste for economic studies had been developed in the society of such men as Genovesi and Intieri, and prompted the composition of his *Trattato della Moneta*, in which many aspects of the question of exchange are set forth, always with a special reference to the state of confusion then presented by the whole monetary system of the Neapolitan Government. Galiani's fame as a humorist dated from the appearance of the *Raccolta in Morte del Boia*, a work as popular in Italian literary circles during the last century as the *Rejected Addresses* and *Bon Gaultier Ballads* have been in our own. In this volume Galiani parodied with exquisite felicity, in a series of discourses on the death of the public hangman, the style of the most pompous and pedantic Neapolitan writers of the day. Galiani's political knowledge and social qualities now pointed him out to the discriminating eye of Charles III., and his liberal minister Tanucci, as one eminently fitted to serve the Government as a diplomatist in France. He was, therefore, attached in the character of secretary to the Neapolitan embassy at Paris. Thither he repaired in 1759, at a time when a change in the relations between the courts of Paris and Vienna was about to exercise an influence on the course of the Seven Years' War, when the different Bourbon courts were engaged in a common action against the Jesuits, and when economic science held a foremost place in the speculations of the most eminent French writers. Galiani is chiefly remembered by posterity by the part which he took in these economic discussions. His *Dialogues sur les blés*, though published after his return to Naples, produced on its appearance a great impression, and has again and again furnished to future controversialists arguments more specious than solid against the liberty of exporting corn. The criticism of Voltaire, that Galiani's volume united the wisdom of Plato and the wit of Molière, will not be accepted as a decisive judgment on the merits of the treatise; but it may be viewed as a tolerably fair test of the regard in which it was held by Galiani's contemporaries. Galiani returned to Naples after a ten years' residence in Paris, where his reputation as a wit had long surpassed that of an economist or a statesman. Until his death at Naples, on October 30, 1787, he kept up with his old Parisian friends a correspondence, of which the tone on his side can only be compared to the wailing and howling sent forth by Ovid during his banishment to the shores of the Euxine. Absence from Paris was with him the synonym of social and literary death.

To the common editions of Galiani which are found in great public libraries must be added the essay recently published at Naples, *L'Abate Galiani*, by Alberto Marghieri, 1878, and the copious extracts from his correspondence with Tanucci, likewise published very recently in the new series of Viesseux's *L'Archivio Storico*, Florence, 1878.

GALICIA, in German *Galizien*, and in Polish *Halicz*, a crown-land of Austria which comprises the old kingdoms of Galicia and Lodomeria, the duchies of Auschwitz and Zator, and the grand-duchy of Cracow. Towards the N. and E. it has an extensive and irregular frontier conterminous with the Russian empire; in the S. W. it meets the Hungarian territory along the ridge of the Carpathian Mountains; its western borders, which are of small extent, touch both Austrian and Prussian Silesia; and in the S. it is bounded by the province of Bukowina, which was separated from it in 1849. As its area is 30,299 square miles, or more than 10,000 square miles greater than that of Bohemia, it is the largest of all the crown-lands of Austria. The population in 1869 was 5,418,016, which showed an increase since 1857 of 785,150. Of the whole 2,660,518 were males, and 2,757,498 females. The density was greatest in the circles of Biala, Tarnow, and Cracow, and least in the circle of Radworna. In 1876 the total was 6,000,326.

About a third of the whole area of Galicia is occupied by the Carpathians, and the greater proportion of the remainder consists of the terraces by which the mountain system gradually sinks down to the great eastern plains of Russia. Only a very small district near the Vistula can properly be described as lowland. The two most prominent summits of the Galician Carpathians are the Babia Gora or Women's Mountain, 5648 feet above the level of the sea, and the Waxmundska, 7189. Of the famous massif of the Tatra, hardly a fourth is within the Galician boundaries.

By its rivers Galicia belongs partly to the basin of the Baltic and partly to the basin of the Black Sea. The Dunajec, the San, and the Premsza, tributaries of the Vistula, are the navigable streams of the western region; and the Dniester, which is the principal river of the east, is navigable as far as Czartoria. There are few lakes in the country except mountain tarns; but considerable morasses exist about the Upper Dniester, the Vistula, and the San, and the ponds or dams in the Podolian valleys are estimated to cover an area of 208 square miles. Of the 35 mineral springs which can be counted in Galicia, the most frequented are Konopowka, south of Tarnopol, and Lubian and Sklo, west of Lemberg. The last is a good example of the intermittent class. The Galician climate is exceedingly severe, the range of temperature being nearly 145°. In July and August the mean temperature is 66° or 67° Fahr.; in March it is 32° or 33°. Winter is long, and the snowfall, which often begins in the early part of October, is very abundant. At Cracow the annual precipitation is about 23 inches, and at Lemberg about 28. Rather more than 6 per cent. of the surface of Galicia is unproductive. Forests occupy upwards of 4 million acres, but they are so badly managed that in some districts straw has to be used as fuel; 1,550,128 acres are devoted to pasture, 8,486,358 are under tillage, and 3,007,024 are under gardens and meadows. Barley, oats, and rye are the prevailing cereals; but wheat, maize, and leguminous plants are also cultivated, and hemp, flax, tobacco, and hops are of considerable importance. In 1873 the whole crop of cereals amounted to 9,878,563 bushels; and there were 2,016,326 bushels of pulse, and 65,581,331 bushels of potatoes. In 1869 the number of horses in the crown-land was 695,610; of asses and mules, about 2000; of cattle, 2,070,572; sheep, 966,763; goats, 35,825; and swine, 734,572. The stocks of bees were upwards of 257,490, and the yearly produce of honey and wax is about 18,300 and 7166 cwt. respectively. In West Galicia there are mines of coal, ironstone, and zinc ore; and in Eastern Galicia a certain quantity of lignite is obtained. The iron ore is poor, containing only 10 or 11 per cent. of metal; and in 1873 the out-put did not exceed 108,546 cwt. Salt is procured both from mines and from salt-springs in sufficient abundance to make it an article of export to Russia. The great factory at Kalusz for the making of potash was closed in 1875, the company having failed; and the exploitation of the rich petroleum springs of East Galicia languishes for lack of capital. Cracow is the centre of the iron manufacture, but it is of comparatively small development. Tile works are very numerous; stoneware is produced in a few establishments; and the glass works number about 15. In 1874 there were 237 breweries, 598 distilleries, and 3746 mills,—no fewer than 3524 of the mills being driven by water and 172 by wind. Cigars are manufactured at Monasteryska and Winniki, Cracow, Jupielnica, and Zablotow. The textile industries are for the most part very slightly developed, but the linen trade employs 11,255 looms. Railway traffic is rapidly increasing. There is a large transit trade down the river Dniester to Russia by means of light boats built at Zuravero, Halicz, Marianpol, etc., which are usually broken up for firewood when they reach Odessa; and all the navigable streams, both north and south, are used for the transport of wood from the forests. Large quantities of Galician timber thus find their way to Dantzic, Stettin, Hamburg, and Berlin. The country is divided into the eight districts of Lemberg, Zloczow, Tarnopol, Stanislawow, Sambor, Przemysl, Tarnow, and Cracow, which altogether comprise 74 administrative circles. There are in all 83 towns, 230 market villages, and 11,000 hamlets, the most populous places being Lemberg, 87,109; Cracow, 49,835; Tarnow, 21,779; Tarnopol, 20,087; Brody, 18,890; Kolomiya, 17,679; Drohibiez, 16,888; Przemysl, 15,185; Stanislau, 14,479; Sambor, 11,749; Jaroslau, 11,166; Rzesznow, 10,090; and Sniatyn, 10,305. The chief town is Lemberg, which is the seat of the royal imperial lieutenancy or K. K. Statthalterei. According to the laws of 1861 the diet of Galicia consists of the three archbishops (those of the Roman Catholic, the Greek Catholic, and Armenian Catholic Churches), the three Roman Catholic bishops, the rectors of the universities of Lemberg and Cracow, 44 representatives of the larger landowners, 4 representatives of the capital, 3 representatives of the chambers of trade and industry, 16 from the towns and industrial centres, and 74 from the rural communes. Sixty-three members are sent to the imperial diet, of whom 20 represent the landowners, 13 the towns, 27 the rural communes, and 3 the chambers of trade, etc. The two principal nationalities in Galicia are the Poles and the Ruthenians—the former predominating in the west and the latter in the east. The Poles who inhabit the Carpathians are distinguished as Goralians (from gor, a mountain), and those of the lower regions as Mazures and Cracoviaks. The Ruthenian highlanders bear the name of Huzulians.

Galicia (or Halicz) took its rise along with the neighboring principality of Lodomeria (or Vladimir) in the course of the 12th century—the seat of the ruling dynasty being Halicz or Halitch, a town in the present district of Stanislawow at the confluence of the Lukev with the Dniester. Disputes between the Galician and Lodomerian houses led to the interference of the king of Hungary, Bela III., who in 1190 assumed the title of *Rex Galatiæ*, and appointed his son Andreas lieutenant of the kingdom. Polish assistance, however, enabled Vladimir the former possessor to expel Andreas, and in 1198 Roman, prince of Lodomeria, made himself master of Galicia also. On his death in 1205 the struggle between Poland and Hungary for supremacy in the country was resumed; but in 1215 it was arranged that Daniel, son of Roman, should be invested with Lodomeria, and Koloman, son of the Hungarian king, with Galicia. Koloman, however, was expelled by Mstislaff of Novgorod; and in his turn Andreas, Mstislaff's nominee, was expelled by Daniel of Lodomeria, a powerful prince, who by a flexible policy succeeded in maintaining his position. Though in 1235 he had recognized the overlordship of Hungary, yet when he found himself hard pressed by the Mongolian general Batu, he called in the assistance of Innocent IV. and accepted the crown of Galicia from the hands of a papal legate; and again, when Innocent disappointed his expectation, he returned to his former connection with the Greek Church. On the extinction of his line in 1340 Casimir III. of Poland incorporated Galicia and Lemberg; on Casimir's death in 1377 Louis the Great of Hungary, in accordance with previous treaties, became king of Poland, Galicia, and Lodomeria; and in 1382, by the marriage of Louis's daughter with Ladislaus II., Galicia, which he had regarded as part of his Hungarian rather than of his Polish possessions, became definitively assigned to Poland. On the first partition of Poland, in 1772, the kingdom of Galicia and Lodomeria came to Austria, and to this was added the district of New or West Galicia in 1795; but at the peace of Vienna in 1809 West Galicia and Cracow were surrendered to the Grand-duchy of Warsaw, and in 1810 part of East Galicia, including Tarnopol, was made over to Russia. This latter portion was recovered by Austria at the peace of Paris, and the former came back on the suppression of the independence of Cracow in 1846. Within the short period since 1860 great advances have been made in many ways in the development of the natural resources of the country and in the education of the people: and the general prosperity of the kingdom is evidenced by the rapid growth of several of its larger towns.

See Lill de Lilienbach, "Description du bassin de la Galicie et de la Podolie," in *Mémoires de la Société géologique de France*, tome i., mém. iv., 1833–34; Schmedes, *Geogr.-statist. Uebersicht Galiziens*, Lemberg, 1869; Lipp, *Verkehrsund Handelsverhältnisse Galiziens*, Prague, 1870; Zehlicke, "Die polit. und socialen Zustände Galiziens," in *Unsere Zeit*, 1870; "Die Ruthener in Galizien," in *Die Globus*, 1870; Pilat, *Statist. Mittheil. über die Verhältnisse Galiziens*, Lemberg, 1874; *Ortsrepertorium des Königreichs Galizien und Lodomerien* (official), Vienna, 1874; Zelicke, "Die deutschen Kolonien in Galizien," in *Im Neuen Reich*, 1876; Kelb in *Jahrbericht der K. Geol. Reichs-Anstalt*, 1876; "Culturfortschritte in Galizien," in *Das Ausland*, 1876. Remarkable sketches of Galician life have been given by Sacher-Masoch, whose works are well known in France and Germany. A rich literature on the subject exists in Polish.

GALICIA (Gallæcia or Callæcia, *Καλλαικία*, *Καλαικία*), an ancient kingdom, countship, or province in the N. W. angle of Spain, now divided into the provinces of Coruña, Lugo, Orense, and Pontevedra, lies between 41° 51′ and 43° 47′ N. lat., 6° 50′ and 9° 16′ W. long., and is bounded on the N. and W. by the Bay of Biscay and the Atlantic, on the S. by the Portuguese provinces of Entre Douro e Minho and Traz os Montes, and on the E. by Leon and the Asturias. The greatest length is about 125 miles, greatest breadth 115 miles; area, 11,222 square miles; population (1867), 1,937,792. Galicia is traversed from E. to W. by a continuation of the great Pyrenean and Cantabrian chain; and its surface is further broken by two spurs from that system, which, running in a south-westerly direction, enclose the basin of the Miño. The average elevation of the province is considerable, and the maximum height (6593 feet) is reached in the Peña Trevinca on the east border of Orense. The principal river is the Miño (Portuguese, *Minho;* Latin, *Minius;* so named, it is said, from the minium or vermilion found in its bed), which, rising near Mondoñedo, within 20 miles of the northern coast, after a course of 170 miles in a south and south-west direction, enters the Atlantic near the port of La Guardia. It is navigable by small vessels on the lower part of its course. Of the numerous affluents of the Miño, the most important are—on the left the Sil, which rises among the lofty mountains between Leon and Asturias, and on the right the Tea, which rises on the eastern flank of Monte Fano. Among other rivers having a westerly direction may be mentioned the Tambre, the Ulla, and the Lerez or Ler, which fall into the Atlantic by estuaries or *rias* called respectively Ria Muros y Noya, Ria Arosa, and Ria Pontevedra. The rivers of the northern versant, such as the Eume, the Juvia, and the Mero, are, like those of the Asturias, for the most part short, rapid, and subject to violent floods. The coast-line of Galicia, extending to about 240 miles, is everywhere bold and deeply indented, presenting a large number of secure harbors, in this respect forming a marked contrast to the neighboring province. The Eo, which bounds Galicia on the east, has a deep estuary, the Rivadeo, which offers a safe and commodious anchorage in 3 fathoms water at ebb-tide. Further to the west is Vivero Bay, 1 mile wide and 3 in length, affording good anchorage throughout, with from 6 to 8 fathoms of water. The Ria del Varquero y Vares is of a similar character; while the harbor of Ferrol (see FERROL) ranks among the best in Europe. On the opposite side of Betanzos Bay (the *μέγας λιμήν* or Portus Magnus of the ancients) is the great port of Coruña (see CORUNNA). The principal port on the western coast of Galicia is that formed by the deep and sheltered bay of Vigo, which is navigable for vessels of 500 tons to a distance of 16 miles from the ocean; but there are also good roadsteads at Corcubion under Cape Finisterre, at Marin, and at Carril. The climate of the Galician coast is mild and equable, but the interior, owing to the great elevation (the town of Lugo is upwards of 1900 feet above the sea level), has a wide range of temperature. The rainfall is exceptionally large, and snow lies on some of the loftier elevations for a considerable portion of the year. The soil is on the whole fertile, and the produce very varied. A considerable quantity of timber is grown on the high lands, and the rich valley pastures support large herds of cattle, while the abundance of oak and chestnut favors the rearing of swine. In the lowland districts good crops of maize, wheat, barley, oats, and rye, as well as of turnips and potatoes, are obtained. The fruit also is of excellent quality and in great variety, although the culture of the vine is limited to some of the warmer valleys in the southern districts. The dehesas or moorlands abound in game, and fish are plentiful in all the streams. The mineral resources of the province, which are considerable, were known to some extent to the ancients. Strabo speaks of its gold and tin, and Pliny mentions the gemma Gallaica. Mines of lead, tin, copper, and iron pyrites continue to be wrought, though under considerable disadvantages, and chiefly by foreign capitalists. Galicia is also remarkable for the number of its sulphur and other warm springs, the most important of which are those at Lugo and those from which Orense is said to take its name (Aquæ urentes).

Ethnologically the Galicians (Gallegos) are allied to the Portuguese, whom they resemble in dialect, in appearance, and in habits more than the other inhabitants of the peninsula. The men are well known all over Spain, and also in Portugal, as hardy, honest, and industrious, but for the most part somewhat unskilled, laborers; indeed the word Gallego has come to be almost a synonym in Madrid for a "hewer of wood and drawer of water." Agriculture engages the greater part of the resident population, both male and female; other industries are little developed, and the fisheries are not extensive. There are a few linen and cotton factories in the larger towns. The principal exports are live cattle, preserved meats, eggs, bones, mineral ore, fish oil, salt fish (especially sardines), chestnuts and other nuts, grain (especially maize), and potatoes. The first-mentioned item is the most considerable; the exports to England from Coruña alone having mounted in 1875 to 17,000 head, at an average value of £15. The chief imports are coal, iron, tobacco, and manufactured goods. Apart from the few carreteras reales or royal roads, which are, as elsewhere in the Peninsula, unexceptionable, the means of internal communication in Galicia are decidedly defective. The only railways are those betwixt Lugo and Coruña (61 miles), and betwixt Santiago and Carril (24½ miles). Another line from Vigo to Orense has been in course of construction for some time, and it is also proposed to connect Lugo with Astorga. Galicia has 10 cities and 115 towns. The capital is Santiago, which is also an archbishopric, with a population of 29,000. Lugo, Tuy, Mondoñedo, Orense, are also episcopal sees. The largest city is Coruña, the seat of the audiencia (population about 40,000). The others are Ferrol, Vigo, Betanzos, and Pontevedra.

Gallæcia, the country of the Callaici or Gallaici, seems to have been very imperfectly known to the earlier geographers. According to Eratosthenes the entire population of the peninsula were at one time called Galatæ. The region properly called by their name, bounded on the S. by the Douro and on the E. by the Navia, was first entered by the Roman legions under Decius Junius Brutus in 137–6 B. C. (Livy, lv., lvi., *Epit.*); but the final subjugation cannot be placed earlier than the time of Augustus. Under the Antonines, possibly even under Hadrian, Gallæcia and Asturia were erected into a separate Provincia Cæsaris, having been regarded previously as merely a portion of Lusitania. On the partition of Spain, which followed the successful invasions of the Suevians, Alans, and Vandals, Gallæcia fell to the lot of the first-named (411 A. D.). After an independent subsistence of nearly 200 years, the Suevian Kingdom was annexed to the Visigothic dominions under Leovigild in 590. In 713 it was occupied by the Moors, who in turn were driven out of it about the year 734 by Alphonso I. of Asturias and his brother Froela. During the 9th and 10th centuries it was the subject of dispute between more than one count of Galicia and the suzerain, and its coasts were repeatedly ravaged by the Norsemen. When Ferdinand I. divided his kingdom among his sons in 1063, Galicia was the portion allotted to Garcia, the youngest of the three. Ten years afterwards it was forcibly reannexed by Garcia's brother Alphonso, and thenceforward it remained an integral part of the kingdom of Castile or of Leon. The honorary title of count of Galicia has frequently been borne by younger sons of the Spanish sovereign. In the patriotic struggles of 1808 the junta of Galicia took an important part. For administrative purposes the ancient province has since 1833 been divided into four, namely, Coruña, Lugo, Orense, and Pontevedra.

GALILEE (*Γαλιλαία*, גָּלִיל), the most northerly of the three provinces into which Palestine was at the Roman period divided, was bounded on the E. by the Jordan, on the S. by Samaria, on the W. by the Mediterranean, on the N. W. by Phœnicia, and on the N. by the Leontes, the extreme length being about 60 miles, the extreme breadth 30, and the area 1000 square miles. The Galilee thus defined, however, though doubtless the Galilee of Herod's tetrarchy and of later centuries, was hardly that of ordinary parlance at the beginning of the Christian era. Josephus himself, while substantially giving these boundaries (*B. J.*, iii. 3, 1, and elsewhere), yet incidentally in one place speaks of Upper Galilee as constituting the whole of Galilee proper (*Ant.* xx. 6, 1), and elsewhere in giving Xaloth (Iksâl) and Dabaratta (Debûrieh) as boundary towns, seems to exclude from Galilee the plain of Esdraelon. In the early period of the history of Israel, the word גָּלִיל or גְּלִילָה, meaning a circle, was hardly a proper name at all, but was applied to several districts with considerable generality. Thus in Josh. xiii. 2 and Joel iv. 4 reference is made to the "borders" or "coasts" (Geliloth) of the Philistines. In Josh. xxii. 10, 11, however, the "Geliloth" of Jordan means the plain of Jordan referred to in Ezekiel xlvii. 8 as "the eastern Gelilah" (compare Josh. xviii. 7); while in Josh. xx. 7, xxi. 32, hag-Galil denotes the north portion of the territory of Naphtali westward of Merom, where Kadesh, one of the six cities of refuge, lay. Here were situated the twenty "worthless" cities which Solomon gave to Hiram (1 Kings ix. 11; 2 Chr. viii. 2); and here, notwithstanding the conquests made successively by Joshua, several of the judges, David, and Solomon, the population seems to have retained a prevailingly ethnic character; for even in Isaiah's time "the land of Zebulun and the land of Naphtali" is called "Galilee of the Gentiles" (Isa. ix. 1). After the deportation by Tiglath-Pileser (2 Kings xv. 29), in which it is to be presumed that chiefly Israelites were carried away, this ethnic character would most probably be intensified and extended rather than diminished either in area or in amount; and already in the time of the Maccabees, accordingly, we find the word apparently used in a considerably wider sense than in earlier times (1 Macc. v. 14, 15, x. 30; *cf.* Tob. i. 2). The latter extension of the designation cannot be more particularly traced, but we know with considerable exactness what the limits were at the time of the Talmudists. The southern boundary was defined by the towns of Bethshean (Beisân), Ginæa (Jenîn), Caphar Utheni (Kefr Adân), and by the ridge of Carmel; on the east the Jordan formed the limit; while on the west and north the line ran from Carmel to Accho (Akka), and thence ascended eastwards by a great valley just south of Achzib (ez Zîb) extending 8 miles, past Kabartha (el Kâbry), Gathin (J'athûn), and Beth Zanita (Zueinîta), to Gelila (Jelîl), where it turned north near M'alia, probably the Melloth which Josephus notices as on his boundary (*B. J.*, iii. 3, 1). From Melloth it ran 12 miles north to Kania and Aiya (probably Kânah and 'Aiya), and then appears to have run east along a high ridge by Berii and Tirii (Beriâs and Tîreh), and thence, after a course of 5 miles, it trended north-east by Tifni (Tibnîn), Sifneta (Safed el Battîkh), Ailshitha ('Atshîth), and Aulam (Almôn), arriving thus at the deep gorge of the Leontes. Turning east it passed Migdol Kherub (el Khurbeh) and the "hollow of Ayun" (Merj 'Ayûn), past Takra (unknown) to Tortalga ("the snowy mountain," or Hermon), and to Kisrîn and the bounds of Iitir—that is, to Cæsarea Philippi (now Bânias), and thus to beyond Jordan. The boundary between Upper and Lower Galilee was natural, being marked on the east by the town of Caphar Hananya (Kefr 'Anân), situated at the foot of the high ridge which formed the actual line; Bersobe, on the same boundary (Josephus, *B. J.*, iii. 3, 1), is not as yet known.

Lower Galilee.—The whole of Galilee presents country more or less disturbed by volcanic action. In the lower division the hills are all tilted up towards the east, and broad streams of lava have flowed over the plateau above the Sea of Galilee. In this district the highest hills are only about 1800 feet above the sea. The ridge of Nazareth rises north of the great plain of Esdraelon, and north of this again is the fertile basin of the Buttauf, separated from the sea-coast plains by low hills. East of the Buttauf extends the basaltic plateau called el Ahma ("the inaccessible"), rising 1700 feet above the Sea of Galilee. North of the Buttauf is a confused hill country, the spurs falling towards a broad valley which lies at the foot of the mountains of Upper Galilee. This broad valley, running westwards to the coast, is the old boundary of Zebulun—the valley of Jiphthah-el (Josh. xix. 14). The great plain of Esdraelon is of triangular form, bounded by Gilboa on the east and by the ridge which runs to Carmel on the west. It is 14 miles long from Jenîn to the Nazareth hills, and has a mean measurement of 9 miles east and west. It rises 200 feet above the sea, the hills on both sides being some 1500 feet higher. The whole drainage is collected by the Kishon, which runs through a narrow gorge at the north-west corner of the plain, descending beside the ridge of Carmel to the sea. The broad valley of Jezreel on the east, descending towards the Jordan valley, forms the gate by which Palestine is entered from beyond Jordan. Mount Tabor stands isolated in the plain at the north-east corner, and rather further south the conical hill called Neby Duhy rises between Tabor and Gilboa. The whole of Lower Galilee is well watered. The Kishon is fed by springs from near Tabor and from a copious stream from the west side of the plain of Esdraelon. North-west of Nazareth is Wâdy el Melek, an open valley full of springs. The river Belus, just south of Acre, rising in the sea-coast marshes, drains the whole valley of Jiphthah-el. On the east the broad valley of Jezreel is full of magnificent springs, many of which are thermal. The plains of Esdraelon, and the Buttauf, and the plateau of el Ahma, are all remarkable for the rich basaltic soil which covers them, in which corn, cotton, maize, sesame, tobacco, millet, and various kinds of vegetables are grown, while indigo and sugar-cane were cultivated in former times. The Nazareth hills and Gilboa are bare and white, but west of Nazareth is a fine oak wood, and another thick wood spreads over the northern slopes of Tabor. The hills west of the great plain are partly of bare white chalk, partly covered with dense thickets. The mountains north of the Buttauf are rugged and covered with scrub, except near the villages, where fine olive groves exist. The principal places of importance in Lower Galilee are Nazareth (10,000 inhabitants), Sepphoris (now Seffûrieh), a large village standing above the Buttauf on the spurs of the southern hills, and Jenîn (En Gannim), a flourishing village, with a palm garden (3000 inhabitants). The ancient capital, Jezreel (Zerin), is now a miserable village on a precipitous spur of Gilboa; north of this are the small mud hamlets, Solam (Shunem), Endûr (Endor), Nein (Nain); on the west side of the plain is the ruin of Lejjûn (the Legio of the 4th century, which was then a place of importance). In the hills north of the Buttauf is Jefât, situated on a steep hilltop, and representing the Jotapata defended by Josephus. Kefr Kenna, now a flourishing Christian village at the foot of the Nazareth hills, south of the Buttauf, represents the probable site of Cana of Galilee, and the ruin Kâna, on the north side of the same plain, represents the site pointed out to the pilgrims of the 12th and 13th centuries.

Upper Galilee.—The mountains are tilted up towards the Sea of Galilee, and the drainage of the district is towards the north-west. On the south the rocky range of Jebel Jermûk rises to 4000 feet above the sea; on the east a narrow ridge 2800 feet high forms the watershed, with steep eastern slopes falling towards Jordan. Immediately west of the watershed are two small plateaus, covered with basaltic débris, near el Jish and Kades. On the west are rugged mountains with deep intricate valleys. The main drains of the country are—first, Wâdy el 'Ayûn, rising north of Jebel Jermûk, and running north-west as an open valley, and secondly, Wâdy el Ahjâr, a rugged precipitous gorge running north to join the Leontes. The district is well provided with springs throughout, and the valleys are full of water in the spring time. Though rocky and difficult, Upper Galilee is not barren, the soil of the plateaus is rich, and the vine flourishes in the higher hills, especially in the neighborhood of Kefr Birim. The principal town is Safed, perched on a white mountain 2700 feet above the sea. It has a population of about 9000, including Jews, Christians, and Moslems. It is one of the four sacred cities in Palestine revered by the Jews, to which nationality the majority of the inhabitants belong. Among the smaller towns we may notice Meirûn, near Safed, a place also much revered by the Jews as containing the tombs of Hillel, Shammai, and Simeon bar Jochai. A yearly festival of most curious character is here celebrated in honor of these rabbis. The site of Hazor, one of the chief towns of Galilee in Bible times, has also been lately recovered. It was situated, according to Josephus, above the Lake Semechonitis (Bahr el Hûleh), and the name Hudîreh, identical with the Hebrew Hazor, has been found by the survey party in 1877 applying to a mountain and plain, near an ancient ruin, in the required position. The little village of Kades represents the once important town of Kadesh Naphtali (Josh. xix. 37). The ruins are here extensive and interesting, but belong apparently to the Greek period.

The population of Galilee is mixed. In Lower Galilee the peasants are principally Moslem, with a sprinkling of Greek Christians round Nazareth, which is a Christian town. In Upper Galilee, however, there is a mixture of Jews and Maronites, Druses and Moslems (natives or Algerine settlers), while the slopes above the Jordan are inhabited by wandering Arabs. The Jews are engaged in trade, and the Christians, Druses, and Moslems in agriculture; and the Arabs are an entirely pastoral people.

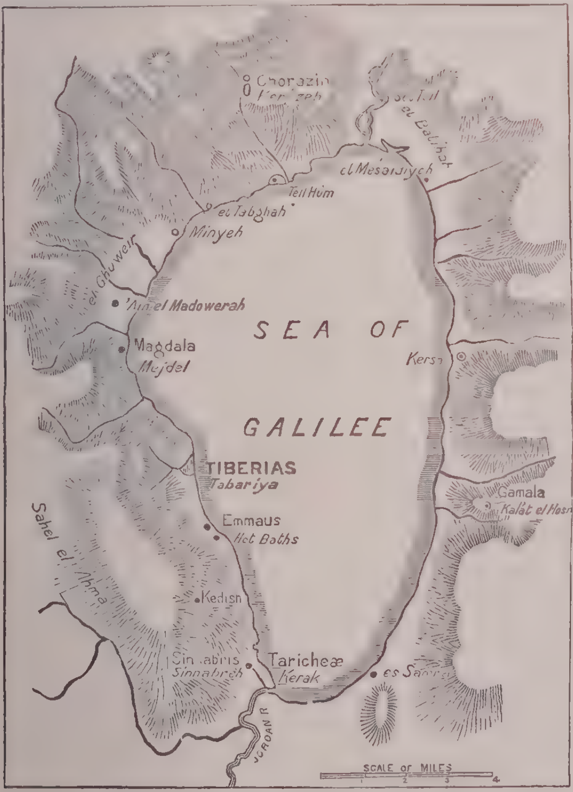
The principal products of the country are corn, wine, oil, and soap (from the olives), with every species of pulse and gourd.

The antiquities of Galilee include cromlechs and rude stone monuments, rock-cut tombs, and wine-presses, with numerous remains of Byzantine monasteries and fine churches of the time of the crusades. There are also remains of Greek architecture in various places, but the most interesting buildings are the ancient synagogues. These have not been found in other parts of Palestine, but in Galilee eleven examples are now known. They are rectangular, with the door to the south, and three rows of columns forming four aisles east and west. The architecture is a peculiar and debased imitation of classic style, attributed by architects to the 2d century of our era. The builder of the examples at Kefr Birim, el Jish, and Meirûn is known to have been the famous Simeon bar Jochai, who lived about 150 A. D., and built 24 synagogues in Galilee. The similarity of style renders it probable that the other examples at Tell Hûm, Kerâzeh, Nebartein, Umm el 'Amed, and Sufsâf were also his work. Both at el Jish and at Kefr Birim there are two synagogues, large and small. At Irbid, above Tiberias, is another synagogue of rather different character, which is said to have been built by Rabbi Nitai. Traces of synagogues have also been found on Carmel, and at Tireh, west of Nazareth. It is curious to find the representation of various animals in relief on the lintels of these buildings.

Hebrew inscriptions also occur, and the carved work of the cornices and capitals is very rich. These synagogues were erected at a time when the Galilean Jews were flourishing under the Roman empire, and when Tiberias was the central seat of Jewish learning and of the Sanhedrin.

In the 12th century Galilee was the outpost of the Christian kingdom of Jerusalem, and its borders were strongly protected by fortresses, the magnificent remains of which still crown the most important strategical points. Toron (now Tibnîn) was built in 1104, the first fortress erected by the crusaders, and standing on the summit of the mountains of Upper Galilee. Beauvoir (Kaukab, built in 1182) stood on a precipice above Jordan south-west of the Sea of Galilee, and guarded the advance by the valley of Jezreel; and about the same time Château Neuf (Hunîn) was erected above the Hûleh lake. Belfort (esh Shukîf) on the north bank of the Leontes, the finest and most important, dates somewhat earlier; and Montfort (Kalat el Kurn) stood on a narrow spur north-east of Acre, completing the chain of frontier fortresses. The town of Bânias, with its castle, formed also a strong outpost against Damascus, and was the scene, in common with the other strongholds, of many desperate encounters between Moslems and Christians. Lower Galilee was the last remaining portion of the Holy Land held by the Christians. In 1250 the knights of the Teutonic order owned lands extending round Acre as far east as the Sea of Galilee, and including Safed. These possessions were lost in 1291, on the fall of Acre. (C. R. C.)

GALILEE, THE SEA OF, with its surrounding shores deserves a more special description than that given of the rest of the district, as being the part of Palestine which most interests modern students and travellers. The lake was also called the Sea of Chinnereth or Chinneroth, and the Lake of Gennesaret or Tiberias; and by Pliny it is said to have been once called Lake of Taricheæ. In form it is pear-shaped, 12½ English miles in length, and 7½ at its greatest width. The level is now known to be 682·5 feet below the Mediterranean. The water is fresh and clear, and large shoals of fish abound in it. The formation of the lake basin occurred later than the Chalk period, and was due to a subsidence of the strata, which appears to have been sudden and violent, and probably accompanied by extensive volcanic eruptions from three centres east, west, and north of the lake. The district has always been liable to volcanic disturbance and to earthquakes. In 1837 Safed and Tiberias were destroyed by earthquake, and the temperature of the hot springs round the lake was then observed to rise considerably for a time.



Sea of Galilee.

The Sea of Galilee is best seen from the top of the western precipices, and presents a desolate appearance. On the north the hills rise gradually from the shore, which is fringed with oleander bushes and indented with small bays. The ground is here covered with black basalt. On the west the plateau of el Ahma terminates in precipices 1700 feet above the lake, and over these the black rocky tops called "the Horns of Hattîn" are conspicuous objects. On the south is a broad valley through which the Jordan flows. On the east are furrowed and rugged slopes, rising to the great plateau of the Jaulân (Gaulonitis). The Jordan enters the lake through a narrow gorge between lower hills. A marshy plain, 2½ miles long and 1½ broad, called el Batîhah, exists immediately east of the Jordan inlet. There is also on the west side of the lake a small plain called el Ghuweir, formed by the junction of three large valleys. It measures 3½ miles along the shore, and is 1 mile wide. This plain, naturally fertile, but now almost uncultivated, is recognized to be the plain of Gennesareth, described by Josephus (*B. J.*, iii. 10, 8). The shores of the lake are of fine shingle. On the east the hills approach in one place within 40 feet of the water, but there is generally a width of about ¾ of a mile from the hills to the beach. On the west the flat ground at the foot of the hills has an average width of about 200 yards. A few scattered palms dot the western shores, and a palm grove is to be found near Kefr Hârib on the south-east. Thermal springs are found on each side of the lake, with an average temperature of about 80° Fahr. The hot baths south of Tiberias include seven springs, the largest of which has a temperature of 137° Fahr. The plain of Gennesareth, with its environs, is the best watered part of the lake-basin. North of this plain are the five springs of et Tâbghah, the largest of which was enclosed about a century ago by Aly, son of Dhahr el 'Amr, in an octagonal reservoir, and the water led off by an aqueduct 52 feet above the lake. The Tâbghah springs, though abundant, are warm and brackish. At the north end of the plain is 'Ain et Tînch ("spring of the fig-tree"), also a brackish spring with a good stream; south of the plain is 'Ain el Bârdeh ("the cold spring"), which is sweet, but scarcely lower in temperature than the others. The most important spring remains still to be noticed, namely, 'Ain el Madâwerah ("the round spring"), situated 1 mile from the south end of the plain and half a mile from the shore. The water rises in a circular well 32 feet in diameter, and is clear and sweet, with a temperature of 73° Fahr. The bottom is of loose sand, and the fish called coracinus by Josephus (*B. J.*, iii. 10, 8) is here found in abundance. Dr. Tristram was the first explorer to identify this fish, and points out that it could not exist in the other springs. We are thus able to identify the "round spring" with the fountain of Capharnaum, which, according to Josephus, watered the plain of Gennesareth.

The principal sites of interest round the lake may be enumerated from north to west and from south to east. Kerâzeh, the undoubted site of Chorazin, stands on a rocky spur 900 feet above the lake, 2 miles north of the shore. Foundations and scattered stones cover the slopes and the flat valley below. On the west is a rugged gorge. In the middle of the ruins are the remains of a synagogue of richly ornamental style built of black basalt. A small spring occurs on the north. Tell Hûm is an important ruin on the shore south of the last mentioned site. The remains consist of foundations and scattered stones (which in spring are concealed by gigantic thistles) extending about half a mile along the shore. The foundations of a fine synagogue, measuring 75 feet by 57, and built in white limestone, have been excavated. A conspicuous building has been erected close to the water, from the fragments of the Tell Hûm synagogue. Since the 4th century Tell Hûm has been pointed out by all the Christian writers as the site of Capernaum, but the fatal objections to such an identification are—(1) the great distance from the fountain of Capharnaum, and (2) the fact that Jewish tradition preserves another site. The ruins at Tell Hûm are not of necessity as old as the time of Christ. The name Hûm means "black," and is probably connected with the surrounding black basalt. The place seems to be mentioned in the Talmud under the titles Caphar Ahim and Caphar Tanhumin (see Neubauer's *Geog. Tal.*, p. 220). Minyeh is a ruined site at the north end of the plain of Gennesareth, 2½ miles from the last, and close to the shore. There are extensive ruins on flat ground, consisting of mounds and foundations, with traces of a wall once surrounding the site. Masonry of well-dressed stones has also been here discovered in course of excavation. Near the ruins are remains of an old khân, which appears to have been built in the Middle Ages; and above this a curious hillock, with an artificial rock-platform, called el 'Oreimeh, "the little knoll." Immediately to the north-east a precipice projects to the lake, and the aqueduct from the Tâbghah spring is led to an ancient rock-cut channel, which seems to have been once intended for a road in the face of the cliff. In the 17th century Quaresmius speaks of this place, Minyeh, as the site of Capernaum. In the 14th Isaac Chelo was apparently shown the same site as containing the tomb of Nahum, and as being the "city of the Minai." The "Minai," or "sorcerers," are mentioned in the Talmud, and by this title the Jews stigmatized the early Christians; and these "Minai" are called in one passage of the Talmud "sons of Capernaum." There is thus a close connection between this Minyeh—named from the Minai—and the town of Capernaum. The position of the site is also suitable for that of Capernaum, being in the plain of Gennesareth, two miles from the "round spring," or fountain of Capharnaum. No other site of any importance exists in the plain of Gennesareth. See CAPERNAUM.

South of the plain of Gennesareth is the undisputed site of the New Testament town of Magdala. A few lotus trees and some rock-cut tombs are here found beside a miserable mud hamlet on the hill slope, with a modern tomb-house or *kubbeh*. Passing beneath rugged cliffs a recess in the hills is next reached, where stands Tabarîya, the ancient Tiberias or Rakkath, containing 3000 inhabitants, more than half of whom are Jews. The walls, flanked with round towers, and now partly destroyed by the earthquake of 1837, were built by Dhahr el 'Amr, as was the serai or court-house. The two mosques, now partly ruinous, were erected by his sons. There are remains of a crusading church, and the tomb of the celebrated Maimonides is shown in the town, while Rabbi Akiba and Rabbi Meir lie buried outside. The ruins of the ancient city, including granite columns and traces of a sea-wall with towers, stretch southwards a mile beyond the modern town. An aqueduct in the cliff once brought water a distance of 9 miles from the south.

Kerak, at the south end of the lake, is an important site on a peninsula surrounded by the water of the lake, by the Jordan, and by a broad water ditch, while on the north-west a narrow neck of land remains. The plateau thus enclosed is partly artificial, and banked up 50 or 60 feet above the water. A ruined citadel remains on the north-west, and on the east was a bridge over the Jordan; broken pottery and fragments of sculptured stone strew the site. The ruin of Kerak answers to the description given by Josephus of the city of Taricheæ, which lay 30 stadia from Tiberias, the hot baths being between the two cities. Taricheæ was situated, as is Kerak, on the shore below the cliffs, and partly surrounded by water, while before the city was a plain (the Ghôr). Pliny further informs us that Taricheæ was at the south end of the Sea of Galilee. Sinnabreh, a ruin on a spur of the hills close to the last-mentioned site, is undoubtedly the ancient Sinnabris, where Vespasian (Joseph., *B. J.*, iii. 9, 7) fixed his camp, advancing from Scythopolis (Beisân) on Taricheæ and Tiberias. Sinnabris was 30 stadia from Tiberias, or about the distance of the ruin now existing.

The eastern shores of the Sea of Galilee have been less fully explored than the western, and the sites are not so perfectly recovered. The town of Hippos, one of the cities of Decapolis, was situated 30 stadia from Tiberias, and 60 stadia from Gadara (Umm Keis). It is conjectured that the town Susitha, mentioned in the Talmud, is the same place, and the name Susyeh seems to have existed east of the Sea of Galilee at a late period. Susitha, from "sus," meaning "horse," is, etymologically at least, suggestive of the Greek "hippos." The site is at present unknown. Kalat el Hosn ("castle of the stronghold") is a ruin on a rocky spur opposite Tiberias. Two large ruined buildings remain, with traces of an old street and fallen columns and capitals. A strong wall once surrounded the town; a narrow neck of land exists on the east where the rock has been scarped. Rugged valleys enclose the site on the north and south; broken sarcophagi and rock-cut tombs are found beneath the ruin. This site answers to the description Josephus gives of Gamala, an important fortress besieged by Vespasian (*Bell. Jud.*, iv. 1, 1). Gersa, an insignificant ruin north of the last, is thought to represent the Gerasa or Gergesa of the 4th century, situated east of the lake; and the projecting spur of hill south of this ruin is conjectured to be the place where the swine "ran violently down a steep place" (Matt. viii. 32). The site of Bethsaida Julias, east of Jordan, is also unknown. It has been supposed (and the theory is supported by even so important an authority as Reland) that two separate places named Bethsaida are mentioned in the New Testament. The grounds for this conclusion are, however, very insufficient; and only one Bethsaida is mentioned by Josephus. It was near the Jordan inlet, on the east side of the river, and under its later Greek name of Julias, it is mentioned, with Hippos, by Pliny. The site usually pointed out is the ruin of et Tell, north of the Batîhah plain; the remains are, however, modern and insignificant. Just south of the same plain is a ruined village called Mes'aidîyeh, the name of which approaches Bethsaida in sound but not in meaning. This is the site pointed out by Vandevelde, and it is possible that the course of Jordan has shifted westwards, and that the old mouth is marked by the two creeks running into the shore on the east, in which case the site of Mes'aidîyeh might be accepted as the Bethsaida of the gospels, which appears to have been east of Jordan.

Literature.—The most important works on the subject of Galilee and the Sea of Galilee are the following:—Robinson's *Biblical Researches*; Stanley's *Sinai and Palestine*; Tristram's *Land of Israel*; Warren and Wilson's *Recovery of Jerusalem*; Conder's *Tent Work in Palestine*; and the *Memoirs of the Survey of Palestine* (sheets 1–6, 8, 9). (C. R. C.)

GALILEO. Galileo Galilei (1564–1642), one of the earliest and greatest of experimental philosophers, was born at Pisa, February 18, 1564. His father, Vincenzo, was an impoverished descendant of a noble Florentine house, which had exchanged the surname of Bonajuti for that of Galilei, on the election, in 1343, of one of its members, Galileo de' Bonajuti, to the college of the twelve Buonuomini. The family, which was fifteen times represented in the signoria, and in 1445 gave a gonfalonier to Florence, flourished with the republic and declined with its fall. Vincenzo Galilei was a man of better parts than fortune. He was a competent mathematician, wrote with considerable ability on the theory and practice of music, and was especially distinguished amongst his contemporaries for the grace and skill of his performance upon the lute. By his wife, Giulia de' Ammannati of Pistoja, he had two sons, Galileo and Michelangiolo, and two daughters, Virginia and Livia. From his earliest childhood Galileo was remarkable for intellectual aptitude, as well as for mechanical invention. His favorite pastime was the construction of toy-machines, not the less original and ingenious that their successful working was usually much hindered by the scarcity of suitable materials. His application to literary studies was equally conspicuous. In the monastery of Vallombrosa, near Florence, where his education was principally conducted, he not only made himself acquainted with the best Latin authors, but acquired a fair command of the Greek tongue, thus laying the foundation of the brilliant and elegant style for which his writings were afterwards distinguished. From one of the monks he also received instruction in logic, according to the system then in vogue; but the futilities of the science revolted, while its subtleties failed to interest his understanding, and he was soon permitted to abandon a study so distasteful to him. A document published by M. Selmi in 1864 proves that he was at this time so far attracted towards a religious life as to have joined the novitiate of the order; but his father, who had other designs for him, seized the opportunity of an attack of ophthalmia to withdraw him permanently from the care of the monks. Having had personal experience of the unremunerative character both of music and of mathematics, he desired that his son should apply himself to the more profitable study of medicine, and, not without some straining of his slender resources, placed him, before he had completed his eighteenth year, at the university of Pisa. He accordingly matriculated, November 5, 1581, and immediately entered upon attendance at the lectures of the celebrated physician and botanist, Andrea Cesalpino.

The natural gifts of the young student, not less multifarious than those of an earlier Tuscan prodigy, Leonardo da Vinci, seemed at this time equally ready to develop in any direction towards which choice or hazard might incline them. In musical skill and invention he already vied with the best professors of the art in Italy; his personal taste would have led him to choose painting as his profession, and one of the most eminent artists of his day, Lodovico Cigoli, owned that to his judgment and counsel he was mainly indebted for the success of his works; his wit and eloquence gave promise that he would one day add to the literary glories of his country; while his mathematical and mechanical genius only awaited a suitable opportunity for full display and development. In 1583, while watching the vibrations of the great bronze lamp still to be seen swinging from the roof of the cathedral of Pisa, he observed that, whatever the range of its oscillations, they were invariably executed in equal times. The experimental verification of this fact led him to the important discovery of the isochronism of the pendulum. He at first applied the new principle to pulse-measurement, and more than fifty years later turned it to account in the construction of an astronomical clock. Up to this time he was entirely ignorant of mathematics, his father having carefully held him aloof from a study which he rightly apprehended would lead to his total alienation from that of medicine. Accident, however, frustrated this purpose. A lesson in geometry, given by Ostilio Ricci to the pages of the grand-ducal court, then temporarily resident at Pisa, chanced to have Galileo for an unseen listener; his attention was riveted, his dormant genius was roused, and he threw all his energies into the new pursuit thus unexpectedly presented to him. With Ricci's assistance, he rapidly mastered the elements of the science, and eventually extorted his father's reluctant permission to exchange Hippocrates and Galen for Euclid and Archimedes. In 1586 he was withdrawn from the university, through lack of means, before he had taken a degree, and returned to Florence, where his family habitually resided. We next hear of him as lecturing before the Florentine Academy on the site and dimensions of Dante's *Inferno;* and he shortly afterwards published an essay descriptive of his invention of the hydrostatical balance, which rapidly made his name known throughout Italy. His first patron was the Marchese Guidubaldo del Monte of Pesaro, a man eminent for his scientific attainments, as well as influential by his family connections. At his request he wrote, in 1588, a treatise on the centre of gravity in solids, which obtained for him, together with the title of "the Archimedes of his time," the honorable though not lucrative post of mathematical lecturer at the Pisan university. During the ensuing two years (1589–91) he carried on that remarkable series of experiments, by which he established the first principles of dynamical science, and by which he earned for himself the undying hostility of the bigoted Aristotelians of that day. From the leaning tower of Pisa he afforded to all the professors and students of the university ocular demonstration of the falsehood of the Peripatetic dictum that heavy bodies fall with velocities proportional to their weights, and with unanswerable logic demolished all the time-honored maxims of the schools regarding the motion of projectiles, and elemental weight or levity. But while he convinced, he failed to conciliate his adversaries. The keen sarcasm of his polished rhetoric was not calculated to sooth the susceptibilities of men already smarting under the deprivation of their most cherished illusions. He seems, in addition, to have compromised his position with the grand-ducal family by the imprudent candor with which he condemned a machine for clearing the port of Leghorn, invented by Giovanni de' Medici, an illegitimate son of Cosmo I. Princely favor being withdrawn, private rancor was free to show itself. He was publicly hissed at his lecture, and found it prudent to resign his professorship and withdraw to Florence in 1591. Through the death of his father in July of that year family cares and responsibilities devolved upon him as eldest son, and thus his nomination to the chair of mathematics at the university of Padua, secured by the influence of the Marchese Guidubaldo with the Venetian senate, was welcome, as affording a relief from pecuniary embarrassment, no less than as opening a field for scientific distinction.

His residence at Padua, which extended over a period of eighteen years, from 1592 to 1610, was a course of uninterrupted prosperity. His appointment was three times renewed, on each occasion with expressions of the highest esteem on the part of the governing body, and his yearly salary was progressively raised from 180 to 1000 florins. His lectures were attended by persons of the highest distinction from all parts of Europe, and such was the charm of his demonstrations that a hall capable of containing 2000 people had eventually to be assigned for the accommodation of the overflowing audiences which they attracted. His ingenious invention of the proportional compasses—an instrument still used in geometrical drawing—dates from 1597; and about the same time he constructed the first thermometer, consisting of a bulb and tube filled with air and water, and terminating in a vessel of water. In this instrument, the results of varying atmospheric pressure were not distinguishable from the expansive and contractive effects of heat and cold, and it became an efficient measure of temperature only when Rinieri, in 1646, introduced the improvement of hermetically sealing the liquid in glass. The substitution, in 1670, of mercury for water completed the modern thermometer.

Galileo seems, at an early period of his life, to have adopted the Copernican theory of the solar system, and was deterred from avowing his opinions—as is proved by his letter to Kepler of August 4, 1597—by the fear of ridicule rather than of persecution. The appearance, in September, 1604, of a new star in the constellation Serpentarius, afforded him indeed an opportunity, of which he eagerly availed himself, for making an onslaught upon the Aristotelian axiom of the incorruptibility of the heavens; but he continued to conform his public teachings in the main to Ptolemaic principles, until the discovery of a novel and potent implement of research placed at his command startling and hitherto unsuspected evidence as to the constitution and mutual relations of the heavenly bodies. Galileo was not the original inventor of the telescope.[1] That honor must be assigned to Hans Lippershey, an obscure optician of Middleburg, who, on the 21st of October, 1608, offered to the states of Holland three instruments by which the apparent size of remote objects was increased. But here his glory ends, and that of Galileo begins. The rumor of the new invention, which reached Venice in April or May, 1609, was sufficient to set the Italian philosopher on the track; and after one night's profound meditation on the principles of refraction, he succeeded in producing a telescope of threefold magnifying power. Upon this first attempt he rapidly improved, until he attained to a power of thirty-two, and his instruments, of which he manufactured hundreds with his own hands, were soon in request in every part of Europe. Two lenses only—a plano-convex and a plano-concave—were needed for the composition of each, and this simple principle is that still employed in the construction of opera-glasses. Galileo's direction of his new instrument to the heavens formed an era in the history of astronomy. Discoveries followed upon it with astounding rapidity and in bewildering variety. The *Sidereus Nuncius*, published at Venice in the early part of 1610, contained the first-fruits of the new mode of investigation, which were sufficient to startle and surprise the learned on both sides of the Alps. The mountainous configuration of the moon's surface was there first described, and the so-called "phosphorescence" of the dark portion of our satellite attributed to its true cause—namely, illumination by sun-light reflected from the earth.[2] All the time-worn fables and conjectures regarding the composition of the Milky Way were at once dissipated by the simple statement that to the eye, reinforced by the telescope, it appeared as a congeries of lesser stars, while the great nebulæ were equally declared to be resolvable into similar elements. But the discovery which was at once perceived to be most important in itself, and most revolutionary in its effects, was that of Jupiter's satellites, first seen by Galileo

[1] The word *telescope*, from τῆλε, far, σκοπέω, to view, was invented by Demiscianus, an eminent Greek scholar, at the request of Prince Cesi, president of the Lyncean Academy. It was used by Galileo as early as 1612, but was not introduced into English until much later. In 1655 the word *telescope* was inserted in Bagwell's *Mysteries of Astronomy*, as a term requiring explanation, *trunk* or *cylinder* being commonly used instead.

[2] Leonardo da Vinci, more than a hundred years earlier, had come to the same conclusion.

January 7, 1610, and by him named *Sidera Medicea*, in honor of the grand-duke of Tuscany, Cosmo II., who had been his pupil, and was about to become his employer. An illustration is, with the general run of mankind, more powerful to convince than an argument; and the cogency of the visible plea for the Copernican theory offered by the miniature system, then for the first time disclosed to view, was recognizable in the triumph of its advocates, as well as in the increased acrimony of its opponents.

In September, 1610, Galileo finally abandoned Padua for Florence. His researches with the telescope had been rewarded by the Venetian senate with the appointment for life to his professorship, at an unprecedentedly high salary. His discovery of the "Medicean Stars" was acknowledged by his nomination (July 12, 1610) as philosopher and mathematician extraordinary to the grand-duke of Tuscany. The emoluments of this office, which involved no duties save that of continuing his scientific labors, were fixed at 1000 scudi; and it was the desire of increased leisure, rather than the promptings of local patriotism, which induced him to accept an offer, the first suggestion of which had indeed come from himself. Before the close of 1610 the memorable cycle of discoveries begun in the previous year was completed by the observation of the ansated or, as it appeared to Galileo, triple form of Saturn (the ring-formation was first recognized by Huygens in 1655), of the phases of Venus, and of the spots upon the sun. Although his priority in several of these discoveries has been contested, inquiry has in each case proved favorable to his claims. In the spring of 1611 he visited Rome, and exhibited in the gardens of the Quirinal Palace the telescopic wonders of the heavens to the most eminent personages at the pontifical court. Encouraged by the flattering reception accorded to him, he ventured, in his *Letters on the Solar Spots*, printed at Rome in 1613, to take up a more decided position towards that doctrine on the establishment of which, as he avowed in a letter to Belisario Vinta, secretary to the grand-duke, "all his life and being henceforward depended." Even in the time of Copernicus some well-meaning persons had suspected a discrepancy between the new view of the solar system and certain passages of Scripture—a suspicion strengthened by the anti-Christian inferences drawn from it by Giordano Bruno; but the question was never formally debated until Galileo's brilliant discoveries, enhanced by his formidable dialectic and enthusiastic zeal, irresistibly challenged for it the attention of the authorities. Although he earnestly deprecated the raising of the theological issue, and desired nothing better than permission to pursue unmolested his physical demonstrations, it must be admitted that, the discussion once set on foot, he threw himself into it with characteristic impetuosity, and thus helped to precipitate a decision which it was his ardent wish to avert. In December, 1613, a Benedictine monk named Benedetto Castelli, at that time professor of mathematics at the university of Pisa, wrote to inform Galileo of a recent discussion at the grand-ducal table, in which he had been called upon to defend the Copernican doctrine against theological objections. This task Castelli, who was a steady friend and disciple of the Tuscan astronomer, seems to have discharged with moderation and success. Galileo's answer, written, as he said himself, *currente calamo*, was an exposition of a formal theory as to the relations of physical science to Holy Writ, still further developed in an elaborate apology addressed by him in the following year (1614) to Christina of Lorraine dowager grand-duchess of Tuscany. Not satisfied with explaining adverse texts, he met his opponents with unwise audacity on their own ground, and endeavored to produce scriptural confirmation of a system which to the ignorant many seemed an incredible paradox, and to the scientific few was a beautiful but daring innovation. The rising agitation on the subject which, originating probably with the sincere upholders of the integrity of Scripture, was fomented for their own purposes by the rabid Aristotelians of the schools, was heightened rather than allayed by these manifestoes, and on the fourth Sunday of the following Advent found a voice in the pulpit of Santa Maria Novella. Padre Caccini's denunciation of the new astronomy was indeed disavowed and strongly condemned by his superiors; nevertheless, on the 5th of February, 1615, another Dominican monk named Lorini laid Galileo's letter to Castelli before the Inquisition.

Cardinal Robert Bellarmine was at that time by far the most influential member of the Sacred College. He was a man of vast learning and upright piety, but, although personally friendly to Galileo, there is no doubt that he saw in his scientific teachings a danger to religion. The year 1615 seems, however, to have been a period of suspense. Galileo received, as the result of a conference between Cardinals Bellarmine and Del Monte, a semi-official warning to avoid theology and limit himself to physical reasoning. "Write freely," he was told by Monsignor Dini, "but keep outside the sacristy." Unfortunately, he had already committed himself to dangerous ground. In December he repaired personally to Rome, full of confidence that the weight of his arguments and the vivacity of his eloquence could not fail to convert the entire pontifical court to his views. He was cordially received, and eagerly listened to, but his imprudent ardor served but to injure his cause. On the 24th of February, 1616, the consulting theologians of the Holy Office characterized the two propositions—that the sun is immovable in the centre of the world, and that the earth has a diurnal motion of rotation—the first as "absurd in philosophy, and formally heretical, because expressly contrary to Holy Scripture," and the second as "open to the same censure in philosophy, and at least erroneous as to faith." Two days later Galileo was, by command of the pope (Paul V.), summoned to the palace of Cardinal Bellarmine, and there officially admonished not thenceforward to "hold, teach, or defend" the condemned doctrine. This injunction he promised to obey. On the 5th of March the Congregation of the Index issued a decree reiterating, with the omission of the word "heretical," the censure of the theologians, suspending, *usque corrigatur*, the great work of Copernicus, *De Revolutionibus orbium cœlestium*, and absolutely prohibiting a treatise by a Carmelite monk named Foscarini, which treated the same subject from a theological point of view. At the same time it was given to be understood that the new theory of the solar system might be held *ex hypothesi*, and the trivial verbal alterations introduced into the Polish astronomer's book in 1620, when the work of revision was completed by Cardinal Gaetani, confirmed this interpretation. This edict, it is essential to observe, of which the responsibility rests with a disciplinary congregation in no sense representing the church, was never confirmed by the pope, and was virtually repealed in 1757 under Benedict XIV.

Galileo returned to Florence three months later, not ill-pleased, as his letters testify, with the result of his visit to Rome. He brought with him, for the refutation of calumnious reports circulated by his enemies, a written certificate from Cardinal Bellarmine, to the effect that no abjuration had been required of or penance imposed upon him. During a prolonged audience, he had received from the pope assurances of private esteem and personal protection; and he trusted to his dialectical ingenuity to find the means of presenting his scientific convictions under the transparent veil of an hypothesis. Although a sincere Catholic, he seems to have laid but little stress on the secret admonition of the Holy Office, which his sanguine temperament encouraged him gradually to dismiss from his mind. He preserved no written memorandum of its terms, and it was represented to him, according to his own deposition in 1633, solely by Cardinal Bellarmine's certificate, in which, for obvious reasons, it was glossed over rather than expressly recorded. For seven years, however, during which he led a life of studious retirement in the Villa Segni at Bellosguardo, near Florence, he maintained an almost unbroken silence. At the end of that time he appeared in public with his *Saggiatore*, a polemical treatise written in reply to the *Libra Astronomica* of Padre Grassi (under the pseudonym of Lotario Sarsi), the Jesuit astronomer of the Collegio Romano. The subject in debate was the nature of comets, the conspicuous appearance of three of which bodies in the year 1618 furnished the occasion of the controversy. Galileo's views, although erroneous, since he held comets to be mere atmospheric emanations reflecting sunlight after the evanescent fashion of a halo or a rainbow, were expressed with such triumphant vigor, and embellished with such telling sarcasms, that his opponent did not venture upon a reply. The *Saggiatore* was printed at Rome in October, 1623, by the Academy of the Lincei, of which Galileo was a member, with a dedication to the new pope, Urban VIII., and notwithstanding some passages containing a covert defence of Copernican opinions, was received with acclamation by the ecclesiastical, no less than by the scientific authorities. Everything seemed now to promise a close of unbroken prosperity to Galileo's career. Maffeo Barberini, his warmest friend and admirer in the Sacred College, was, by the election of August 8, 1623, seated on the pontifical throne; and the marked distinction with which he was received on his visit of congratulation to Rome in 1624 encouraged him to hope for the realization of his utmost wishes. He received every mark of private favor. The pope admitted him to six long audiences in the course of two months, wrote an enthusiastic letter to the grand-duke praising the great astronomer, not only for his distinguished learning, but also for his exemplary piety, and granted a pension to his son Vincenzo, which was afterwards transferred to himself, and paid, with some irregularities, to the end of his life. But on the subject of the decree of 1616, the revocation of which Galileo had hoped to obtain through his personal influence, he found him inexorable. Nevertheless, the sanguine philosopher trusted, not without reason, that it would at least be interpreted in a liberal spirit, and his friends encouraged his imprudent confidence by eagerly retailing to him every papal utterance which it was possible to construe in a favorable sense. To Cardinal Hohenzollern Urban was reported to have said that the theory of the earth's motion had not been and could not be condemned as heretical, but only as rash; and in 1630 the learned Dominican monk Campanella wrote to Galileo that the pope had expressed to him in conversation his disapproval of the prohibitory decree. Thus, in the full anticipation of added renown, and without any misgiving as to ulterior consequences, Galileo set himself, on his return to Florence, to complete his famous but ill-starred work, the *Dialogo dei due Massimi Sistemi del Mondo.* Finished in 1630, it was not until January, 1632, that it emerged from the presses of Landini at Florence. The book was originally intended to appear in Rome, but unexpected obstacles interposed. The Lyncean Academy collapsed with the death of Prince Federigo Cesi, its founder and president; an outbreak of plague impeded communication between the various Italian cities; and the *imprimatur* was finally extorted, rather than accorded, under the pressure of private friendship and powerful interest. A tumult of applause from every part of Europe followed its publication; and it would be difficult to find in any language a book in which animation and elegance of style are so happily combined with strength and clearness of scientific exposition. Three interlocutors, named respectively Salviati, Sagredo, and Simplicio, take part in the four dialogues of which the work is composed. The first-named expounds the views of the author; the second is an eager and intelligent listener; the third represents a well-meaning but obtuse Peripatetic, whom the others treat at times with undisguised contempt. Salviati and Sagredo took their names from two of Galileo's early friends, the former a learned Florentine, the latter a distinguished Venetian gentleman; Simplicio ostensibly derived his from the Cilician commentator of Aristotle, but the choice was doubtless instigated by a sarcastic regard to the double meaning of the word. There were not wanting those who insinuated that Galileo intended to depict the pope himself in the guise of the simpleton of the party; this charge, however, was not only preposterous in itself, but wholly unsupported by intrinsic evidence, and Urban was far too sagacious to give any permanent credit to it.

It was at once evident that the whole tenor of this remarkable work was in flagrant contradiction with the edict passed sixteen years before its publication, as well as with the author's personal pledge of conformity to it. The ironical submission with which it opened, and the assumed indetermination with which it closed, were hardly intended to mask the vigorous assertion of Copernican principles which formed its substance. It is a singular circumstance, however, that the argument upon which Galileo mainly relied as furnishing a physical demonstration of the truth of the new theory rested on a misconception. The ebb and flow of the tides, he asserted, were a visible effect of the terrestrial double movement, since they resulted from the inequality of the absolute velocities through space of the various parts of the earth's surface, produced by the motion of rotation. To this notion, which took its rise in a confusion of thought, he attached capital importance, and he treated with scorn Kepler's suggestion that a certain occult attraction of the moon was in some way concerned in the phenomenon. The theological censures which the book did not fail to incur were not slow in making themselves felt. Towards the end of August the sale was prohibited; on the 1st of October the author was cited to Rome by the Inquisition. He pleaded his age, now close upon seventy years, his infirm health, and the obstacles to travel caused by quarantine regulations; but the pope was sternly indignant at what he held to be his ingratitude and insubordination, and no excuse was admitted. At length, on the 13th of February, 1633, he arrived at the residence of Niccolini, the Tuscan ambassador to the pontifical court, and there abode in deep dejection for two months. From the 12th to the 30th of April he was detained in the palace of the Inquisition, where he occupied the apartments of the fiscal, and was treated with unexampled indulgence. On the 30th he was restored to the hospitality of Niccolini, his warm and generous partisan. The accusation against him was that he had written in contravention of the decree of 1616, and in defiance of the command of the Holy Office communicated to him by Cardinal Bellarmine; and his defence consisted mainly in a disavowal of his opinions, and an appeal to his good intentions. On the 21st of June he was finally examined under menace of torture; but he continued to maintain his assertion that, after its condemnation by the Congregation of the Index, he had never held the Copernican theory. Since the publication of the documents relating to this memorable trial, there can no longer be any doubt, not only that the threat of torture was not carried into execution, but that it was never intended that it should be. On the 22d of June, in the church of Santa Maria sopra Minerva, Galileo read his recantation, and received his sentence. He was condemned, as "vehemently suspected of heresy," to incarceration at the pleasure of the tribunal, and by way of penance was enjoined to recite once a week for three years the seven penitential psalms. This sentence was signed by seven cardinals, but did not receive the customary papal ratification. The legend according to which Galileo, rising from his knees after repeating the formula of abjuration, stamped on the ground, and exclaimed, "*E pur si muove!*" is, as may readily be supposed, entirely apocryphal. The earliest ascertained authority for it is the seventh edition of an *Historical Dictionary*, published at Caen in 1789. It seems probable that Galileo remained in the custody of the Inquisition from the 21st to the 24th of June, on which day he was relegated to the Villa Medici on the Trinità de' Monti. Thence, on the 6th of July, he was permitted to depart for Siena, where he spent several months in the house of the archbishop, Ascanio Piccolomini, one of his numerous and trusty friends. It was not until December that his earnest desire of returning to Florence was realized, and there, in the Villa Martellini at Arcetri, he spent the remaining eight years of his life in the strict retirement which was the prescribed condition of his comparative freedom.

Domestic afflictions combined with numerous and painful infirmities to embitter his old age. His sister-in-law and her whole family, who came to live with him on his return from Rome, perished shortly afterwards of the plague; and on the 1st of April, 1634, died, to the inexpressible grief of her father, his eldest and best-beloved daughter, a nun in the convent of San Matteo at Arcetri. Galileo was never married; but by a Venetian woman named Marina Gamba he had three children—a son who married and left descendants, and two daughters who took the veil at an early age. Notwithstanding this stain on the morality of his early life, which was in some degree compensated by the regularity of his subsequent conduct, Galileo's general character was one which commanded the respect of all who approached him. His prodigious mental activity continued undiminished to the last, nor were his latter years the least profitable to science of his long and eventful career. In 1636 he completed his *Dialoghi delle Nuove Scienze*, in which he recapitulated the results of his early experiments and mature meditations on the principles of mechanics. This, in many respects his most valuable work, was printed by the Elzevirs at Leyden in 1638, and excited admiration equally universal and more lasting than that accorded to his astronomical treatises. His last telescopic discovery—that of the moon's diurnal and monthly librations—was made in 1637, only a few months before his eyes were for ever closed in hopeless blindness. It was in this condition that Milton found him when he visited him at Arcetri in 1638. But the fire of his genius was not even yet extinct.

He continued his scientific correspondence with unbroken interest and undiminished logical acumen; he thought out the application of the pendulum to the regulation of clockwork, which Huygens successfully realized seventeen years later; and he was engaged in dictating to his disciples, Viviani and Torricelli, his latest ideas on the theory of impact when he was seized with the slow fever which in two months brought him to the grave. On the 8th January, 1642, he closed his long life of triumph and humiliation, and the coincidence of the day of his birth with that of Michelangelo's death was paralleled by the coincidence of the year of his death with that of the birth of Isaac Newton.

The direct services which Galileo rendered to astronomy are virtually summed up in his telescopic discoveries. To the theoretical perfection of the science he contributed little or nothing. He pointed out indeed that the so-called "third motion," introduced by Copernicus to account for the constant parallelism of the earth's axis, was a superfluous complication. But he substituted the equally unnecessary hypothesis of a magnetic attraction, and failed to perceive that the phenomenon to be explained was, in relation to absolute space, not a movement, but the absence of movement. The circumstance, however, which most seriously detracts from his scientific reputation is his neglect of the discoveries made during his life-time by the greatest of his contemporaries. Kepler's first and second laws were published in 1609, and his third ten years later. By these momentous inductions the geometrical theory of the solar system was perfected, and a hitherto unimagined symmetry was perceived to regulate the mutual relations of its members. But by Galileo they were passed over in silence. In his *Dialogo dei Massimi Sistemi*, printed not less than thirteen years after the last of the three laws had been given to the world, the epicycles by which Copernicus, adhering to the ancient postulate of uniform circular motion, had endeavored to reduce to theory the irregularities of the planetary movements, were neither expressly adopted nor expressly rejected; and, after exhausting all the apologies offered, the conclusion seems inevitable that this grave defection from the cause of progress had no other motive than the reluctance of the Florentine astronomer to accept discoveries which he had not originated,—this not through vulgar jealousy, of which he was incapable, but through a certain unconscious intellectual egotism, not always unknown to the greatest minds. His name, however, is justly associated with that vast extension of the bounds of the visible universe which has rendered modern astronomy the most sublime of sciences, and his telescopic observations are not less remarkable for the sagacity which directed, than for the inspiration which prompted them. With the sure instinct of genius, he seized the characteristic features of the phenomena presented to his attention, and his inferences, except when distorted by polemical exigencies, have been strikingly confirmed by modern investigations. Of his two capital errors, regarding respectively the theory of the tides and the nature of comets, the first was insidiously recommended to him by his passionate desire to find a physical confirmation of the earth's double motion; the second was adopted for the purpose of rebutting an ante-Copernican argument founded on the planetary analogies of those erratic subjects of the sun. Within two years of their first discovery, he had constructed approximately accurate tables of the revolutions of Jupiter's satellites, and he proposed their frequent eclipses as a means of determining longitudes, not only on land, but at sea. This method, on which he laid great stress, and for the facilitation of which he invented a binocular glass, and devised some skilful mechanical contrivances, was offered by him in 1616 to the Spanish Government, and afterwards to that of Tuscany, but in each case unsuccessfully; and the close of his life was occupied with prolonged but fruitless negotiations on the same subject with the states-general of Holland. The idea, though ingenious, has been found of little practical utility at sea, where the method founded on the observed distance of the moon from a known star is that usually employed.

A series of careful observations made him acquainted with the principal appearances revealed by modern instruments in the solar spots. He pointed out that they were limited to a certain defined zone on the sun's surface; he noted the *faculæ* with which they are associated, the penumbra by which they are bordered, their slight proper motions, and their rapid changes of form. He inferred from the regularity of their general movements the rotation of the sun on its axis in a period of little less than a month (the actual period is 25d. 7h. 48m.); and he grounded on the varying nature of the paths apparently traversed by them a plausible, though inconclusive argument, in favor of the earth's annual revolution. Twice in the year, he observed, they seem to travel across the solar disk in straight lines; at other times, in curves. These appearances he referred with great acuteness to the slight inclination of the sun's axis of rotation to the plane of the ecliptic. Thus, when the earth finds herself in the plane of the sun's equator, which occurs at two opposite points of her orbit, the spots, travelling in circles parallel with that plane, necessarily appear to describe right lines; but when the earth is above or below the equatorial level, the paths of the spots open out into curves turned downwards or upwards, according to the direction in which they are seen. The explanation, however, of this phenomenon is equally consistent with the geocentric as with the heliocentric theory of the solar system. The idea of a universal force of gravitation seems to have hovered around the borders of this great man's mind, without ever fully entering it. He perceived the analogy between the power which holds the moon in the neighborhood of the earth, and compels Jupiter's satellites to circulate round their primary, and the attraction exercised by the earth on bodies at its surface;[1] but he failed to conceive the combination of central force with initial velocity, and was disposed to connect the revolutions of the planets with the axial rotation of the sun. This notion, it is plain, tended rather towards Descartes's theory of vortices than towards Newton's theory of gravitation. More valid instances of the anticipation of modern discoveries may be found in his prevision that a small annual parallax would eventually be found for some of the fixed stars, and that extra-Saturnian planets would at some future time be ascertained to exist, and in his conviction that light travels with a measurable although, in relation to terrestrial distances, infinite velocity.

The invention of the microscope, attributed to Galileo by his first biographer, Vincenzo Viviani, does not in truth belong to him. Such an instrument was made as early as 1590 by Zacharias Jansen of Middleburg; and although Galileo discovered, in 1610, a means of adapting his telescope to the examination of minute objects, he did not become acquainted with the compound microscope until 1624, when he saw one of Drebbel's instruments in Rome, and, with characteristic ingenuity, immediately introduced some material improvements into its construction.

The most substantial, if not the most brilliant part of his work consisted undoubtedly in his contributions towards the establishment of mechanics as a science. Some valuable but isolated facts and theorems were previously discovered and proved, but it was he who first clearly grasped the idea of force as a mechanical agent, and extended to the external world the conception of the invariability of the relation between cause and effect. From the time of Archimedes there had existed a science of equilibrium, but the science of motion began to exist with Galileo. It is not too much to say that the final triumph of the Copernican system was due in larger measure to his labors in this department than to his direct arguments in its favor. The problem of the heavens is essentially a mechanical one; and without the mechanical conceptions of the dependence of motion upon force which Galileo familiarized to men's minds, that problem might have remained a sealed book even to the intelligence of Newton. The interdependence of motion and force was not indeed formulated into definite laws by Galileo, but his writings on dynamics are everywhere suggestive of those laws, and his solutions of dynamical problems involve their recognition. The extraordinary advances made by him in this branch of knowledge were owing to his happy method of applying mathematical analysis to physical problems. As a pure mathematician he was, it is true, surpassed in profundity by more than one among his pupils and contemporaries; and in the wider imaginative grasp of abstract geometrical principles he cannot be compared with Fermat, Descartes, or Pascal, to say nothing of Newton or Leibnitz. Still, even in the region of pure mathematics, his powerful and original mind left notable traces of its working. He studied the properties of the cycloid, and attempted the problem of its quadrature earlier than Mersenne; and in the "infinitesimals," which he was one of the first to introduce into geometrical demonstrations, was contained the fruitful germ of the differential calculus. But the method which was peculiarly his, and which still forms the open road to discoveries in natural science, consisted in the combination of experiment with calculation—in the transformation of the concrete into the abstract, and the assiduous comparison of results. The first fruits of the new system of investigation was his determination of the laws of falling bodies. Conceiving that the simplest principle is the most likely to be true, he assumed as a postulate that bodies falling freely towards the earth descend with a uniformly accelerated motion, and deduced thence the principal mathematical consequences, as that the velocities acquired are in the direct, and the spaces traversed in the duplicate ratio of the times, counted from the beginning of motion; finally, he proved, by observing the times of descent of bodies falling down long inclined planes, that the postulated law was the true law. Even here, he was obliged to take for granted that the velocities acquired in descending from the same height along planes of every inclination are equal; and it was not until shortly before his death that he found the mathematical demonstration of this not very obvious principle.

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[1] The passage is sufficiently remarkable to deserve quotation in the original:—"Le parti della Terra hanno tal propensione al centro di essa, che quando ella cangiasse luogo, le dette parti, benchè lontane dal globo nel tempo delle mutazioni di esso, lo seguirebbero per tutto; esempio di ciò sia il seguito perpetuo delle Medicee, ancorché separate continuamente da Giove. L'istesso si deve dire della Luna, obbligata a seguir la Terra."—*Diologo dei Massimi Sistemi*, Giornata terza, p. 351 of Albèri's edition.

The first law of motion—that which expresses the principle of inertia—is virtually contained in the idea of uniformly accelerated velocity. The recognition of the second—that of the independence of different motions—must be added to form the true theory of projectiles. This was done by Galileo. Up to his time it was universally held in the schools that the motion of a body must cease with the impulse communicated to it, but for the "reaction of the medium" which helps it forward. Galileo showed, on the contrary, that the nature of motion once impressed is to continue indefinitely in a uniform direction, and that the effect of the medium is a retarding, not an impelling one. Another commonly received axiom was that no body could be affected by more than one movement at one time, and it was thus supposed that a cannon ball, or other projectile, moves forward in a right line until its first impulse is exhausted, when it falls vertically to the ground. In the fourth of Galileo's dialogues on mechanics, he demonstrated that the path described by a projectile, being the result of the combination of a uniform transverse motion with a uniformly accelerated vertical motion, must, apart from the resistance of the air, be a parabola. The establishment of the principle of the composition of motions formed a conclusive answer to the most formidable of the arguments used against the rotation of the earth, and we find it accordingly triumphantly brought forward by Galileo in the second of his dialogues on the systems of the world. It was urged by anti-Copernicans that a body flung upwards or cast downwards would, if the earth were in motion, be left behind by the rapid translation of the point from which it started; Galileo, however, proved that the reception of a fresh impulse in no way interfered with the movement already impressed, and that the rotation of the earth was insensible, because shared equally by all bodies at its surface. His theory of the inclined plane, combined with his satisfactory definition of "momentum," led him towards the third law of motion. We find Newton's theorem, that "action and reaction are equal and opposite," stated with approximate precision in his treatise *Della Scienza Meccanica*, which contains the substance of lectures delivered during his professorship at Padua; and the same principle is involved in the axiom enunciated in the third of his mechanical dialogues, that "the propensity to fall of a body is equal to the least resistance which suffices to support it." The problems of percussion, however, did not receive a definitive solution until after his death.

His services were no less conspicuous in the statical than in the kinetical division of mechanics. He gave the first direct and entirely satisfactory demonstration of equilibrium on an inclined plane, reducing it to the lever by a sound and ingenious train of reasoning; while, by establishing the theory of "virtual velocities," he laid down the fundamental principle which, in the opinion of Lagrange, contains the general expression of the laws of equilibrium. He studied with attention the still obscure subjects of molecular cohesion, and little has been added to what he ascertained on the question of transverse strains and the strength of beams, brought by him for the first time within the scope of mechanical theory. In his *Discorso intorno alle cose che stanno su l'acqua*, published in 1612, he used the principle of virtual velocities to demonstrate the more important theorems of hydrostatics, deducing from it the equilibrium of fluid in a siphon, and proved against the Aristotelians that the floating of solid bodies in a liquid depends not upon their form, but upon their specific gravities relative to such liquid.

In order to form an adequate estimate of the stride made by Galileo in natural philosophy, it would be necessary to enumerate the confused and erroneous opinions prevailing on all such subjects in his time. His best eulogium, it has been truly said, consists in the fallacies which he exposed. The scholastic distinctions between corruptible and incorruptible substances, between absolute gravity and absolute levity, between natural and violent motions, if they did not wholly disappear from scientific phraseology, ceased thenceforward to hold the place of honor in the controversies of the learned. Discarding these obscure and misleading notions, Galileo taught that gravity and levity are relative terms, and that all bodies are heavy, even those which, like the air, are invisible; that motion is the result of force, instantaneous or continuous; that weight is a continuous force, attracting towards the centre of the earth; that, in a vacuum, all bodies would fall with equal velocities; that the "inertia of matter" implies the continuance of motion, as well as the permanence of rest; and that the substance of the heavenly bodies is equally "corruptible" with that of the earth. These simple elementary ideas were eminently capable of development and investigation, and were not only true, but the prelude to further truth; while those they superseded defied inquiry by their vagueness, and baffled it with their obscurity. Galileo was a man born in due time. He was superior to his contemporaries, but not isolated amongst them. He represented and intensified a growing tendency of the age in which he lived. It was beginning to be suspected that from Aristotle an appeal lay to nature, and some were found who no longer treated the *ipse dixit* of the Stagirite as the final authority in matters of science. A vigorous but ineffectual warfare had already been waged against the blind traditions of the schools by Ramus and Telesius, by Patricius and Campanella, and the revolution which Galileo completed had been prepared by his predecessors. Nevertheless, the task which he so effectually accomplished demanded the highest and rarest quality of genius. He struck out for himself the happy middle path between the *a priori* and the empirical systems, and exemplified with brilliant success the method by which experimental science has wrested from nature so many of her secrets. His mind was an eminently practical one. He concerned himself above all with what fell within the range of exact inquiry, and left to others the larger but less fruitful speculations which can never be brought to the direct test of experiment. Thus, while far-reaching but hasty generalizations have had their day and been forgotten, his work has proved permanent, because he made sure of its foundations. His keen intuition of truth, his vigor and yet sobriety of argument, his fertility of illustration and acuteness of sarcasm, made him irresistible to his antagonists; and the evanescent triumphs of successful controversy have been succeeded by the lasting applause of posterity.

The first complete edition of Galileo's writings was published at Florence (1842–1856), in 15 8vo vols., by the Società Editrice Fiorentina, under the able supervision of Signor Eugenio Albèri. Besides the works already enumerated, it contains the hitherto inedited *Sermones de Motu Gravium*, composed at Pisa between 1589 and 1591; his letters to his friends, with many of their replies, as well as several of the essays of his scientific opponents; his private comments on the *Orlando Furioso*, of which he was an enthusiastic admirer, and on the *Gerusalemme Liberata*, of which he was an equally persistent depreciator; some stanzas and sonnets of no great merit, together with the sketch of a comedy; finally, a reprint of Viviani's *Life*, with valuable notes and corrections. The original documents from the archives of the Inquisition, relating to the events of 1616 and 1633, recovered from Paris in 1846 by the efforts of Count Rossi, and now in the Vatican Library, were to a limited extent made public by Monsignor Marino-Marini in 1850, and more unreservedly by M. Henri de l'Épinois, in an essay entitled

"Galilée, son Procès, sa Condemnation," published in 1867 in the *Revue des Questions Historiques.* He was followed M. Karl von Gebler, who, in an able and exhaustive but somewhat prejudiced work, *Galileo Galilei und die Römische Curie* (Stuttgart, 1876), sought to impeach the authenticity of a document of prime importance in the trial of 1633. He has, however, been victoriously answered by Signor Domenico Berti, in *Il Processo originale di Galileo Galilei* (Rome, 1876), and by M. de l'Épinois; with *Les Pièces du Procès de Galilée* (Rome, Paris, 1877). The touching letters of Galileo's eldest daughter, Sister Maria Celeste, to her father were printed in 1864 by Professor Carlo Arduini, in a publication entitled *La Primogenita di Galileo Galilei.* See also M. Th. Henri Martin's excellent biography, *Galilée, les Droits de la Science et la Méthode des Sciences Physiques,* Paris, 1868; and the anonymous *Private Life of Galileo,* London, 1870. (A. M. C.)

GALITCH, or HALICZ, a town of Russia, at the head of a district in the government of Kostroma, 80 miles N. E. of Kostroma, in 57° 15′ N. lat. and 42° 56′ E. long., on the low south-eastern shore of Galitch Lake. Among its public buildings are a hospital, a poorhouse opened in 1855, about 15 churches, and a convent of the third class. The chief occupation of the inhabitants is the manufacture of leather and gloves; and the fisheries of the lake yield about 30,000 rubles per annum, and give employment to about 400 fishermen, whose rights are secured by ancient charters. At the annual fair a considerable trade is done in woollen and cotton goods, earthenware, and miscellaneous articles. In 1860 the population was 6536; but in the *St. Petersburg Calendar* for 1878 it is given at 5620.

GALL, FRANZ JOSEPH (1758–1828), anatomist, physiologist, and founder of phrenology, was born at Tiefenbrunn near Pforzheim, Baden, on the 9th of March, 1758. After completing the usual literary course at Baden and Bruchsal, he began the study of medicine under Hermann at Strasburg, whence, attracted by the names of Van Swieten and Stoll, he removed to Vienna in 1781. Having received his diploma, he began to practise as a physician there in 1785; but his energies were mainly devoted to the scientific investigation of problems which, even from boyhood, had been occupying his attention. At a comparatively early period he had formed a generalization which he believed to be a sound one, that in the human subject at least a powerful memory is invariably associated with prominent eyes; and further observation had enabled him, as he thought, also to define the external characteristics indicative of special talents for painting, music, and the mechanical arts. Following out these researches, he gradually reached the strong personal conviction, not only that the talents and dispositions of men are dependent upon the functions of the brain, but also that they may be inferred with perfect exactitude and precision from the external appearances of the skull. Gall's first appearance as an author was made in 1791, when he published the first two chapters of a (never completed) work entitled *Philosophisch-medicinische Untersuchungen über Natur u. Kunst im kranken u. gesunden Zustande des Menschen.* The first public notice of his inquiries in cranioscopy, however, was in the form of a familiar letter addressed to a friend, which appeared in Wieland's *Deutscher Mercur* in 1798; but two years before this Gall had commenced giving private courses of phrenological lectures in Vienna, where his doctrines soon attracted general attention, and met with increasing success until, in 1802, they were interdicted by the Government on the ground that they were dangerous to religion. This step on the part of the authorities had the effect of greatly stimulating public curiosity and increasing Gall's celebrity. In March, 1805, he finally left Vienna, in company with his friend and associate Spurzheim, and made a tour through Germany, in the course of which he lectured in Berlin, Dresden, Magdeburg, and several of the university towns. These expositions, which he knew how to make popular and attractive, were much resorted to by the public, and excited considerable controversy in the scientific world. He had almost reached the zenith of his fame when, in 1807, he repaired to Paris and established himself there as a medical practitioner, at the same time continuing his activity as a lecturer and writer. In 1808 appeared his *Introduction au cours de physiologie du cerveau,* which was followed in 1809 by the *Recherches sur le système nerveux en général, et sur celui du cerveau en particulier* (originally laid before the Institute of France in March, 1808), and in 1810 by the first instalment of the *Anatomie et Physiologie du système nerveux en général, et du cerveau en particulier, avec des observations sur la possibilité de reconnaître plusiers dispositions intellectuelles et morales de l'homme et des animaux par la configuration de leurs têtes.* The *Recherches,* and the first two volumes of the *Anatomie,* bear the conjoint names of Gall and Spurzheim. The latter work was completed in 1819, and appeared in a second edition of six 8vo volumes shortly afterwards (1822–25). In 1811 he replied to a charge of Spinozism or atheism, which had been strongly urged against him in certain quarters, by a treatise entitled *Des dispositions innées de l'âme et de l'esprit,* which he afterwards incorporated with his greater work. In 1819 he became a naturalized French subject, but his efforts two years afterwards to obtain admission to the Academy of Sciences, although supported by Geoffroy St. Hilaire, were unsuccessful. In 1823 he visited London with the intention of giving a series of phrenological lectures, but was disappointed of the reception he had anticipated, and speedily abandoned his plans. He continued to lecture and practise in Paris until the beginning of 1828, when he was disabled by an apoplectic seizure. His death took place at Montrouge near Paris, on the 22d of August, 1828. The *Anatomie* has been translated into English by Lewis (Boston, U.S., 1835).

GALLAND, ANTOINE (1646–1715), Orientalist and archæologist, the first European translator of the *Arabian Nights,* was born in 1646 at Rollot, in the department of Somme. The completion of his school education at Noyon was followed by a brief apprenticeship to a trade, from which, however, he soon escaped, to pursue his linguistic studies at Paris. After having been employed for some time in making a catalogue of the Oriental manuscripts at the Sorbonne, he was, in 1670, attached to the French embassy at Constantinople; and in 1673 he also accompanied his chief (De Nointel) to Syria and the Levant, where he availed himself of the opportunity to copy a great number of inscriptions, and also to sketch, in some cases even to remove, historical monuments. After a brief visit to France, where his collection of antiquities attracted some attention, Galland returned to the Levant in 1676; and in 1679 he undertook a third voyage, being commissioned by the French East India Company to collect for the cabinet of Colbert; on the expiry of this commission he was instructed by the Government to continue his researches, and had the title of "antiquary to the king" conferred upon him. During his prolonged residences abroad he acquired a thorough knowledge of the Arabic, Turkish, and Persian languages and literatures, which, on his final return to France, enabled him to render valuable assistance to Thevenot, the keeper of the royal library, and to D'Herbelot. After their deaths he lived for some time at Caen under the roof of Foucault the intendant, himself no mean archæologist; and there he began the publication (1704–17) of *Les Mille et Une Nuits,* a translation which excited immense interest during the time of its appearance, and which is still the standard French translation (last edition 1872). In 1701 Galland had been admitted into the Academy of Inscriptions, and in 1709 he was appointed to the chair of Arabic in the Collége de France. He continued to discharge the duties of this post until his death, which took place February 17, 1715.

Besides a number of meritorious archæological works, especially in the department of numismatics, he also published a compilation from the Arabic, Persian, and Turkish, entitled *Paroles remarquables, bons mots et maximes des Orientaux* (1694), and a translation from an Arabic manuscript, *De l'origine et du progrès du Caffé* (1699). The former of these works appeared in an English translation in 1795. His *Contes et Fables Indiennes de Bidpaï et de Lokman* was published after his death (1724). Among his numerous unpublished manuscripts are said to be included a translation of the Koran and a Turkish dictionary.

GALLARATE, a flourishing town of Italy, the head of a circle in the province of Milan, situated on the railway 23 miles N. W. of Milan at the junction of the line running N. to Varese. It has a technical school, and carries on the manufacture of cotton and linen. In the Middle Ages it is mentioned as Galaratum and Glareatum, and especially in the 10th century it appears to have been a strongly fortified and important place. Population in 1871, 7576.

GALLAS, or more correctly GALLA, a powerful race of eastern Africa, scattered over the wide region which extends for about 1000 miles from the interior of Abyssinia to the neighborhood of the river Sabacki, in 3° 12′ of S. latitude. Almost nothing has been definitely ascertained about the early homes and migrations of the race;

but it appears to have occupied the southern portion of its present territory for nearly four centuries at least. According to Ludolf and Bruce, the Galla invaders first crossed the Abyssinian frontiers in the year 1537. The Gallas of Gojam (a district along the northern side of the river Abai) tell how their savage forefathers came from the south-east from a country on the other side of a bahr (lake or river), and the Yedju and Raia Galla also point towards the east and commemorate the passage of a bahr. Among the southern Gallas tradition appears to be mainly concerned with the expulsion of the race from the country now occupied by the Somali. It is usually maintained that the Gallas are ethnographically of Semitic affinity, and find their nearest kinsmen in the Somali, the Dankali, and the Abyssinians; but M. Lejean is of opinion that they rather belong to the Aryan race, and this is so far supported by their physiological characteristics. One thing is certain, that they have nothing in common with the negro type; the "musculation" of the arms, thighs, and calves is altogether different, and they have none of the fetor developed by the negro skin; their frame is large and powerful, their complexion a very dark brown, their brow broad and lofty, their eyes deep-sunk and lively, and their features not unfrequently of a regular and finely-shaped description. Of the Semitic affinity of the language there is no question, and according to the usual classification it belongs to the same Semitico-Hamitic group as the Somali, the Saho, and the Dankali.[1]

The Gallas are for the most part still in the nomadic and pastoral stage; though, as we advance northwards into Abyssinia, we find them more and more assimilated to the settled and agricultural inhabitants of that kingdom. Among the southern tribes it is said that about 7 or 8 head of cattle are kept for every man, woman, and child; and among the northern tribes, as neither man nor woman ever thinks of going any distance on foot, the number of horses is very large. The ordinary food consists of flesh, blood, milk, butter, and honey, the last being considered of so much importance by the southern Gallas that a rude system of bee-keeping is in vogue, and the husband who fails to furnish his wife with a sufficient supply of honey may be excluded from all conjugal rights. This last fact is one of those which indicate the comparatively high position occupied by the Galla women, who, moreover, have the right, but rarely granted in a savage state of society, of refusing an unacceptable offer of marriage. In the south monogamy is the rule, but in the north the number of a man's wives is limited only by his wishes and his wealth. Each tribe has its own heiitch or sultan, who enjoys the strange privilege of being the only merchant for his people, but in all public concerns must take the advice of the fathers of families assembled in council. The greater proportion of the tribes are still pagan, worshipping a supreme god Waka, and the subordinate god and goddess Oglia and Atilia, whose favor is secured by sacrifices of oxen and sheep. With a strange liberality of sentiment, they say that at a certain time of the year Waka leaves them and goes to attend to the wants of their enemies the Somali, whom also he has created. Some tribes, and notably the Wollo-Galla, have been converted to Mahometanism, and very bigoted adherents of the prophet they are. In the north a kind of superficial Christianization has taken place, to the extent at least that the people are familiar with the names of Maremma or Mary, Balawold or Jesus, Girgis or St. George, etc.; but to all practical intents paganism is still in force. The serpent is a special object of worship, the northern Gallas believing that he is the author of the human race. A considerable number of the men find employment in the Abyssinian armies, and in comparison with their neighbors are brave and warlike. The total number of the Gallas was estimated by Krapf at from six to eight millions, and Plowden mentions individual tribes that could bring into the field 20,000 or 30,000 horse. Among the more important tribes in the south (the name in each instance being compounded with Galla) are the Ramatta, the Kukatta, the Baôle, the Aurova, the Wadjole, the Ilani, the Arrar, and the Kanigo Galla; the Borani, a very powerful tribe, may be considered to mark the division between north and south; and in the north we find the Amoro, the Jarso, the Toolama, the Wollo, the Ambassil, the Aijjo, and the Azobo Galla.

See Beke "On the Origin of the Gallas," in *Trans. of Brit. Assoc.*, 1847; Krapf, *Travels . . . in Eastern Africa*, 1860; D'Abbadie, *Douze Ans en Haute-Éthiopie*, 1868; Brenner, "Forschungen in Ost-Afrika," in Petermann's *Mittheilungen*, 1868; Plowden, *Travels in Abyssinia and the Galla Country*, 1868; and a paper by Louis Lande in *Revue des Deux Mondes*, 1878.

GALLATIN, ALBERT[2] (*copyright, 1879, by Henry Cabot Lodge*). Family pride led the Gallatins to boast a descent from A. Atilius Callatinus, the Roman consul (A. U. C. 494 and 498). A gap of fifteen hundred years between the consul and the first appearance of the name in European history tends to invalidate this rather splendid bit of genealogy, but there can be no doubt that the Gallatins were both an old and noble family. They are first heard of in Savoy in the year 1258, and more than two centuries later they came to Geneva (1510), united with Calvin in his opposition to Rome, and associated their fortunes with those of the little Swiss city. Here they remained, and with one or two other great families governed Geneva, and sent forth many representatives to seek their fortune and win distinction in the service of foreign princes, both as soldiers and ministers. On the eve of the French Revolution the Gallatins were still in Geneva, occupying the same position which they had held for two hundred years. They were republican nobles, simple in their manners, frugal and unostentatious in their habits of life, but genuine aristocrats of high breeding and cultivated minds. They numbered among their friends such widely different persons as Voltaire and the landgrave of Hesse, and, although not wealthy, had everything that could reasonably be desired both socially and politically.

Albert Gallatin, the most famous of the name, was born in Geneva on the 29th of January, 1761. His father died in 1765, his mother five years later, and his only sister in 1777. Although left an orphan at nine years old, Albert Gallatin was by no means lonely or unprotected. His grand-parents, a large circle of near relations, and Mlle. Pictet, an intimate friend, cared for him during his boyhood. He was thoroughly educated at the schools of Geneva, and graduated with honor from the college or academy in 1779. His grandmother then wished him to enter the army of the landgrave of Hesse, but he declined to serve "a tyrant," and a year later slipped away from Geneva and embarked for the United States. No man ever had less reason to emigrate. A competent fortune, good prospects, social position, and a strong family connection, were all thrown aside in order to tempt fate in the New World. His relations very properly opposed his course, but they nevertheless did all in their power to smooth his way, and continued to treat him kindly, and he himself in after-life always admitted the justice of their opinions. The temper of the times, a vague discontent with the established order of things, and some political enthusiasm imbibed from the writings of Rousseau, are the best reasons that can now be assigned for Gallatin's ill-considered desertion of home and friends.

In July, 1780, Gallatin and his friend Serre landed in Massachusetts. They brought with them youth, hope, courage, and a little money, and at once entered into business. The times were unfavorable. The great convulsion of the Revolution was drawing to a close, and everything was in an unsettled condition. The young Genevans failed in business, passed an aimless and severe winter in the wilds of Maine, and returned to Boston penniless. Gallatin tried to earn a living by teaching French in Harvard College, apparently not without success, but the cold and rigid civilization of New England repelled him, and he made his way to the South. In the backwoods of Pennsylvania and Virginia there seemed to be better chances for a young adventurer. Gallatin engaged in land speculations, and tried to lay the foundation of his fortune in a frontier farm. In 1789 he married Sophia Allegre, and every prospect seemed to be brightening. But clouds soon gathered again. After only a few months of wedlock his wife died, and Gallatin was once more alone. The solitary and desolate frontier life became now more dreary than ever; he flung himself into politics, the only outside resource open to him, and his long and eventful public career began.

The constitution of 1787 was then before the people, and Gallatin, with his dislike of strong government still upon him, threw himself into opposition and became one of the founders of the Anti-Federalist, or, as it was afterwards called, the Republican party. Elections followed to State conventions and legislatures, and Gallatin rose with surprising rapidity. Despite his foreign birth and his inability to speak English with correctness or fluency, he succeeded wonderfully. He was helped of course, by his sound education; but the true cause of his success lay in his strong sense, untiring industry, courage, clear-sightedness, and great intellectual force. In 1793 he was chosen United States Senator from Pennsylvania by the votes of both political parties. No higher tribute was ever paid to character and ability than that conveyed by this election. But although party feeling did not run high enough in Pennsylvania to prevent Gallatin's election, the staunch Federalists of the Senate, who had begun to draw the party lines rather sharply, found the presence of the young Genevan highly distasteful. They disliked his French origin, and suspected him to be a man of levelling principles. His seat was contested on account of a technical flaw in regard to the duration of his citizenship, and the Senate annulled the election and sent him back to Pennsylvania with all the glory of political martyrdom.

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[1] The similarity to the Semitic was pointed out by Benfey in *Götting. Gelehrte Anzeigen*, 1846, in a review of Tutschek's lexicon and grammar (1844, 1845). Further details in regard to its vocabulary and structure will be found in Lottner's paper in the *Transactions of the Philological Society*, London, 1860–61, and in the *Novara Reise*, 1867. Krapf had published a grammar as early as 1840.

[2] This is reprinted here, with the consent of Mr. Henry Cabot Lodge, of Massachusetts, from his work entitled *Albert Gallatin*, by Henry Cabot Lodge. New York, Charles Scribner's Sons, 1879. Copyright, 1879, by Henry Cabot Lodge.

The part he had already taken in the exciting scenes to which he now returned had without doubt been an efficient cause in his rejection by the Senate. The success of the new scheme of national government turned at the outset upon the re-establishment of sound finances. To carry out the great plans which he had set on foot, Hamilton had found it necessary to lay an excise on domestic spirits. This tax bore hardly upon the western counties of Pennsylvania, Virginia, and North Carolina, where the people worked many small stills, and were thus able to get their grain to market in a portable form. Strong opposition was manifested. Hamilton and his party modified the original excise law, and partly by their action, partly through the influence of Washington, the murmurs in the two Southern States died away. But in Pennsylvania concession proved fruitless, and hostility became daily more active and dangerous.

In this resistance to the excise, which was peculiarly odious to the people among whom he lived, Gallatin took a leading part. He intended fully to restrain opposition within legal bounds, but he made the great mistake of embarking upon the stormy sea of resistance to law without sufficiently allowing for the character of the population. The frontiersmen of the Alleghanies were a rough and sturdy race, with a large and unfortunate admixture of wild Irish. The law-abiding American spirit was by no means supreme. Legal resistance soon developed into insurrection. Houses were burned, revenue officers assaulted and driven from the country, and the United States mail was stopped and the letters seized by the rioters. The people began to arm and associate, thus preparing forcible resistance to the Government.

Gallatin did his best to retrieve his error and prevent open war. With fine courage he faced the excited bands of riflemen who gathered at Redstone Old Fort on the 20th of August, 1794, and opposed with vigorous eloquence the use of force against the Government. He checked the excitement sufficiently to prevent bloodshed; but he was only just in time. Washington and Hamilton had at last determined to test the strength of the new Government, and were moving with an overwhelming force upon the western counties. Gallatin had blundered in exciting and leading opposition to law among so rude a people, but he had also interposed with sufficient effect to stop desperate measures, and the whiskey rebellion faded away helplessly before the national power.

Of all the men who took part in this opposition to the excise, Gallatin alone came out with credit. He was at once elected to Congress, and took his seat as a member of the Lower House in the autumn of 1795. A foreigner, still young, and speaking English with a very defective pronunciation, he nevertheless by sheer force of ability and industry wrested from all competitors the leadership of the Republicans in the House, and almost at once became the most dangerous opponent whom the Federalists had ever encountered in Congress. That great party, by simple weight of ability, generally in a minority, and never in full sympathy with the mass of their countrymen, maintained their power unbroken for the first twelve years of the Government. They had established and organized that Government, and in so doing had borne down opposition with a high hand. They were as domineering as they were able, and inflamed with hatred of France, just then rising to the dignity of a party principle, they found in Gallatin an enemy who was both by origin and opinion peculiarly obnoxious to them. They attacked him unsparingly, but in vain. His perfect command of temper, and moderation of speech and action, in a bitterly personal age, never failed, and were his most effective weapons. But he made his power felt in other ways. His clear mind and industrious habits drew him to questions of finance. He became the financier of his party, and preached unceasingly his cardinal doctrines of simplicity and economy, and was an effective critic of the measures of Government. Cool and temperate, Gallatin, when following his own theories, was usually in the right, although accused by his followers of trimming. Thus, in regard to the Jay treaty, he defended the constitutional right of the House to consider the treaty, but he did not urge rejection in this specific case. On the other hand, when following a purely party policy, he generally erred. He resisted the navy, the mainspring of Washington's foreign policy and the chief glory of the Federalists. He opposed commercial treaties and diplomatic intercourse in a similar fashion. On all these points he was grievously wrong, and on all he changed his views after a good deal of bitter experience. The greatest period of Gallatin's career in Congress was in 1798, after the publication of the famous X.Y.Z. despatches. The insults of Talleyrand, and his shameless attempts to extort bribes from the American commissioners, roused the deep anger of the people against France. The Federalists swept all before them, and the members of the opposition either retired from Philadelphia or went over to the Government. Alone and single-handed, Gallatin carried on the fight in Congress. The Federalists bore down on him unmercifully, and even attempted a constitutional amendment in regard to citizenship, in order to drive him from office. Still he held on, making a national struggle in the national legislature, and relying very little upon the rights of States so eagerly grasped by Jefferson and Madison. But even then the tide was turning. The strong measures of the Federalists shocked the country; the leaders of the dominant party quarrelled fiercely among themselves; and the Republicans carried the elections of 1800.

Jefferson and Burr obtained an equal number of votes, and as the constitution then stood either was entitled to the presidency, although no one questioned that it had been intended for Jefferson. The election was thrown into the House, and the Federalists, maddened by defeat, strove to give the presidency to Burr. They fortunately failed, but it was Gallatin who led the Republicans, prevented rash measures, retained the sympathy of the country, and had a careful plan prepared for any emergency.

When, after this exciting contest, Jefferson took possession of the White House (1801), there were two men, and two only, whose commanding abilities marked them for the first places in the cabinet. James Madison became secretary of state, and Albert Gallatin secretary of the treasury. Wise, prudent, and conservative, Gallatin made few changes in Hamilton's arrangements, and for twelve years administered the national finances with the greatest skill. He and Jefferson were both imbued with the idea that government reduced to the lowest possible point could be carried on upon *a priori* principles resting on the assumed perfectness of human nature, and that, if this were done honestly, its authors would be implicitly trusted, and a political millennium would surely ensue. The chief burden of carrying out this theory fell upon Gallatin. His guiding principles still were simplicity of administration and speedy extinction of all debt, and everything bent to these objects. Fighting or bribing the Barbary pirates was a mere question of expense. It was cheaper to seize Louisiana than to await the settlement of doubtful points. Commercial warfare was to be avoided because of the cost. All wars were bad, but if they could not be evaded it was less extravagant to be ready than to rush to arms unprepared. Amid many difficulties, and thwarted even by Jefferson himself in the matter of the navy, Gallatin pushed on; and after six years the debt was as far as possible paid, a large surplus was on hand, a comprehensive and beneficent scheme of internal improvements was ready for execution, and the promised land seemed in sight. Then came the stress of war in Europe, a wretched neutrality at home, fierce outbreaks of human passions, and the fair structure of government by *a priori* theories based on the goodness of unoppressed humanity came to the ground. Gallatin was thrown helplessly back upon the rejected Federalist doctrine of government according to circumstances. He uttered no vain regrets, but the position was a trying one. The sworn foe of strong government, he was compelled, in pursuance of Jefferson's policy, to put into execution the embargo and the most stringent measures ever taken by an American legislature. He did his best, but all was in vain. Commercial warfare failed, the embargo was repealed, and Jefferson, having hopelessly entangled foreign relations and brought the country to the verge of civil war, retired to private life defeated and broken, and leaving to his successor Madison, and to Gallatin, the task of extricating the nation from its difficulties. From 1809 the new administration, drifting steadily towards war, struggled on from one abortive and exasperating negotiation to another. It was a period of sore trial to Gallatin. The peace policy had failed, and nothing else replaced it. He had lost his hold upon Pennsylvania and his support in the House, while a cabal in the Senate, bitterly and personally hostile to the treasury, crippled the administration and reduced every Government measure to mere inanity. At last, however, one of their blundering acts struck Napoleon in a vital spot. To escape its effects he set himself to hoodwink the administration and trick the United States into war with England. The deception was successful, and was powerfully aided by a war party, violent and ignorant, but with plenty of fresh ability, full of the new spirit of nationality, and determined to fight at all hazards. The result was inevitable, and Madison was forced to take the lead in June, 1812, in declaring war against England.

Gallatin never wasted time in futile complaints. His cherished schemes were shattered. War and extravagant expenditure had come, and he believed both to be fatal to the prosperity and progress of America. He therefore put the finances in the best order he could, and set himself to mitigate the evil effects of the war by obtaining an early peace. With this end in view he grasped eagerly at the proffered mediation of Russia, and without resigning the treasury sailed for Europe in May, 1813.

Russian mediation proved barren, but Gallatin persevered, catching at every opportunity for negotiation. In the midst of his labors came the news that his old foes in the Senate had refused to confirm his appointment. He still toiled on unofficially until, Madison having filled the treasury, his nomination for the second time met the approval of the Senate, and he was able to proceed with direct negotiations. The English and American commissioners finally met at Ghent, and in the tedious and irritating discussions which ensued Gallatin took the leading part. He dealt easily with his antagonists, who were all second-rate and obstinate persons, and drove them by quiet persistence and firmness from their first arrogant and impossible demands. His great difficulty lay in managing his own colleagues, who were, especially Henry Clay and John Quincy Adams, able men of strong wills and jarring tempers. He succeeded in preserving harmony, and thus established his own reputation as an able diplomat. Peace was his reward, and, after visiting Geneva for the first time since his boyhood, and negotiating a commercial convention with England, Gallatin returned to America.

He received an immediate offer of the treasury, which he declined, but accepted the mission to France (1816), where he remained for the next seven years, which were in all probability the pleasantest of his life. He passed his time in thoroughly congenial society, seeing everybody of note or merit in Europe. He did not neglect the duties of his official position, but strove assiduously and with his wonted patience to settle the commercial relations of his adopted country with the nations of Europe.

In 1823 he resigned his post and returned to the United States, when he found himself plunged at once in the bitter struggle then in progress for the presidency. His favorite candidate was his personal friend William H. Crawford, whom he regarded as the true heir and representative of the old Jeffersonian principles. With these feelings he consented to run for the vice-presidency on the Crawford ticket. But Gallatin had come home to new scenes and new actors, and he did not fully appreciate the situation. The contest was bitter, personal, factious, and full of intrigue. Van Buren, then in the Crawford interest, came to the conclusion that the candidate for the second place, by his foreign origin, weakened the ticket, and Gallatin therefore withdrew his name and retired from the contest without reluctance. The election, undecided by the popular vote, was thrown into the house, and resulted in the choice of J. Quincy Adams, who in 1826 drew Gallatin from his retirement and sent him as minister to England to conduct another complicated and arduous negotiation with that power. Gallatin worked at his new task with his usual industry, tact, and patience, but the results were meagre, although an open breach was successfully avoided. In 1828 he once more returned to the United States, and bade farewell to public life.

Accepting a business position in New York which gave him a sufficient income, Gallatin turned his attention to the congenial pursuits of science and literature. In both fields he displayed great talent, and his book upon Indian languages laid the foundations of the ethnology of the American aborigines. He continued, of course, to interest himself in public affairs, although no longer an active participant, and in all financial questions, especially in regard to the bank charter, the resumption of specie payments, and the panic of 1837, he exerted a wide and beneficial influence. The rise of the slavery question touched him nearly. Gallatin had always been a consistent opponent of slavery, and in the early days of the government had boldly attacked that institution when unable to find a dozen men of any party to side with him. He felt keenly, therefore, the attempts of the South to extend the slave power and confirm its existence, and the remnant of his strength was devoted in his last days to writing and distributing two able pamphlets against the war with Mexico. Almost his last public act was a speech against the annexation of Texas; and, although more than eighty years old, he confronted a howling New York mob with the same cool, unflinching courage which he had displayed half a century before when he faced the armed frontiersmen of Redstone Old Fort.

During the winter of 1848–9 his health failed, and on the 12th of August, 1848, he passed peacefully away.

Gallatin was twice married. His second wife was Miss Hannah Nicholson, of New York, by whom he had three children, two sons and a daughter, all of whom survived him. In personal appearance he was above middle height, with strongly-marked features, indicating great strength of intellect and character. He was reserved and extremely reticent, cold in manner and not sympathetic. There was, too, a certain Calvinistic austerity about him, but he was much beloved by his family. He was never a popular man, nor did he ever have a strong personal following, or many attached friends. He stood with Jefferson and Madison at the head of his party, and won his place by force of character, courage, application, and great intellectual power. His eminent and manifold services to his adopted country, his great abilities and upright character, assure him a high position in the history of the United States.

GALLE, or Point de Galle, a town and port in the southern province of Ceylon, on the south-western coast, about 72 miles S. of Colombo, with which it is connected by a good carriage road. It was made a municipality in 1865, and divided into the five districts of the Fort, Callowelle, Galopiadde, Hirimbure, and Cumbalwalla. The fort, which is more than a mile in circumference, commands the whole harbor, but is commanded by a range of hills. Within its enclosure are not only several Government buildings, but an old church erected by the Dutch East India Company, a mosque, a Wesleyan chapel, a hospital, and a considerable number of houses occupied by Europeans. The old Dutch building known as the queen's house or governor's residence, which dated from the year 1687, was in such a dilapidated state that it was sold by Governor Gregory in 1873. Elsewhere there are few buildings of individual note, but the general style of domestic architecture is pleasant and comfortable, though not pretentious. One of the most delightful features of the place is the profusion of trees, even within the town, and along the edge of the shore—suriyas, palms, cocoa-nut trees, and bread-fruit trees. The ramparts towards the sea furnish fine promenades. In the harbor deep water is found close to the shore, and the outer roads are spacious; but the south-west monsoon renders entrance difficult, and not unfrequently drives vessels from their moorings. Galle is an important point on the lines of communication between Calcutta and Australia, and between Suez and Singapore. The Peninsular and Oriental Steam Navigation Company, the *Messageries Maritimes*, and the British India Steam Navigation Company have agencies at the port. The trade is mainly in the productions of the surrounding country, of which in 1873 there was shipped 11,477 cwts. of cocoa-nut oil, 10,083 cwts. of cinnamon, 23,377 cwts. of plumbago, and 22,932 cwts of coir. Cotton goods are the principal import, 143,410 pieces being the amount for 1873. The inhabitants of Galle are of very mingled origin, comprising not only Singhalese European residents and Eurasian half-castes, who are locally denominated "Burghers" as being mainly the descendants of the old Dutch settlers, but also "Moors" or "Moormen" (that is, Arabians or semi-Arabians), Hindus, Parsees, people from the Coromandel coast, and Maldivians. The Moors are largely engaged as lapidaries and workers in tortoise-shell; and the urgency of the itinerant vendors is one of the inevitable plagues of the European visitor to the town. According to the returns of 1871, the total population of the municipality was 47,059, distributed in 8979 families, occupying 7496 houses, and consisting of 24,294 males and 22,765 females.

Galle, according to Sir J. E. Tennent, is the Tarshish of Solomon; but of this opinion there is no proof, even if it were certain that the Jewish fleets visited the island of Ceylon at all. The place is mentioned by none of the Greek or Latin geographers, unless the identification with Ptolemy's Avium Promontorium or Cape of Birds be a correct one. It is hardly mentioned in the native chronicles before 1267, and Ibn Batuta, in the middle of the 14th century, distinctly states that Kali —that is, Galle—was a *small* town. It was not till the period of Portuguese occupation that it rose to importance. When the Dutch succeeded the Portuguese they greatly strengthened the fortifications, which had been vigorously defended against their admiral, Kosten; and under their rule the place had the rank of a commandancy. In the marriage treaty of the infanta of Portugal with Charles II. of England it was agreed that if the Portuguese recovered Ceylon they were to hand over Galle to the English; but as the Portuguese did not recover Ceylon, the town was left to fall into English hands at the conquest of the island in 1796. The name Galle is derived from the Singhalese *galla*, equivalent to rock; but the Portuguese and Dutch settlers, being better fighters than philologists, connected it with the Latin *gallus*, a cock, and the image of a cock was carved as a symbol of the town in the front of the old Government house.

GALLIC ACID, trioxybenzoic acid, or dioxysalicylic acid, $C_7H_6O_5+H_2O$ or $C_6H_2(OH)_3.CO(OH)+H_2O$, the *acidum gallicum* of pharmacy, is a substance discovered by Scheele, which exists as such in the leaves of the bearberry, in pomegranate root-bark, and in tea, in gall-nuts to the extent of about 3 per cent., and in other vegetable productions. It may be prepared by keeping moist and exposed to the air for from four to six weeks, at a temperature of 20° to 25° C., a paste of powdered gall-nuts and water, and removing from time to time the mould which forms on its surface; the paste is then boiled with water for twenty minutes to obtain a solution of the gallic acid; this is filtered through calico, and the deposit of acid it affords on cooling is drained by pressure between folds of bibulous paper, and purified by dissolving in boiling water, by recrystallization at about 27° C., and washing of the crystals with ice-cold water. The production of the acid appears to be due to the presence in the galls of a ferment. This is not contained in Chinese gall-nuts, which consequently require the addition of yeast or of common galls to determine the decomposition of their tannin necessary for the formation of gallic acid (see C. H. Viedt, *Dingler's Polyt. Journ.*, ccxvi., 1875, p. 454). Powdered gall-nuts, containing 43 per cent. of tannic acid, were found by M. Sace to yield 50·4 per cent. of pure dry gallic acid (*Compt. Rend.*, lxxii., 1871, p. 766). Gallic acid is most readily obtained by boiling with weak solution of acids the tannin procured from oak-galls by means of alcohol and ether. The changes which take place in this, as in the first described mode of preparation, apparently consist in the splitting up of tannin, or gallo-tannic acid, which, according to some experiments, is a glucoside of tannic acid, of the formula $C_{34}H_{28}O_{22}$, to give with two molecules of water two molecules of digallic [illegible] tannic acid, $C_{14}H_{10}O_9$, and glucose, $C_6H_{12}O_6$. The former [illegible]y, which may be represented as an etheric anhydride [illegible] gallic acid, $C_6H_2(OH)_2.CO(OH).O.CO.(OH)_3C_6H_2$, by the assimilation of a molecule of water is then converted into two molecules of gallic acid (see Armstrong, *Organic Chemistry*, p. 304, 1874). Gallic acid may be produced by heating an aqueous solution of diiodosalicylic acid with excess of alkaline carbonate, by acting on dibromosalicylic acid with moist silver oxide, and by other chemical methods. It crystallizes in white or pale fawn-colored acicular prisms or silky needles, and is soluble in alcohol and ether, and in 100 parts of cold, and 3 of boiling water, is without odor, and has an astringent, acidulous taste, and an acid reaction. Dried at 100° C. it loses 9·5 per cent. of its weight of water; at about 200° C. it melts; and at 210 to 215° it is resolved into carbon dioxide and pyrogallol, $C_6H_3(OH)_3$. With ferric salts its solution gives a deep blue color, and with ferrous salts, after exposure to the air, an insoluble, blue-black, ferroso-ferric gallate. Bases of the alkali metals give with it four series of salts; these are stable except in alkaline solutions, in which they absorb oxygen and turn brown. Solution of acid calcium carbonate becomes with gallic acid, on exposure to the air, of a dark blue color. Unlike tannic acid, gallic acid does not precipitate albumen or salts of the alkaloids, or, except when mixed with gum, gelatin. Salts of gold and silver are reduced by it, slowly in cold, instantaneously in warm solutions, hence its employment in photography. With phosphorus oxychloride at 120° C. gallic acid yields tannic acid, and with concentrated sulphuric acid at 100°, *rufigallic acid*, $C_{14}H_8O_8$. Phosphorus perchloride, and also, after several hours, solution of arsenic acid near the boiling point (J. Löwe, quoted *Chem. News*, xix., 1869, p. 41), convert it into *ellagic acid*, $C_{14}H_8O_9 - H_2O$, a substance which occurs in gall-nuts, in the external membrane of the episperm of the walnut (T. L. Phipson, *Chem. News*, xx. p. 116), and probably many plants, and composes the "bezoar stones" found in the intestines of Persian wild goats. Gallic acid may be estimated, after removal of tannic acid by gelatin, by means of permanganate of potassium, with which it evolves carbon dioxide, and (F. Jean, *Compt. Rend.*, lxxxii., 1876, pp. 982–4) by means of iodine in the presence of an alkaline carbonate.

Gallic acid has been advantageously employed as an internal medicinal agent in scarlatinal albuminuria, in which its effect appears to be due to an astringent and tonic action on the inflamed capillaries of the kidneys;[1] in other forms of albuminuria;[2] in cases of chyluria, in which, as not causing nausea and headache, it is preferable to tannic acid;[3] and in pyrosis, diarrhœa, some forms of dysentery, and tabes and rickets, and atonic states of the alimentary canal and of the body generally. In checking the night-sweats of phthisis it has been found of especial service.[4] As a hæmostatic, when administered internally, it has proved of value in hæmatemesis, epistaxis, fungus hæmatodes,[5] menorrhagia,[6] and more particularly in hæmaturia. Gallic acid has been highly recommended in hæmoptysis,[7] in which, however, ergot, from its not occasioning griping and constipation, or interfering with a liberal use of milk, has been found a better remedy.[8] It may be given in considerable quantities without any evil consequences. The effects of too large a dose are to render the pulse hard and wiry, and to produce pallor, a whizzing sound in the ears, dizziness, and faintness. Its administration in a case of Bright's disease described by Dr. Bence Jones was followed by epilepsy (see *Med. Times*, 1853, ii. 495). As a topical styptic application, gallic is inferior to tannic acid.[9] With glycerin it is combined to form the pharmaceutical preparation *glycerinum acidi gallici*.

GALLIENUS, P. LICINIUS (218-268), Roman emperor, son of the emperor Valerian, was born about 218. From 253 to 260 he reigned conjointly with his father, and gave proof of both bravery and ability, especially in the defeat near Milan of 300,000 Alemanni, with a force of only 10,000 Romans. When, however, his father was defeated and taken prisoner by Sapor, king of Persia, in 260, Gallienus made no effort to obtain his release, or to withstand the incursions of the invaders who threatened the empire from all sides. He occupied part of his time in dabbling in literature, science, and various trifling arts, but gave himself up chiefly to excess and debauchery. His generals rebelled against him in almost every province of the empire, and this period of Roman history came to be called the reign of the thirty tyrants, although in reality the usurpers numbered only nineteen. Gallienus was killed at Milan in 268 while besieging Aureolus, who had been proclaimed emperor by the Illyrian legions.

GALLINULE. See MOORHEN.

GALLIO, JUNIUS ANNÆUS, proconsul or "deputy" of Achaia at the time of the apostle Paul's first visit to Corinth (53 A. D.), was the son of M. Annæus Seneca, a Roman eques and rhetorician, and was born at Cordova about the beginning of the Christian era. His mother's name was Helvia; and L. Annæus Seneca, the philosopher, and L. Annæus Mela, the geographer, were his full brothers, his own proper name being Marcus Annæus Novatus. After he had received a careful education from his father at Cordova, he went to Rome, where he attracted the notice of L. Junius Gallio, a rhetorician of some repute, who ultimately adopted him, thus conferring the name by which he is usually known. The terms on which he lived with his kindred and with the world are well illustrated in the epithet "dulcis" applied to him by Statius (*Silv.*, ii. 7, 32), and by Seneca (*Nat. Qu.*, 4 pref.—"nemo mortalium uni tam dulcis est quam hic omnibus"). It is probable that Gallio shared the misfortunes of his brother when the latter, having incurred the enmity of Messalina, was banished to Corsica; and that both returned together to Rome when Agrippina had selected Seneca to be tutor to Nero. Towards the close of the reign of Claudius, Gallio received the proconsulship of the newly constituted senatorial province of Achaia (Acts xviii. 12), but seems to have been compelled by ill health to resign the post within a few years (Pliny, *H. N.* xxxi. 33; Seneca, *Ep.* civ.). In the fifth year of Nero we hear of him as having been again in Rome (Dio Cassius, lxi. 20, 21), and on the same authority we learn that he finally became one of the last victims of that emperor (lxii. 25). The statement of Jerome in the chronicle of Eusebius, that Junius Gallio "frater Senecæ, egregius declamator, propria se manu interfecit," appears to be founded on a confusion of names. Seneca's works, *De Ira* and *De Vita Beata*, are dedicated to Gallio, who himself appears to have written some treatises in natural history (Sen., *N. Q.*, v. 11). Compare Tacitus, *Ann.*, xv. 73; xvi. 17; Dio Cassius, lx. 35.

GALLIPOLI, the ancient Καλλίπολις, a seaport town of Turkey in Europe, in the province of Rumili and vilayet of Edirneh, at the north-east extremity of the Straits of Dardanelles, on a narrow peninsula 130 miles S. W. of Constantinople, and 90 miles due S. of Adrianople, in 40° 24′ N. lat. and 26° 40′ 30″ E. long. Nearly opposite is Lapsaki on the Asiatic side of the channel, which is here about 2 miles wide. The town of Gallipoli presents a miserable aspect; the streets are narrow, the houses mostly of wood and ill built, though there are a few better structures near the harbor, and the Anglo-French occupation of 1853–6 led to some improvements. The only noteworthy buildings are the large, crowded, and well-furnished bazaars, with leaden domes. There are several mosques, none of them remarkable, and many interesting Roman and Byzantine remains, especially a magazine of the emperor Justinian, a square castle and tower attributed to Bajazet I., and some tumuli on the south said to be the tombs of the Thracian kings. The lighthouse, built on a cliff, has a fine appearance as seen from the Dardanelles. Gallipoli is the residence of a captain-pasha and the seat of a Greek bishop. It has two good harbors, and is the principal station for the Turkish fleet. From its position as the key of the Dardanelles, it was occupied by the allied French and English armies in 1854. Then the isthmus a few miles to the north of the town, between it and Boulair, was fortified with strong earthworks by English and French engineers, mainly on the lines of the old works constructed in 1357, when the Turks first crossed over into Europe, nearly 100 years before they gained possession of Constantinople. These fortifications were renewed and enlarged in January, 1878, on the Russians threatening to take possession of Constantinople. The peninsula thus isolated by the fortified positions has the Gulf of Saros on the N. W., and extends some 50 miles to the S. W. The guns of Gallipoli command the Dardanelles just before the strait joins the Sea of Marmora. The town itself is not very strongly fortified, the principal fortifications being further down the Dardanelles, where the passage is narrower. The District of Gallipoli is exceedingly fertile and well adapted for agriculture; a great variety of crops are raised, but, previous to the war of 1877–8, nearly all progress was stopped on account of the maladministration of the Turkish authorities. Nevertheless considerable quantities of the various cereals were exported, besides wine, oil, skins, cotton, sheep, etc., much of the trade being transit. The principal imports are manufactured goods, coal, sugar, coffee, rice, soap, iron. The line of railway between Adrianople and the Egean Sea has been prejudicial to the transit trade of Gallipoli, and several attempts have been made to obtain concessions for the construction of a railway that would connect this part with the Turkish railway system. There is little industry in Gallipoli, though previous to the war attempts had been made to extend and improve the manufacture of silk thread and silk goods, and some little business was done in the construction of coasting vessels. Steamers to and from Constantinople call regularly at Gallipoli. Widely different estimates have been given of the population of the town; it is probably somewhere about 25,000 or 30,000.

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[1] *Braithwaite's Retrospect*, lxxiii., 1876, 114.

[2] *Lancet*, 1878, ii. 580; *Med. Times*, 1853, ii. 55, and 1854, i. 594; according to Parkes (*ib.*, 1854, ii. pp. 28, 29), ferric chloride is superior to it as a means of reducing the albumen in nephritis.

[3] Bence Jones, *Med. Times*, 1852, ii. 653, and 1853, ii. 494.

[4] *Ib.*, 1854, i. 594; and *Brit. and For. Med.-Chir. Rev.*, 1862, i. 194.

[5] *Med. Times*, 1858, ii. 373.

[6] *Ib.*, 1862, i. 49; and *Lancet*, 1860, ii. 254.

[7] Williams, *Ranking's Abstracts*, 1862, i. 73; and Waters, *ib.*, 1871, i. 56.

[8] Williamson, *Lancet*, 1876, ii. 696.

[9] On the therapeutics of gallic acid see further R. Neale, "Clinical notes upon the use of gallic acid in various diseases," *Medical Times*, 1855, i. 458 *sq.*; and W. Bayes, "On Gallic Acid," *Association Medical Journal*, 1854, p. 506.

GALLIPOLI, an important seaport town of Italy, in the province of Lecce, and about 25 miles N. E. of the city of that name, beautifully situated on a rocky islet on the east shore of the Gulf of Taranto, and connected by a long stone bridge of twelve arches with the surburb of Lizza on the mainland. The town is well built and fortified, and has a castle erected by Charles I. of Anjou, a large cathedral, a gymnasium, and an episcopal seminary. It is chiefly noted for its extensive cisterns cut in the solid rock for containing the olive oil collected from all parts of Puglia; but it has besides a productive tunny fishery, and manufactures muslins, cotton stockings, and woollen goods. The harbor has been improved since 1855 by a new mole, but the entrance is still somewhat dangerous. In 1873 there entered 350 vessels, with a total tonnage of 66,652 tons, 281 being Italian and 29 British. The principal exports are oil (of which 9628 tons were shipped in 1875), wine, oats, and cotton seed; and the imports, fish from Norway, manufactured goods from France, petroleum from the United States, staves from Austria, and wheat and barley from Greece and Turkey. The population of the town in 1871 was 7578, and of the commune 9951. Gallipoli preserves the name and almost certainly occupies the site of the ancient Callipolis, the "Beautiful City," founded, according to Dionysius, by a Spartan named Leucippus and a number of the citizens of Tarentum.

GALLIUM, so called in honor of France (Gallia), symbol Ga, atomic weight 69·9, a metal discovered, August 27, 1875, by M. Lecoq de Boisbaudran, in the spectroscopic examination of zinc-blende from Pierrefitte in the valley of Argeles, Hautes-Pyrénées, and since found to exist in blende from several other localities, notably in that of the mines of Lüdrich and Apfel at Bensberg, on the Rhine, which contains nearly 16 milligrammes per kilogramme. Its density and approximate atomic weight, and other of its characters, were predicted by Mendeljeff, in accordance with his law that the properties of the elementary bodies, as also the constitution and properties of their combinations, are periodic functions of their atomic weights (see article CHEMISTRY, vol. v., p. 470, col. 2). Gallium may be prepared by a process the chief features of which are the treatment of the ore, which contains the metal in only very minute quantity, with zinc; the removal, from a hydrochloric acid solution of the gelatinous precipitate thereby produced, of various foreign metals by means of hydrogen sulphide; the fractionation of the residual liquid with sodium carbonate, gallium being thrown down before zinc by that reagent; the formation of a sulphate from the resultant precipitate; and, lastly, the electrolysis of a potash solution of the purified oxide obtained therefrom, the metal appearing on the negative platinum electrode. Solid gallium is grayish-white, of octahedral crystallization, and remarkably hard and resistant even at a temperature little below its melting point, and is but slightly malleable and flexible, though thin plates of it will bear bending several times without breaking. It melts when held in the fingers, its point of fusion being 30°·15 C. (86°·27 Fahr.). The liquid metal is of a silvery white color, and adheres to glass, forming a mirror resembling that of mercury. It exhibits in a remarkable degree the phenomenon of superfusion, but when some degrees below its melting point crystallizes immediately if a small fragment of the solid metal attached to a platinum wire be inserted into it. At 24°·5 C. (76°·1 Fahr.) the specific gravity of the solid metal is 5·956, and of the liquid 6·069; the specific heat of the former between 12° and 23° C. is 0·079, giving atomic heat 5·52, and that of the latter between 119° and 106° C. is 0·0802 (Berthelot, *Compt. Rend.*, lxxxvi., 786–7). At a red heat in air gallium is not perceptibly volatilized. It is little affected by cold nitric acid, but dissolves readily in hydrochloric acid; with potash solution it liberates hydrogen. It furnishes a deliquescent and very soluble chloride, $GaCl_3$ or Ga_2Cl_6, a corresponding bromide and iodide, and an ammonio-gallic alum. Its oxide is more soluble in ammonia than is alumina. In basicity it holds a place intermediate between aluminium and indium. It is precipitated by alkaline carbonates and barium carbonate, but not by hydrogen sulphide and ammonium sulphide in the absence of zinc. Gallium affords two brilliant lines in the violet part of the spectrum.

See L. de Boisbaudran, in *Chemical News*, 1877, i., pp. 148, 157, 167; also L. de Boisbaudran and E. Jungfleisch, *Compt. Rend.*, lxxxvi., pp. 475–478 and 577–579, and *Journ. Pharm. Chim.*, ser. 4, xxvii., pp. 338–340—quoted in *Phil. Mag.*, 1878, p. 319, and *Journ. Chem. Soc.*, "Abstracts," 1878, pp. 556 and 837.

GALLOWAY, THOMAS (1796–1851), a Scottish mathematician, was born at Symington, in the upper ward of Lanarkshire, 26th February, 1796. After receiving such education as the schools of his own and adjoining parishes could give, he entered in 1812 the university of Edinburgh, where he distinguished himself specially in mathematics. In 1823 he was appointed one of the teachers of mathematics at the military college of Sandhurst, and on the death of Sir John Leslie in 1832 he was an unsuccessful candidate for the vacant chair of natural philosophy in Edinburgh. In the following year he was appointed actuary to the Amicable Life Assurance Office, the oldest institution of that kind in London, and in this situation he remained till his death, November 1, 1851. Galloway was a voluminous though, for the most part, an anonymous writer, and took a leading part in the proceedings of the principal scientific societies of London. He contributed largely to the seventh edition of the *Encyclopædia Britannica*, and also wrote several scientific papers for the *Edinburgh* and *Foreign Quarterly Reviews*. His *Encyclopædia* article "Probability" was published separately.

GALLS. In animals galls occur mostly on or under the skin of living mammals and birds, and are produced by

Acaridea, and by dipterous insects of the genus *Œstrus.* Signor Moriggia[1] has described and figured a horny excrescence, nearly 8 inches in length, from the back of the human hand, which was caused by *Acarus domesticus.* What are commonly known as galls are vegetable deformities or excrescences, due to parenchymatous hypertrophy, and, according to the definition of Lacaze-Duthiers, comprise "all abnormal vegetable productions developed on plants by the action of animals, more particularly by insects, whatever may be their form, bulk, or situation." For the larvæ of their makers the galls provide shelter and sustenance. The exciting cause of the hypertrophy, in the case of the typical galls, appears to be a minute quantity of some irritating fluid, or virus, secreted by the female insect, and deposited with her egg in the puncture made by her ovipositor in the cortical or foliaceous parts of plants. This virus causes the rapid enlargement and subdivision of the cells affected by it, so as to form the tissues of the gall. Oval or larval irritation also, without doubt, plays an important part in the formation of many galls. Though, as Lacaze-Duthiers remarks, a certain relation is necessary between the "stimulus" and the "supporter of the stimulus," as evidenced by the limitation in the majority of cases of each species of gall-insect to some one vegetable structure, still it must be the quality of the irritant of the tissues, rather than the specific peculiarities or the part of the plant affected, that principally determines the nature of the gall. Thus the characteristics of the currant-gall of *Spathegaster baccarum*, L., which occurs alike on the leaves and on the flower-stalks of the oak, are obviously due to the act of oviposition, and not to the functions of the parts producing it; the bright red galls of the saw-fly *Nematus gallicola* are found on four different species of willow, *Salix fragilis, S. alba, S. caprea,* and *S. cinerea ;*[2] and the galls of a Cynipid, *Biorhiza aptera*, usually developed on the rootlets of the oak, have been procured also from the deodar.[3] Often the gall bears no visible resemblance to the structures out of which it is developed; commonly, however, outside the larval chamber, or gall proper, and giving to the gall its distinctive form, are to be detected certain more or less modified special organs of the plant. The gall of *Cecidomyia strobilina*, formed from willow-buds, is mainly a rosette of leaves the stalks of which have had their growth arrested. The small, smooth, seed-shaped gall of the American *Cynips seminator*, Harris, according to Mr. W. F. Bassett,[4] is the petiole, and its terminal tuft of woolly hairs the enormously developed pubescence of the young oak-leaf. The moss-like covering of the "bedeguars" of the wild rose, the galls of a Cynipid, *Rhodites rosæ*, represents leaves which have been developed with scarcely any parenchyma between their fibro-vascular bundles; and the "artichoke-galls" or "oak-strobile," produced by *Aphilothrix gemmæ*, L., which insect arrests the development of the acorn, consist of a cupule to which more or less modified leaf-scales are attached, with a peduncular, oviform, inner gall.[5] Mr. E. Newman held the view that many oak galls are pseudobalani, or false acorns: "to produce an acorn has been the intention of the oak, but the gall-fly has frustrated the attempt." Their formation from buds which normally would have yielded leaves and shoots is explained by Parfitt as the outcome of an effort at fructification induced by oviposition, such as has been found to result in several plants from injury by insect-agency or otherwise.[6] Galls vary remarkably in size and shape according to the species of their makers. The polythalamous gall of *Aphilothrix radicis*, found on the roots of old oak-trees, may attain the size of a man's fist; the galls of another Cynipid, *Andricus occultus*, Tschek,[7] which occurs on the male flowers of *Quercus sessiliflora*, is 2 millimetres, or barely a line, in length. Many galls are brightly colored, as, for instance, the oak-leaf hairy galls of *Spathegaster tricolor*, which are of a crimson hue, more or less diffused according to exposure to light. The variety of forms of galls is very great. Some are like urns or cups, others lenticular. The "knoppern" galls of *Cynips polycera*, Gir., are cones having the broad, slightly convex, upper surface surrounded with a toothed ridge. Of the Ceylonese galls "some are as symmetrical as a composite flower when in bud, others smooth and spherical like a berry; some protected by long spines, others clothed with a yellow wool formed of long cellular hairs, others with regularly tufted hairs."[8] The characters of galls are constant, and as a rule exceedingly diagnostic, even when, as in the case of ten different gall-gnats of an American willow, *Salix humilis*, it is difficult or impossible to tell the full-grown insects that produce them from one another. In degree of complexity of internal structure galls differ considerably. Some are monothalamous, and contain but one larva of the gall-maker, whilst others are many-celled, and numerously inhabited. The largest class are the unilocular, or simple, external galls, divided by Lacaze-Duthiers into those with and those without a superficial protective layer or rind, and composed of hard, or spongy, or cellular tissue. In a common gall-nut that authority distinguished seven constituent portions:—an epidermis; a subdermic cellular tissue; a spongy and a hard layer, composing the parenchyma proper; vessels which, without forming a complete investment, underlie the parenchyma; a hard protective layer; and lastly, within that, an alimentary central mass inhabited by the growing larva.[9]

Galls are formed by insects of several orders. Among the Hymenoptera are the gall-wasps (*Cynips* and its allies), which infect the various species of oak. They are small insects, having straight antennæ, and a compressed, usually very short abdomen, with the second, or second and third segments greatly developed, and the rest imbricated, and concealing the partially coiled ovipositor. The transformations from the larval state are completed within the gall, out of which the imago, or perfect insect, tunnels its way,—usually in Autumn, though sometimes, as has been observed of some individuals of *Cynips Kollari*, after hibernation.

The phenomena of development in *Cynips* and associated genera present many features of interest. Not fewer than 12,000 living specimens of *C. Kollari*, Gir. (*C. lignicola*, Hart.), from Devonshire galls, were examined by the late Mr. Frederick Smith,[10] of the British Museum, and proved to be all females, as also were the flies obtained in two successive years from some of these by breeding on isolated oak trees in the neighborhood of London. The same observer detected among about 1200 flies of the gregarious species *Aphilothrix* (*Cynips*) *radicis* not a single male. In many thousands of Cynipids, representing 28 species, Hartig failed to discover any male. Von Schlectendal, on the other hand, between 24th April and 1st May, 1871, from three galls of *Rhodites rosæ*, L., obtained in the previous year, bred only 2 females and 32 males. These males were of the normal coloration and shape; but some which appeared in the latter part of May, when the females were in larger numerical proportion, were varieties of three kinds, partly resembling the females in coloration.[11] Walsh[12] ascertained with respect to the galls of the American Black Oak, that their growth commences in May, and is completed in a few weeks, and that near the middle of June about a fourth of them yield both male and female fully developed gall-flies of the species *Cynips spongifica*, Osten Sacken. In the remainder of the galls the larvæ do not attain their pupal condition till more than two months later, and the flies they produce, which appear about October, are all females. This autumnal brood has been experimentally ascertained to cause the generation of oak-apples in the following spring on trees not previously infected. Mr. W. F. Bassett[13] considers that most, if not all, species of *Cynips* are double-brooded, and that one of the two broods consists of females only. "There are," he remarks, "so many one-gendered species, that we may reasonably suppose each to be the progenitor of the equally numerous double-gendered species, whose relationships have not yet been observed."

Among the commoner of the galls of the *Cynipidæ* are the "oak-apple" or "oak-sponge" of *Andricus terminalis*, Fab.; the "currant" or "berry galls" of *Spathegaster baccarum*, L., above mentioned; and the "oak-spangles" of *Neuroterus lenticularis*,[14] Oliv., generally reputed to be fungoid growths, until the discovery of their true nature by Mr. Frederick Smith;[15] and the succulent "cherry-galls" of *Dryophanta scutellaris*, Oliv. The "marble" or "Devonshire woody galls" of oak-buds, which often destroy the leading shoots of young trees, are produced by *Cynips Kollari*,[1] already alluded to. They were first introduced into Devonshire about the year 1847, had become common near Birmingham by 1866, and two or three years later were observed in several parts of Scotland.[2] They contain about 17 per cent. of tannin.[3] On account of their regular form they have been used, threaded on wire, for making ornamental baskets. The large purplish Mecca or Bussorah galls,[4] produced on a species of oak by *Cynips insana*, Westw., have been regarded by many writers as the Dead Sea fruit, mad-apples (*mala insana*), or apples of Sodom (*poma sodomitica*), alluded to by Josephus and others, which, however, are stated by E. Robinson (*Bibl. Researches in Palestine*, vol. i. pp. 522–4, 3d ed., 1867) to be the singular fruit called by the Arabs, *'Ösher*, produced by the *Asclepias gigantea* or *procera* of botanists. What in California are known as "flea seeds" are oak-galls made by a species of *Cynips*; in August they become detached from the leaves that bear them, and are caused to jump by the spasmodic movements of the grub within the thin-walled gall-cavity.[5]

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[1] Quoted in *Zoological Record*, iv., 1867, p. 192.

[2] P. Cameron, *Scottish Naturalist*, ii., pp. 11–15.

[3] *Entomologist*, vii., p. 47.

[4] See in *Proc. Entom. Soc. of London for the year 1873*, p. xvi.

[5] See A. Müller, *Gardener's Chronicle*, 1871, pp. 1162 and 1518; and E. A. Fitch, *Entomologist*, xi., p. 129.

[6] *Entomologist*, vi., pp. 275–8, 339–40.

[7] *Verhandl. d. zoolog.-bot. Ges. in Wien*, xxi., p. 799.

[8] Darwin, *Variations of Animals and Plants under Domestication*, ii., p. 282.

[9] "Recherches pour servir à l'Histoire des Galles," *Ann. des Sci. Nat.*, xix., pp. 293 *sqq.*

[10] *Zoologist*, xix., 1861, pp. 7330–3.

[11] *Jahresber. des Vereins f. Naturk. zu Zwickau*, 1871.

[12] *American Entomologist*, i., 1868, p. 103.

[13] *Proc. Entom. Soc. of London for the year 1873*, p. xv.

[14] According to Dr. Adler, alternation of generation takes place between *N. lenticularis* and *Spathegaster baccarum* (see E. A. Ormerod, *Entomologist*, xi., p. 34).

[15] See Westwood, *Introd. to the Mod. Classif. of Insects*, ii., 1840, p. 130.

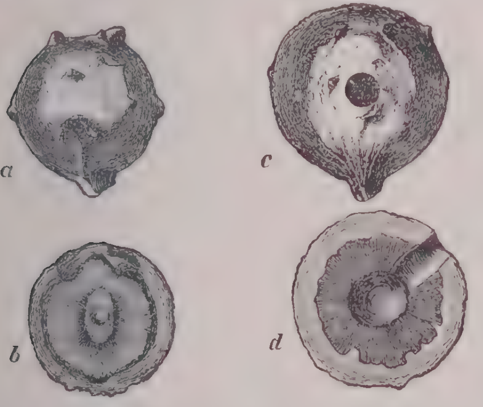

FIG. 1.—*a*, Aleppo "blue" gall; *b*, ditto in section, showing central cavity for grub; *c*, Aleppo "white" gall, perforated by insect; *d*, the same in section (natural size).

Common gall-nuts, nut-galls, or oak-galls, the Aleppo, Turkey, or Levant galls of commerce (German, *Galläpfel*, *Levantische Gallen*; French, *Noix de Galle*), are produced on *Quercus infectoria*, a variety of *Q. Lusitanica*, Webb, by *Cynips* (*Diplolepis*, Latr.) *tinctoria*, L., or *C. gallæ tinctoriæ*, Oliv. Aleppo galls (*gallæ halepenses*) are brittle, hard, spherical bodies, $\frac{2}{5}$–$\frac{4}{5}$-inch in diameter, ridged and warty on the upper half, and light brown to dark grayish-yellow within. What are termed "blue," "black," or "green" galls contain the insect; the inferior "white" galls, which are lighter colored, and not so compact, heavy, or astringent, are gathered after its escape (see fig. 1). Less valued are the galls of Tripoli (Tarasplus or Tarabulus, whence the name "Tarablous galls"). The most esteemed Syrian galls, according to Pereira, are those of Mosul on the Tigris. Other varieties of nut-galls, besides the above mentioned, are employed in Europe for various purposes. Commercial gall-nuts have yielded on analysis from 26 (H. Davy) to 77 (Buchner) per cent. of tannin (see Vinen, *loc. cit*), with gallic and ellagic acids, ligneous fibre, water, and minute quantities of proteids, chlorophyll, resin, free sugar, and, in the cells around the inner shelly chamber, calcium oxalate. Oak-galls are mentioned by Theophrastus, Dioscorides (i. 146), and other ancient writers, including Pliny (*Nat. Hist.*, xvi. 9, 10; xxiv. 5), according to whom they may be produced "in a single night." Their insect origin appears to have been entirely unsuspected until within comparatively recent times, though Pliny, indeed, makes the observation that a kind of gnat is produced in certain excrescences on oak leaves. Bacon describes oak-apples as "an exudation of plants joined with putrefaction." Pomet[6] thought that gall-nuts were the fruit of the oak, and a similar opinion obtains among the modern Chinese, who apply to them the term *Mu-shih-tsze*, or "fruits for the foodless."[7] Hippocrates administered gall-nuts for their astringent properties, and Pliny (*Nat. Hist.*, xxiv. 5) recommends them as a remedy in affections of the gums and uvula, ulcerations of the mouth, and some dozen more complaints. The drug has been used in the treatment of intermittent fevers,[8] but appears to be adapted only for their mildest phases.[9] In India it is given also in chronic diarrhœa, dysentery, gonorrhœa, and several other diseases.[10] In British pharmacy gall-nuts are used in the preparation of the two astringent ointments *unguentum gallæ* and *unguentum gallæ cum opio* and of the *tinctura gallæ*, and also as a source of tannin and of gallic acid (*q. v.*). They have from very early times been resorted to as a means of staining the hair of a dark color, and they are the base of the tattooing dye of the Somali women.[11] On the Continent they are employed in tanning. With respect to the technical application of gall-nuts, see further BLASTING, vol. iii. p. 702, DYEING, vol. vii. p. 501, and INK. In consequence of the increased consumption in dyeing of sumach, myrobalans, and new chemical substances, the British importations of gall-nuts have on the whole declined considerably.

The quantities and values of galls imported into the United Kingdom in 1877 were as follows:—From Germany, 1963 cwts., £7759; Turkey, 6420 cwts., £20,712; Egypt, 1702 cwts., £6244; China, 11,748 cwts., £32,715; British India (Bombay and Scinde), 2181 cwts., £2230; other countries, 2411 cwts., £7176; total, 26,425 cwts., of the value of £76,836, against 25,884 cwts., value £64,704, in 1876.

The gall-making Hymenoptera include, besides the *Cynipidæ* proper, certain species of the genus *Eurytoma* (*Isosoma*, Walsh) and family *Chalcididæ*, *e.g.*, *E. hordei*, the "joint-worm" of the United States, which produces galls on the stalks of wheat;[12] also various members of the family *Tenthredinidæ*, or saw-flies. The larvæ of the latter usually vacate their galls to spin their cocoons in the earth, or, as in the case of *Athalia abdominalis*, Klg., of the clematis, may emerge from their shelter to feed for some days on the leaves of the gall-bearing plant.

The dipterous gall-formers include the gall-midges, or gall-gnats (*Cecidomyidæ*), minute slender-bodied insects, with bodies usually covered with long hairs, and the wings folded over the back. Some of them build cocoons within their galls, others descend to the ground to become pupæ. The true willow-galls are the work either of these or of saw-flies. Their galls are to be met with on a great variety of plants of widely distinct genera, *e.g.*, the ash, maple, hornbeam, oak,[13] grape-vine,[14] alder, gooseberry, blackberry, pine, juniper, thistle, fennel, meadowsweet,[15] common cabbage, and cereals. In the northern United States, in May, "legions of these delicate minute flies fill the air at twilight, hovering over wheat-fields and shrubbery. A strong northwest wind, at such times, is of incalculable value to the farmer."[16] Other gall-making dipterous flies are members of the family *Trypetidæ*, which disfigure the seed-heads of plants, and of the family *Mycetophilidæ*, such as the species *Sciara tilicola*,[17] Löw, the cause of the oblong or rounded green and red galls of the young shoots and leaves of the lime.

Galls are formed also by hemipterous and homopterous insects of the families *Tingidæ*, *Psyllidæ*, *Coccidæ*, and *Aphidæ*. *Coccus pinicorticis* causes the growth of patches of white flocculent and downy matter on the smooth bark of young trees of the white pine in America.[18] The galls of examples of the last family are common objects on lime-leaves, and on the petioles of the poplar. An American Aphid of the genus *Pemphigus* produces black, ragged, leathery, and cup-shaped excrescences on the young branches of the hickory.

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[1] For figures and descriptions of insect and gall, see *Entomologist*, iv., p. 17; vii., p. 241; ix., p. 53; xi., p. 131.

[2] *Scottish Naturalist*, i., 1871, p. 116, etc.

[3] Vinen, *Journ. de Pharm. et de Chim.*, xxx., 1856, p. 290; "English Ink-Galls," *Pharm. Journ.*, 2d ser., iv., p. 520.

[4] See Pereira, *Materia Medica*, vol. ii., pt. i., p. 347; *Pharm. Journ.*, 1st ser., vol. viii., pp. 422–4.

[5] See R. H. Stretch and C. D. Gibbes, *Proc. California Acad. Nat. Sciences*, iv., pp. 265 and 266.

[6] *A Complete History of Drugs* (translation), p. 169, Lond., 1748.

[7] F. Porter Smith, *Contrib. towards the Mat. Medica . . . of China*, p. 100, 1871.

[8] Cullen, *Mat. Med.*, ii. p. 46, 1789.

[9] E. J. Waring, *Pharm. of India*, p. 463, 1868.

[10] E. J. Waring, *Remarks on . . . Bazaar Medicines . . . of India*, Lond., 3d ed., 1875.

[11] R. F. Burton, *First Footsteps in E. Africa*, p. 178, 1856.

[12] A. S. Packard, jun., *Guide to the Study of Insects*, p. 205, Salem, 1870.

[13] On the Cecidomyids of *Quercus Cerris*, see Fitch, *Entomologist*, xi. p. 14.

[14] See, on *Cecidomyia oenephila*, Von Haimhoffen, *Verhandl. d. zoolog.-bot. Ges. in Wien*, xxv. 801–10.

[15] See *Entomologist's Month. Mag.*, iv., 1868, p. 233; and for figure and description, *Entomologist*, xi. p. 13.

[16] A. S. Packard, jun., *Our Common Insects*, p. 203, Salem, U. S., 1873. On the Hessian fly, *Cecidomyia destructor*, Say, the May brood of which produces swellings immediately above the joints of barley attacked by it, see Asa Fitch, *The Hessian Fly*, Albany, 1847, reprinted from *Trans. New York State Agric. Soc.*, vol. vi.

[17] J. Winnertz, *Beitrag zu einer Monographie der Sciarinen*, p. 164, Vienna, 1867.

[18] Asa Fitch, *First and Second Rep. on the Noxious . . . . Insects of the State of New York*, p. 167, Albany, 1856.

The Chinese galls of commerce (*Woo-pei-tsze*) are stated to be produced by *Aphis Chinensis*, Bell, on *Rhus semialata*, Murr. (R. *Bucki-amela*, Roxb.), an Anacardiaceous tree indigenous to N. India, China, and Japan. They are hollow, brittle, irregularly pyriform, tuberculated, or branched vesicles, with thin walls, covered externally with a gray down, and internally with a white chalk-like matter, and insect-remains (see fig. 2). The escape of the insect takes place on the spontaneous bursting of the walls of the vesicle, probably when, after viviparous (thelytokous) reproduction for several generations, male winged insects are developed. The galls are gathered before the frosts set in, and are exposed to steam to kill the insects.[1]

Chinese galls examined by Viedt[2] yielded 72 per cent. of tannin, and less mucilage than Aleppo galls. Several other varieties of galls are produced by Aphides on species of *Pistacia*.

M. J. Lichtenstein has established the fact that from the egg of the Aphis of Pistachio galls, *Anopleura lentisci*, is hatched an apterous insect (the gall-founder), which gives birth to young Aphides (emigrants), and that these, having acquired wings, fly to the roots of certain grasses (*Bromus sterilis* and *Hordeum vulgare*), and by budding underground give rise to several generations of apterous insects, whence finally comes a winged brood (the pupifera). These last issuing from the ground fly to the Pistachio, and on it deposit their pupæ. From the pupæ, again, are developed sexual individuals, the females of which lay fecundated eggs productive of gall-founders, thus recommencing the biological cycle (see *Compt. Rend.* Nov. 18, 1878, p. 782, quoted in *Ann. and Mag. Nat. Hist.* 1879, p. 174).

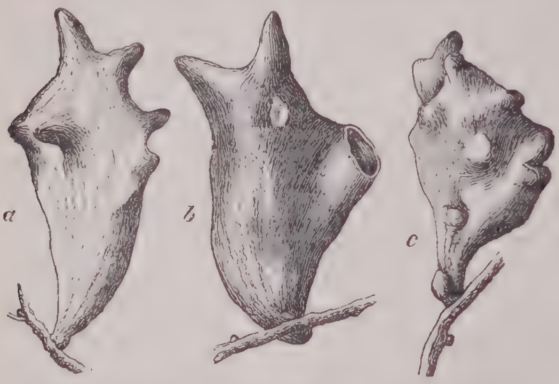

FIG. 2.—*a*, Chinese gall (half natural size); *b*, ditto, broken, showing thin-walled cavity; *c*, Japanese gall (natural size).

Of other insects which have been recognized as gall-makers there are, among the Coleoptera, certain Curculionids (gall-weevils), and species of the exotic *Sagridæ* and *Lamiadæ*, and an American beetle, *Saperda inornata* (*Cerambycidæ*), which forms the pseudo-galls of *Salix longifolia* and *Populus angulata*, or cottonwood. Among the Lepidoptera are gall-forming species belonging to the *Tineidæ*, *Ægeriidæ*, *Tortricidæ*, and *Pterophoridæ*. The larva of a New Zealand moth, *Morova subfasciata*, Walk. (*Cacoëcia gallicolens*), of the family *Drepanulidæ*, causes the stem of a creeping plant, on the pith of which it apparently subsists, to swell up into a fusiform gall.[3]

Mite-galls, or *acarocecidia*, are abnormal growths of the leaves of plants, produced by microscopic Acaridea of the genus *Phytoptus* (gall-mites), and consist of little tufts of hairs, or of thickened portions of the leaves, usually most hypertrophied on the upper surface, so that the lower is drawn up into the interior, producing a bursiform cavity. Mite-galls occur on the sycamore, pear, plum, ash, alder, vine, mulberry, and many other plants; and formerly, *e.g.*, the gall known as *Erineum quercinum*, on the leaves of *Quercus Cerris*, were taken for cryptogamic structures. The lime-leaf "nail-galls" of *Phytoptus tiliæ* closely resemble the "trumpet-galls" formed on American vines by a species of *Cecidomyia.*[4] Certain minute Nematoid worms, as *Anguillula scandens*, which infests the ears of wheat, also give rise to galls.

Besides the larva of the gall-maker, or the householder, galls usually contain inquilines or lodgers, the larvæ of what are termed guest-flies or cuckoo-flies. Thus the galls of *Cynips* and its allies are inhabited by members of other cynipideous genera, as *Synergus*, *Amblynotus*, and *Synophrus*, and the pine-cone-like gall of *Salix strobiloides*, as Walsh has shown,[5] is made by a large species of *Cecidomyia*, which inhabits the heart of the mass, the numerous smaller cecidomyidous larvæ in its outer part being mere inquilines. In many instances the lodgers are not of the same order of insects as the gall-makers. Some saw-flies, for example, are inquilinous in the galls of gall-gnats, and some gall-gnats in the galls of saw-flies. Again, galls may afford harbor to insects which are not essentially gall-feeders, as in the case of the Curculio beetle, *Conotrachelius nenuphar*, Hbst., of which one brood eats the fleshy part of the plum and peach, and another lives in the "black knot" of the plum-tree, regarded by Walsh as probably a true cecidomyidous gall. The same authority (*loc. cit.*, p. 550) mentions a willow-gall which provides no less than sixteen insects with food and protection; these are preyed upon by about eight others, so that altogether some twenty-four insects, representing eight orders, are dependent for their existence on what to the common observer appears to be nothing but "an unmeaning mass of leaves." Among the numerous insects parasitic on the inhabitants of galls are hymenopterous flies of the family *Proctotrypidæ*, and of the family *Chalcididæ*, *e. g.*, *Callimome regius*, the larva of which preys on the larvæ of both *Cynips glutinosa* and its lodger *Synergus facialis*. The oak-apple often contains the larvæ of *Braconidæ* and *Ichneumonidæ*, which Von Schlechtendal (*loc. sup. cit.*, p. 33) considers to be parasites not on the owner of the gall, *Andricus terminalis*, but on inquilinous *Tortricidæ*. Birds are to be included among the enemies of gall-insects. Oak galls, for example, are broken open by the titmouse in order to obtain the grub within, and the "button-galls" of *Neuroterus numismatis*, Oliv., are eaten by pheasants.

On galls and their makers and inhabitants see further—J. T. C. Ratzeburg, *Die Forst-Insecten*, Th. iii. pp. 53 *sq.*, Berlin. 1844; T. W. Harris, *Insects injurious to Vegetation*, Boston, U. S., 2d ed., 1852; C. L. Koch, *Die Pflanzenläuse Aphiden*, Nuremberg, 1854; T. Hartig, *Die Familien der Blattwespen und Holzwespen*, Berlin, 1860; Walsh, "On the Insects, Coleopterous, Hymenopterous, and Dipterous, inhabiting the Galls of certain species of Willow," *Proc. Ent. Soc. Philadelphia*, iii., 1863–4, pp. 543–644, and vi., 1866–7, pp. 223–288; T. A. Marshall, "On some British Cynipidæ," *Ent. Month. Mag.*, iv. pp. 6–8, etc.; H. W. Kidd and Albert Müller, "A List of Gall-Bearing British Plants," *ib.*, v. pp. 118 and 216; G. L. Mayr, *Die mitteleuropäischen Eichengallen in Wort und Bild*, Vienna, 1870–71, and the translation of that work, with notes, in the *Entomologist*, vols. vii. *sq.*; also by the same author, "Die Einmiethler der mitteleuropäischen Eichengallen," *Verhandl. d. zoolog.-bot. Ges. in Wien*, xxii. pp. 669–726; and "Die europäischen Torymiden," *ib.*, xxiv. pp. 53–142 (abstracted in *Cistula Entomologica*, i., Lond., 1869–76); F. Löw, "Beiträge zur Kenntniss der Gallmücken," *ib.*, pp. 143–162, and 321–328; J. E. von Bergenstamm and P. Löw, "Synopsis Cecidomyidarum," *ib.*, xxvi. pp. 1–104; Perris, *Ann. Soc. Entom. de France*, 4th ser., vol. x. pp. 176–185; R. Osten-Sacken, "On the North American Cecidomyidæ," *Smithsonian Miscellaneous Collections*, vol. vi., 1867, p. 173; E. L. Taschenberg, *Entomologie für Gärtner und Gartenfreunden*, Leipsic, 1871; J. W. H. Traill, "Scottish Galls," *Scottish Naturalist*, i., 1871, pp. 123, etc.; Albert Müller, "British Gall Insects," *The Entomologist's Annual for 1872*, pp. 1–22; B. Altum, *Forstzoologie*, iii. "Insecten," pp. 250 *sq.*, Berlin, 1874; J. H. Kaltenbach, *Die Planzen Feinde aus der Classe der Insecten*, Stuttg., 1874; A. d'Arbois de Jubainville and J. Vesque, *Les Maladies des Plantes Cultivées*, pp. 98–105, Paris, 1878. (F. H. B.)

GALLUPPI, PASQUALE (1770–1846), a distinguished Italian philosopher, was born on 2d April, 1770, at Tropea, in Calabria. He was of good family, and after completing his education at the academy of Tropea and the university of Naples he entered the public service, and was for many years employed in the office of the administration of finances. Altogether apart from academic influences he pursued his favorite studies, and it was not till he had reached the age of sixty, and had become widely known by his writings on philosophy, that he was called to a chair in the university of Naples. This chair he held till his death in November, 1846. Galluppi's first work was an essay on analysis and synthesis (*Sull' Analisa e Sulla Sintesi*) published in 1807. This was followed by the important *Saggio filosofico sulla critica della conoscenza*, in 6 volumes, published from 1819 to 1832. In the *Lettere filosofiche sulle vicende della filosofia relativamente ai principii delle conoscenze humana, da Cartesio sino a Kant*, 1827, by which, through the translation into French (by M. Peisse, 1844), he is best known to foreigners, Galluppi traces his own philosophical development from the empiricism of the 18th century writers through the Kantian criticism to his final speculative view, one in many respects resembling the doctrines of the Scotch school as amended by Hamilton. His systematic work, *Elementi di filosofia* (4 vols. 1832), was long used as a text-book for instruction in the Italian colleges. Of other writings may be mentioned the *Lezioni di logica e di metafisica* (1832–3, 5 vols., 1842); the *Filosofia della Volonta* (3 vols., 1832–1842, incomplete); and the *Storia della Filosofia* (1842), of which only the first volume was published. Galluppi, though in many respects Kantian, can hardly be said to have taken up fully the speculative significance of the *Critique of Pure Reason*. He accepts the Kantian demonstration of the necessary unity of consciousness as the indispensable factor in knowledge, regards our knowledge of the ego as knowledge of substance, maintains that in external perception, or, as he puts it, in sensation, we are directly cognizant of the real thing, and holds that the existence of the unconditioned is given in knowledge as the necessary correlate of the conditioned, but rejects entirely the *a priori* element which is the distinguishing characteristic of the Kantian doctrine of cognition. All judgments, according to him, are ultimately identical—a relic of the empiricism of Condillac which is totally irreconcilable with the fundamental principles of his philosophy. On the other hand, Galluppi exaggerates the place and importance of the moral reason; with Kant he finds objective truth in the ideas of desert and duty, and admits that ethical judgments are *a priori*, without endeavoring to explain, in accordance with his theoretical views, how such judgments are at all possible.

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[1] See E. Doubleday, *Pharm. Journ.*, 1st ser., vol. vii. p. 310; and Pereira, *ib.*, vol. iii. p. 377.

[2] *Dingler's Polyt. Journ.* ccxvi. p. 453; *cf. supra* GALLIC ACID.

[3] For figure and description see *Zoology of the Erebus and Terror*, ii. pp. 46, 47, 1844–75.

[4] On the mite-galls and their makers, see F. Löw, "Beiträge zur Naturgesch. der Gallmilben (*Phytoptus*, Duj.)," *Verhandl. d. zoolog.-bot. Ges. in Wien*, xxiv., 1874, pp. 2–16, with plate; and "Ueber Milbengallen (Acarocecidien) der Wiener-Gegend," *ib.*, pp. 495–508; Andrew Murray, *Economic Entomology*, *Aptera*, pp. 331–374, 1876; and F. A. W. Thomas, *Aeltere und neue Beobachtungen über Phytopto-Cecidien*, Halle, 1877.

[5] *Proc. Entomol. Soc. Philadelphia*, iii., 1864, p. 549.

A good view of Galluppi's place in Italian philosophy is given in Ferri, *Essai sur l'Histoire de la Phil. en Italie au XIX*^{me} *Siècle*, vol. i., Paris, 1869. See also V. Botta, in Ueberweg's *History of Phil.* (Eng. transl., vol. ii., appendix ii.); Prof. Barzellotti, "Philosophy in Italy," in *Mind*, October, 1878.

GALLUS, C. CORNELIUS, a Roman poet, orator, and politician, was born of humble parents at Forum Julii (Fréjus), in Gaul, about the year 66 B. C. At an early age he removed to Rome, where he was taught by the same master as Virgil and Varius. In political life he espoused the cause of Octavianus, and as a reward for his services was made prefect of Egypt. His conduct in this position afterwards brought him into disgrace with Augustus, and dreading the exposure of his arrogance, extortion, and cruelty, he put an end to his life by throwing himself on his sword, in the year 26 B. C. Gallus enjoyed a high reputation among his contemporaries as a man of intellect. He associated on terms of equality with Virgil, Ovid, Varius, Asinius Pollio, and others, and on account of his four books of elegies Ovid claimed for him the first place among the elegiac poets of Rome. His fame as an orator was hardly inferior to his renown as a poet; but as not a fragment of his composition has descended to our times, we have no means of judging the worth of his literary pretensions, and have to content ourselves with the somewhat partial estimate of his personal friends.

See Ch. C. Völker, *Commentatio de C. Galli Vita et Scriptis*, part i., Bonn, 1840; part ii., Elberfeld, 1844.

GALT, JOHN (1779–1839), a Scottish novelist, was born at Irvine, in Ayrshire, on May 2, 1779. He received his early education at Irvine and Greenock, and read largely from one of the public libraries while serving as a clerk in a mercantile office. His first compositions appeared in the *Greenock Advertiser* and the *Scots Magazine*. In 1804 he went to settle in London, where he continued to work at a poem on the *Battle of Largs*, which was published anonymously. After unsuccessful attempts to succeed in business, Galt left for the Continent, and met Byron and Sir John Hobhouse at Gibraltar, with whom he had a tour in the Mediterranean. He remained abroad for three years, and then returned to London. His early works are the *Life and Administration of Wolsey*, *Voyages and Travels*, *Letters from the Levant*, the *Life of Benjamin West*, *Historical Pictures*, the *Wandering Jew*, and a volume of dramas; but he first showed his real power in *The Ayrshire Legatees*, which appeared in *Blackwood's Magazine* in 1820. This was followed in 1821 by his masterpiece—*The Annals of the Parish;* and, at short intervals, *Sir Andrew Wylie*, *The Entail*, *The Steam-Boat*, and *The Provost* were published. These are all in his happiest manner, and are unsurpassed as studies of Scottish character. His next works were *Ringan Gilhaize*, a story of the Covenanters; *The Spaewife*, which relates to the times of James I. of Scotland; *Rothelan*, a novel founded on the reign of Edward III.; *The Omen*, which was favorably criticised by Sir Walter Scott; and *The Last of the Lairds*, another picture of Scottish life. In 1826 he visited America for the second time, in connection with the establishment of the Canada Company,—an undertaking which involved him in great difficulties, and ultimately proved disastrous to his worldly prospects. It is pleasant to remember that, although Galt's connection with Canada was unfortunate for himself, his youngest son, Sir Alexander Galt, has had a distinguished career there, and was, for some time, finance minister of the colony. In 1827 Galt founded Guelph in Upper Canada, passing on his way the township of Galt on the Grand River, named after him by the Hon. William Dixon. In 1829 he returned to England commercially a ruined man, and devoted himself with great ardor to literary pursuits, of which the first fruit was *Lawrie Todd*,—one of his best novels. Then came *Southennan*, a tale of Scottish life in the times of Queen Mary. In 1830 he was appointed editor of the *Courier* newspaper,—a post he soon relinquished. His untiring industry was seen in the publication, in rapid succession, of a *Life of Byron*, *Lives of the Players*, *Bogle Corbet*, *Stanley Buxton*, *The Member*, *The Radical*, *Eben Erskine*, *The Stolen Child*, his *Autobiography*, and a collection of tales entitled *Stories of the Study*. In 1834 appeared his *Literary Life and Miscellanies*, dedicated by permission to William IV., who sent the author a present of £200. As soon as this work was published Galt retired to Greenock, where he lingered on in bad health till his death on the 11th of April, 1839.

Galt, like almost all voluminous writers, was exceedingly unequal. His masterpieces are *The Ayrshire Legatees*, *The Annals of the Parish*, *Sir Andrew Wylie*, *The Entail*, *The Provost*, and *Lawrie Todd*. *The Ayrshire Legatees* gives, in the form of a number of exceedingly diverting letters, the adventures of the Rev. Dr. Pringle and his family in London. The letters are made the excuse for endless tea-parties and meetings of kirk session in the rural parish of Garnock. *The Annals of the Parish* are told by the Rev. Micah Balwhidder, Galt's finest character. This work is a splendid picture of the old-fashioned Scottish pastor and the life of a country parish; and, in rich humor, genuine pathos, and truth to nature, it is unsurpassed even by Scott. Like his other Scotch novels, it is a fine specimen of the homely graces of the Scottish dialect, and preserves much vigorous Doric phraseology fast passing out of use even in country districts. In this novel Mr. Galt used, for the first time, the term "Utilitarian," which has since become so intimately associated with the doctrines of John Stuart Mill and his followers (see *Annals of the Parish*, chap. xxxv., and a note by Mr. Mill in *Utilitarianism*, chap. ii.). In *Sir Andrew Wylie* the hero entered London as a poor lad, but achieved remarkable success by his shrewd business qualities. The character is somewhat exaggerated, but excessively amusing. *The Entail* was read thrice by Byron and Scott, and is the best of Galt's longer novels. Leddy Grippy is a wonderful creation, and was considered by Byron equal to any female character in literature since Shakespeare's time. *The Provost*, in which Provost Pawkie tells his own story, portrays inimitably the jobbery, bickerings, and self-seeking of municipal dignitaries in a quaint Scottish burgh. In *Lawrie Todd* Galt, by giving us the Scot in America, has accomplished a feat which Sir Walter never attempted. This novel exhibits more variety of style and a greater love of nature than his other books. The life of a settler is depicted with unerring pencil, and with an [illegible] an imitator of Scott: but the *Annals of the Parish* [illegible] in MS. before *Waverley* was published. As Galt is pre-eminently an illustrator of west-country Scottish life, his range may be said to be narrower than Scott's: but within it he is supreme. It would be difficult to overrate the immense services which Galt has rendered alike to the history of the manners and to the history of the language of the Scottish people.

For further information about Galt, see his *Autobiography*: *The Literary Life of John Galt*; and a biographical memoir by his friend the late Dr. Moir of Musselburgh, prefixed to *The Annals of the Parish*. (T. GL.)

GALOIS, EVARISTE (1811-1832), an eminently original and profound French mathematician, born 26th October, 1811, killed in a duel May, 1832. A necrological notice by his friend M. Auguste Chevalier appeared in the *Revue Encyclopédique*, September, 1832, p. 744: and his collected works are published, *Liouville*, t. xi. (1846), pp. 381–444, about fifty of these pages being occupied by researches on the resolubility of algebraic equations by radicals. But these researches, crowning as it were the previous labors of Lagrange, Gauss, and Abel, have in a signal manner advanced the theory, and it is not too much to say that they are the foundation of all that has since been done, or is doing, in the subject. The fundamental notion consists in the establishment of a group of permutations of the roots of an equation, such that every function of the roots invariable by the substitutions of the group is rationally known, and reciprocally that every rationally determinable function of the roots is invariable by the substitutions of the groups; some further explanation of the theorem, and in connection with it an explanation of the notion of an adjoint radical, is given under EQUATION, No. 32. As part of the theory (but the investigation has a very high independent value as regards the Theory of Numbers, to which it properly belongs), Galois introduces the notion of the imaginary roots of an irreducible congruence of a degree superior to unity; i.e., such a congruence, $F(x) \equiv 0$ (mod. a prime number p), has no integer root; but what is done is to introduce a quantity i subjected to the condition of verifying the congruence in question, $F(i) \equiv 1$ (mod. p), which quantity i is an imaginary of an entirely new kind, occupying [illegible] of $-\sqrt{-1}$ in algebra.

GALUPPI, BALDASSARRE (1706–1785), a musical composer, was born in 1706, in the island of Burano, near Venice. His father, a barber by profession, was a musical [illegible] prepared his son for the music school of Ven[illegible] age [illegible] in tragic opera was produced at St. Petersburg in 1766. The composer had been induced by liberal offers to accept a [illegible] the court of the czar, and is said to have in return done much for the progress of his art in Russia by introducing amongst other things Italian church-music. In 1768 he left Russia, and resumed his position as organist of the cathedral of St. Mark at Venice, to which he had been appointed in 1762, and which had been kept open for him [illegible] preserve several of his operas in MS. At Vienna also some of his works of sacred music may be found. Others are in Paris and Rome.

GALVANI, LUIGI (1737–1798), an eminent Italian [illegible], after whom galvanism received its name, was [illegible], 1737. It was his wish in early life to enter the church, but by his parents he was educated for a medical career. At the university of Bologna, in which city he practised, he was in 1762 appointed [illegible] icity he enunciated in a treatise, "De viribus electricitatis in motu musculari commentarius," published in the 8th volume of the memoirs of the Institute of Sciences at Bologna in 1791, and separately at Modena in the following year, and elsewhere subsequently. The statement has frequently been repeated that, in 1786, Galvani had skinned [illegible] machine, was thrown into violent convulsions; and that it was thus that his attention was first directed to the relations [illegible] From documents in the [illegible] it appears [illegible] on an iron railing by copper hooks caused twitching in the muscles of their legs led him to the invention of his metallic [illegible] part of the *Commentary*, wherein it is registered September 20, 1786. The arc he constructed of two different metals, which, placed in contact the one with a nerve and the other with a muscle of a frog, caused contraction of the latter. In Galvani's view the motions of the muscle were the result of the union, by means of the metallic arc, of its exterior or negative electrical charge with positive electricity which [illegible] the nerve from its inner substance. [illegible] caused in a prepared frog merely by bending back [illegible] also when a nerve is touched at two different points with a morsel of muscle taken from a living frog, phenomena not satisfactorily explicable on the theories of Volta; but after the death of the Bologna professor very little was heard of animal electricity till, in 1827, the study of the subject was [illegible] public on its establishment, he was removed from his professorship. Deprived thus of the means of livelihood, he retired to the house of his brother Giacomo, where he [illegible] The [illegible] Government, in consideration of his great scientific fame, eventually, but [illegible] him [illegible] at the university of Bologna. He died December 4, 1798. A quarto edition of his works was published at Bologna in 1841–42, by the Academy of Sciences of the Institute of [illegible] *Opere edite ed inedite del professore Luigi Galvani.*

[illegible] H. M. Noad, *Manual of Electricity*, chap. x.; also ELECTRICITY, vol. viii. p. 9, col. 2, and VOLTA.

GALVANISM. See ELECTRICITY and PHYSIOLOGY.

GALVANOMETER, an instrument used for indicating or measuring currents of electricity, wherein advantage is [illegible] of the force exerted by such currents on movable magnets in their neighborhood.[1] When a galvanometer is [illegible] without measuring, it is sometimes called a galvanoscope. If we consider only such instruments as have come into actual use, this definition is strict enough for practical purposes. If we were to consider all the instruments that have been or might be made, some would come under the definition whose resemblance to the [illegible] galvanometer would not at first sight be apparent. Such, for instance, is the electro-magnetic balance of Becquerel,[2] which consists of two bar magnets hung from the scale pan of a [illegible] cylindrical bobbin of wire—one being over, the other under its corresponding bobbin (see fig. 1). The north poles of both

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[1] For another definition see the article ELECTROMETER.

[2] For a brief history of the construction of galvanometric apparatus see art. ELECTRICITY, vol. viii. p. 13.

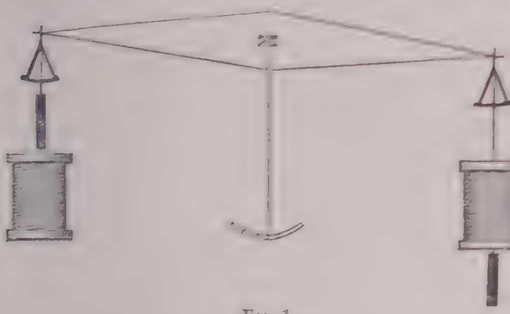

Fig. 1.

magnets hang downwards, and the current to be measured is sent round the bobbin, so that each of the magnets is repelled. Weights are put into the left-hand scale until equilibrium in the original position is restored. The weight thus added is proportional to the current strength, so long as the induced magnetism of the magnets can be neglected. This instrument has fallen into disuse.

In a complete galvanometer of modern construction the following parts may occur:—(1) the coil or multiplier, (2) the needle or moving magnet or magnets, (3) the suspending apparatus, (4) the directing or adjusting magnet, (5) the graduation or reading apparatus, (6) the damping apparatus, (7) accompanying the galvanometer, as a piece of auxiliary apparatus, we may also have a box of shunts. It would be easy to make a more minute enumeration of parts, but the above will serve our present purpose. On the other hand, it is not always that each of the above organs is represented separately; some may be wanting in certain cases, and the functions of two or more may be combined.

1. The multiplier or coil consists of a ring-shaped channel of elliptical, rectangular, or circular shape—usually the last, [illegible]. Into this is wound, as closely and regularly as possible, a quantity of silk-covered wire. The material chosen for the wire is usually copper, which should be as pure as possible in order to secure high conductivity. White silk is preferred for the insulating covering on account of its freedom from iron, though this is for most purposes a needless refinement. Great care should be taken that the wire is dry when it is wound. It is usual, in order to secure and render permanent the insulation, to steep the whole coil in melted paraffin; after this has been done, there is little risk of loss of insulation, provided the layers have been carefully tested during the winding. The idea of the multiplier in sensitive galvanometers is to bring the greatest number of coils of wire within the least possible distances of the magnet. It is evident, therefore, that the insulating covering should be as thin as is consistent with good insulation; this consideration assumes great importance when coils of very fine wire have to be wound. After the wire has reached a certain fineness the proportion of space occupied by insulating matter is so great that further reduction of the section of the wire simply increases the resistance without enabling us to pack more turns into the same space. In general the section of the wire ought to be chosen with reference to the use which the galvanometer is intended to serve. The following ideal case will enable the reader to comprehend the principle which regulates the choice of multiplier under given circumstances. Suppose the dimensions of the channel, and the whole space which the wire is to fill, to be given, and the whole external resistance also given, then it may be shown that the section of the wire[1] ought to be chosen so that the resistance of the galvanometer shall be equal to the external resistance. The case contemplated here is that where we have a simple external circuit; many cases can be reduced to this at once, and we shall consider below a more complicated case of considerable practical importance. Theoretically the section of the wire ought to vary with the distance of the winding from the axis of the coil. The law is that the diameter of the wire in each layer ought to be proportional to the linear dimension of that layer. This is sometimes roughly carried out in practice by winding the outer layers of thicker wire than the inner.[2] The proper form of the longitudinal section of the coil depends on the use for which the instrument is destined, and will be more properly discussed when we describe particular instruments. In a certain class of galvanometers called differential, the wire on the coil is wound double, so that two currents can be sent through side by side in the same or in opposite directions.

2. The needle consists of a piece of magnetized steel, which should be as hard as possible. Watch-spring steel is sometimes used, and file steel is recommended by some authorities. The hardness is important for two reasons—in the first place, to ensure that the permanent magnetism of the needle shall not alter. This is of small importance where permanent deflections are to be observed, provided we can be sure that the direction of the magnetic axis does not alter. In the second place the induced magnetism is less in hard than in soft steel, though not so much less as some writers would lead us to suppose. The best way of avoiding induced magnetism would be to make the needle spherical in form; the advantage thus gained, however, would in most cases be counterbalanced by other defects.

The form of the needle has been much varied by different constructors. In the earlier instruments they were made very long, and were suspended like compass needles by means of a jewelled cap playing on a steel point. We have heard on good authority that for some purposes, such as mounting tangent galvanometer needles, this method of suspension, if carefully carried out, really answers very well. By far the most usual mode of suspension, however, is by means of a raw silk fibre, or by a bundle of such fibres. Weber introduced the use of heavy magnets whose moment of inertia and time of oscillation were great. For many purposes such needles have great advantages—where, for instance, the time of oscillation, the logarithmic decrement, or the extent of swing of the needle has to be observed. Where, on the contrary, the galvanometer is to be used merely as an indicator, particularly in detecting transient currents, a light needle of small moment of inertia should be used. Continental constructors, no doubt unduly influenced by a reverence for Weber's methods, have failed to realize this; and we have seen few, if indeed any, instruments by them really well suited for measuring resistances with the Wheatstone's bridge. This principle has been carried farthest in the galvanometers of Sir William Thomson, in some of which the needle with all its appurtenances weighs little over a grain.

In some galvanometers (*e.g.*, certain telegraphic reading instruments) the needle is movable about a horizontal axis, and is weighted so as to be vertical in its undisturbed position. Owing to the friction at the points where the axis is supported, this method of suspension is useless for sensitive instruments.

3. When, as is usual, the galvanometer magnet is movable in a horizontal plane, the force which balances the electro-magnetic force of the current in the multiplier is the horizontal component of the earth's magnetic force. Each of these forces is proportional to the magnetic moment of the galvanometer needle, and consequently the ratio of the forces, on which depends the magnitude of the deflection of the needle, is independent of the magnetic moment of the needle. We cannot therefore increase the sensitiveness of the galvanometer by simply increasing the magnetic moment of the needle. The action of the earth can, however, be counteracted, and the needle rendered *more or less astatic* in one or other of two ways.

One way is to fix on the same axis of suspension two parallel magnets, whose magnetic moments are as nearly as possible equal, and which are turned opposite ways. The whole system is suspended so that one of the magnets swings inside the multiplier and the other over it, as in fig. 2. In more modern instruments, such as those constructed by Messrs. Elliot Brothers, the multiplier consists of two equal coils placed one vertically over the other, each enclosing one of the magnets of the astatic system, as in fig. 3. Another method is to place a magnet, or a system of magnets, in the neighborhood of the galvanometer, so as to counteract the earth's force. In general, one magnet will suffice, placed vertically under or over the galvanometer, in the magnetic meridian, its north pole of course pointing north. For convenience this magnet should be mounted on a vertical graduated rod, with a rough and a fine adjustment.

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[1] In this and all that follows the silk covering is either neglected or is supposed to vary in thickness as the diameter of the wire.

[2] The cross section of the coil is not a matter of indifference in sensitive galvanometers; but the question is hardly of sufficient importance to need discussion here. Information on the subject will be found in W. Weber's *Elektrodynamische Maassbestimmungen*, Thl. ii.; H. Weber, *Pogg. Ann.*, [illegible]; Maxwell's *Electricity and Magnetism*, vol ii. secs. 716 *sqq.*; Jenkin's *Electricity and Magnetism*, cap. xiii. sec. 9.

In adjusting the sensitiveness of the galvanometer, it will be useful to recollect that the couple tending to bring the needle back to its position of equilibrium varies directly as the square of the number of oscillations which the needle executes in a given time when no current is passing through the multiplier.[1] As the astatizing magnet is brought nearer and nearer to the galvanometer, the oscillations of the needle will be seen to become slower and slower, till at last the equilibrium becomes unstable, and the needle turns round through 180°; after which, on causing the magnet to approach still farther, the rapidity of oscillation increases. If the damping be very strong, and the mirror very light, an intermediate stage called the *aperiodic* state is passed through.

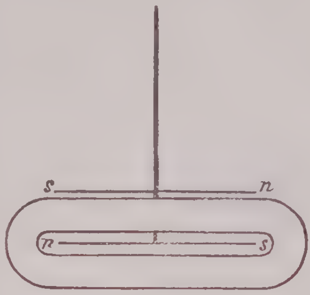

FIG. 2.

4. The normal position of the magnetic axis of the needle, when no current is passing, is parallel to the windings of the multiplier. It is particularly necessary that it should be in this position when the galvanometer is being used as a measuring instrument, and it is advisable in any case, since this is the position in which for a given current the electro-magnetic action on the needle is greatest. The final adjustment might of course be made by moving the multiplier, but it is far more convenient to move the needle, a magnet being used for the purpose. Sometimes the astatizing magnet is used, but it is better to have a much weaker magnet for the fine adjustment, suspended like the astatizer on a vertical axis, having a vertical motion and a motion of rotation. It is better still to use a magnet placed with its axis in the axis of the multiplier, so that it can be slid backwards and forwards at pleasure. We have seen two such magnets placed side by side, with their north and south and their south and north poles together; this gives a differential adjustment which is very convenient. The main advantage of placing magnets in this way is that we can alter the direction of the lines of force with a minimum effect on the strength of the magnetic field.

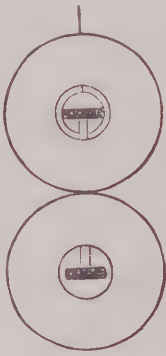

FIG. 3.

5. The graduation or reading apparatus in the older instruments consisted of a pointer or index fixed to the magnet (very often it was the magnet itself), playing over a circular graduation centred as nearly as possible in the axis of rotation of the needle. The mirror method of reading which prevails in most modern instruments was originally suggested by Poggendorff, and carried out in practice by Gauss and Weber. A mirror is rigidly attached to the magnet, so that the reflecting face passes as nearly as possible through the vertical axis of rotation of the needle. The glass of the mirror should be very thin, otherwise a greater or less correction for its thickness will be necessary. In the *subjective* method of reading, a scale is fixed before the mirror, which is usually plane (it must be well made to be of any use), and the image of the scale is observed by means of a telescope fixed over or under the centre of the scale. The scale divisions are seen to pass the wires of the telescope, and if a circular scale be used, whose centre is in the axis of suspension of the mirror, the difference between the numbers on the cross wires in any two positions of the magnet is a measure of twice the deflection of the magnet. A correction is necessary when a straight scale is used. The reader who has occasion to use the method will find practical instructions, with tables of corrections, in Wiedemann's *Galvanismus*, Bd. ii. sec. 181 *sqq.;* Maxwell's *Electricity and Magnetism*, vol. ii. sec. 450 *sqq.* In the *objective* method, which is more usually practised in this country, the mirror is concave, and reflects the image of a fixed illuminated slit (often furnished with a vertical wire where greater accuracy is desired) upon a graduated scale. The readings are proportional to double the deflexion of the needle, or to the tangent of the double deflexion, according as the scale is circular or straight.

6. By damping is meant the decrease of the extent of the oscillations of the galvanometer needle arising from the dissipation of energy through the resistance of the air, the action of currents induced in neighboring metallic circuits, the viscosity of the suspension fibre, and so on. There is always more or less damping owing to the first two causes, and possibly the third; but in many cases, where it is desirable that the oscillations should subside very quickly, the damping is purposely increased. In the older instruments the damping arrangement consisted of masses of copper surrounding the magnet. This is carried to the extreme in Wiedemann's tangent galvanometer, where the needle is ring-shaped, and swings in a ring-shaped cavity not much larger than itself, in the heart of a mass of copper. In the dead-beat galvanometers of Sir William Thomson the magnet with its attached mirror is enclosed in a flat cell, in which it can just move freely to the required extent. The damping, due to the pumping of the air backwards and forwards round the edges of the mirror, is so great that the needle swings off to its position of equilibrium, and remains there without oscillating at all. The same result is attained in Varley's construction by immersing the needle in a cell filled with liquid.

7. The box of shunts is simply a set of resistances; generally there are three,—$\frac{1}{9}$th, $\frac{1}{99}$th, and $\frac{1}{999}$th of the resistance of the multiplier. When it is required to reduce the sensibility of the galvanometer, the terminals of one of these, say the $\frac{1}{99}$th, are connected with the terminals of the multiplier; we thus have a multiple arc in place of the galvanometer, and the current is divided between its branches in the ratio of their conductivities, so that one-hundredth[2] of the whole current flows through the galvanometer. By means of such a box as we have described, we can therefore send through the galvanometer the whole of any current, or the tenth, hundredth, or thousandth part. It must not be forgotten that the introduction of the shunt diminishes the whole resistance of the galvanometer circuit. In most cases, however, this is of little moment; where necessary, the alteration may be either compensated[3] or allowed for.

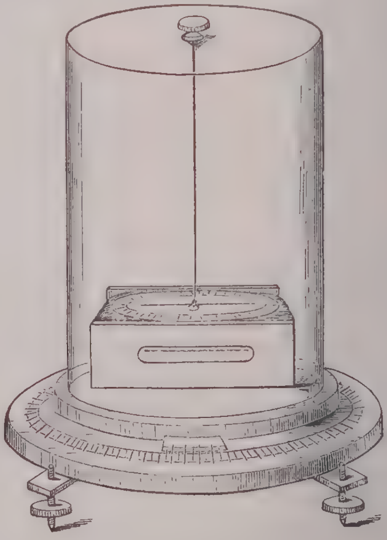

FIG. 4.—Astatic multiplier.

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[1] This is not exactly true where there is damping; but the rule is sufficient for ordinary purposes.

[2] See art. ELECTRICITY, vol. viii. p. 41.

[3] *E. g.*, in above case by introducing into the galvanometer circuit $\frac{9}{10}$ths, $\frac{99}{100}$ths, $\frac{999}{1000}$ths, respectively, of the resistance of the multiplier.

Sensitive Galvanometers.—In galvanometers of this class everything is disposed so as to bring the greatest possible number of turns of wire into the neighborhood of the needle. The needle is therefore made as small and compact as possible, and the windings embrace it as closely as possible, the opening in the centre of the coil being reduced to a minimum. The astatic multiplier (fig. 4) is an instrument of this kind which was formerly much used. The coil is of flat, rectangular shape, with a narrow central opening just large enough to allow one of the magnets of the astatic system to swing freely. The other magnet swings over a graduated circle placed on the top of the coil, and serves also as an index. Sometimes a mirror and scale are substituted for the index and graduated circle. The sole on which the coil stands is movable on a fixed piece which can be levelled by means of three screws. A graduation is often furnished to measure the angle of rotation of the coil about a vertical axis; this is useful when the galvanometer has to be graduated or corrected for the torsion of the fibre.

In the galvanometers of Sir William Thomson, which are the most sensitive hitherto constructed, the central opening of the coil is circular, being just large enough to allow free play to a small concave mirror, a centimetre or so in diameter. Usually the coil is wound in two halves, which can be screwed together with a septum between them, in which is placed the arrangement for suspending the mirror and magnets. In dead-beat instruments the coil is often wound in a single piece, and the mirror is arranged in a cell,[1] glazed back and front, and fitted into a tube which slides into the core of the coil.

Fig. 5 represents a very convenient form of Thomson's galvanometer, the only specimen of its kind we have seen. The peculiarity of its construction consists in the connection between the scale and the galvanometer, which saves much trouble in adjusting the instrument. It was constructed by Elliot Brothers for the British Association Committee on Electrical Standards. Such a galvanometer as this, provided with a high and low resistance coil, would meet all the wants of most laboratories.

In another form called the marine galvanometer, the mirror is strung on a fibre stretched between two fixed points. In order to keep the needle from being influenced by the rolling of the ship, its centre of gravity is carefully adjusted so as to be in the axis of suspension. The mirror is enclosed in a narrow cell which just allows it room to deflect to the required extent, and damps the oscillation so effectually that the instrument is "dead beat." In order to destroy the directive action of the earth, the inconvenience of which in a galvanometer for use on board ship is obvious, the case of this galvanometer is made of thick soft iron, which completely encloses the whole, leaving only a small window for the ingress and egress of the ray of light by means of which the motions of the mirror are read; a flat horse-shoe magnet placed on the top of the case still farther overpowers the earth's force and directs the mirror.

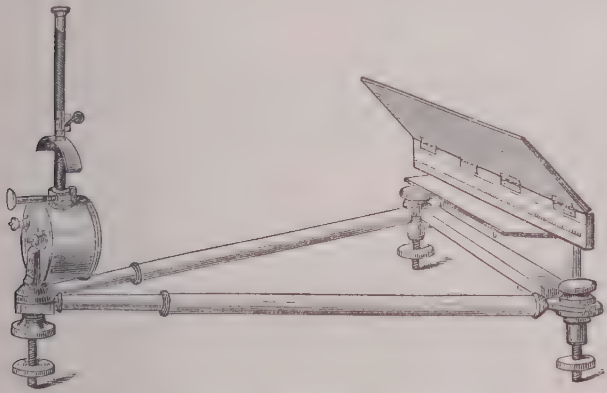

Fig. 5.—Form of Thomson's Galvanometer.

All these galvanometers may, of course, be wound double and used differentially. When this is the case, a small auxiliary compensating coil is often used to correct the inequality of the magnetic fields due to the two sets of windings. This auxiliary coil is usually mounted on a spindle in the axis of the main coil, and can be moved backwards and forwards till a current passing through it and one set of windings in one direction, and through the other set of windings in the other direction, does not sensibly deflect the mirror.

The astatic arrangement described above (p. 46, fig. 4) is often adopted. A galvanometer of this construction by Elliot Brothers is shown in fig. 6. It may be questioned, however, whether for ordinary purposes the additional sensibility thus gained compensates for the increased complexity and cost of the instrument.

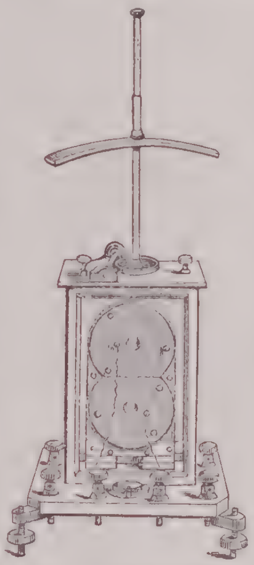

Fig. 6.—Elliot's Astatic Galvanometer.

Standard Galvanometers.—When galvanometers are intended for measuring currents, there must be some law connecting the indications of the needle with the strength of the current in the multiplier. It is therefore of great importance that slight variations in the position of the magnet should not introduce large or irregular (incalculable) variations into the indications of the instrument. Accordingly in standard instruments the windings are much farther removed from the magnet than in sensitive galvanometers, and in the best forms the multiplier is so disposed that it produces a uniform field of magnetic force around the needle.

The earliest forms of standard galvanometer were the tangent and sine compasses invented by Pouillet. The first of these consists simply of a single vertical coil of wire, with a magnet suspended at its centre, whose deflection may be read in any of the various ways already described. If the length of the magnet be very small, the magnetic field in its neighborhood may be regarded as uniform, and the electro-magnetic couple will be proportional to $\cos\theta$, θ being the deflection from the plane of the windings. If the windings be arranged so as to be in the magnetic meridian,[2] the couple due to the earth's action tending to bring the magnet back to its position of equilibrium will be proportional to $\sin\theta$, hence the current strength will be proportional to $\tan\theta$.

If the multiplier be movable about a vertical axis through angles which can be measured in any way, the instrument may be used as a sine compass. The current is applied and the multiplier turned round after the magnet until the axis of the latter is again parallel to the windings. The current strength is now clearly proportional to $\sin\theta$, where θ is the deflexion of the multiplier from the magnetic meridian. When the instrument is used in this way, the needle being always brought into the same position relative to the windings, the uniformity of the magnetic field is a matter of indifference, and there is no necessity for the needle to be short.

Gaugain attempted to improve the tangent galvanometer by suspending the magnet excentrically at a point in the axis of the coil distant from the centre by half the radius of the coil. This, however, is in reality the reverse of an improvement.[3]

A real advance, however, was made by Helmholtz, who placed two equal parallel and vertical coils, one on each side of the magnet, each at a distance from it equal to half the common radius. In fig. 19, at the end of his second volume, Maxwell gives a diagram of the lines of force due to two equal parallel circular circuits, from which it will be seen that the magnetic field at the centre of such an arrangement of currents is very approximately uniform. This approximation may be carried still farther by adding a third coil parallel to the two others, and equidistant from them. In some examples of Helmholtz's galvanometer the windings are arranged on a conical surface, so that the ratio of the radius of each to the distance of its plane from the centre of the magnet shall be 2 : 1. In reality this is unnecessary, provided the ratio of the depth and breadth of the usual rectangular channel be properly adjusted (see Maxwell, vol. ii. sec. 713). Fig. 7 represents a galvanometer of the kind described.

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[1] This arrangement is that adopted by White of Glasgow in the galvanometers made by him after Sir Wm. Thomson's pattern.

[2] This can be done most easily by means of a mirror attached to the multiplier and adjusted so as to be parallel to the windings.

[3] See Maxwell, *Electricity and Magnetism*, vol. ii., secs. 712, 713.

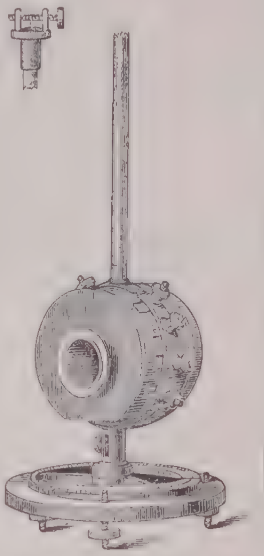

Fig. 7.—Galvanometer designed by Professor Maxwell.

The wire is wound in two parallel channels cut in a cylindrical block of hard wood, each an inch broad and an inch deep. The radius of the bottom of each channel is one inch, and the distance between them is half an inch. The cylindrical perforation in the core of the multiplier is $1\frac{3}{8}$ inch in diameter—large enough to allow the needle to swing freely without causing irregular air currents, etc. Into the ends of the core are screwed two caps containing a piece of plane parallel glass and a plano-convex lens respectively, the former for subjective, the latter for objective reading. By means of a slit and screw in the stem which supports the instrument, a horizontal bar can be fixed parallel to the axis of the multiplier. On this a deflecting magnet can be mounted, so that the galvanometer can be used as a magnetometer.

Reduction of Galvanometer Indications.—When the position of every layer of wire in the multiplier is known with sufficient accuracy, and the multiplier arranged so as to produce a sensibly uniform field, the electro-magnetic action per unit of current can be calculated for every position of the magnet. In this case the galvanometer is an *absolute* instrument. When we possess one absolute instrument it is easy to evaluate the indications of any other in absolute measure by means of it; we have only to pass the same current through both galvanometers in series and compare the readings. The best way, however, to construct a standard galvanometer is to provide for uniformity of field in the core of the multiplier, and find the resultant electro-magnetic force for unit current, or, as it is called, the constant of the instrument, by comparison with a pair of equal standard coils of large diameter (18 in. to 24 in.). These are arranged vertically on the same axis, the distance between them being equal to the mean radius, just as in Helmholtz's galvanometer. The galvanometer to be tested is placed symmetrically between the standard coils, the centre of its multiplier being near the centre of the whole arrangement, and the axes of all the coils coincident. A multiple arc is then formed, one branch of which contains the coils and the other the galvanometer, so that the magnetic actions oppose each other. The resistances of the two branches are then adjusted till the galvanometer needle gives no indication when a current is sent through the multiple arc. The whole arrangement will be understood from fig. 8. If R and S be the resistances in the branches containing the galvanometer and coils respectively, then the constant of the galvanometer is to that of the coils as R : S; so that when the latter is calculated[1] the former is known.

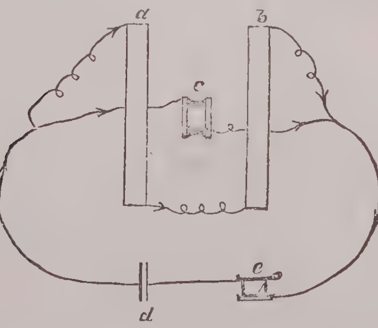

Fig. 8.

The constant of the galvanometer G being known, the value of a current producing a deflexion θ is given in absolute measure by

$$I = \frac{H}{G} \tan \theta,$$

H being the horizontal component of the earth's magnetic force.

In many cases it is necessary to correct for the torsion of the suspending fibre. The value of this correction is easily found by turning the multiplier[2] through 90° either way, and observing how far the needle follows it. The reader will find all necessary details in Maxwell, vol. ii., secs. 452, 742.

In all cases where great accuracy is required it is advisable to *graduate*, or, as it is sometimes said, to *calibrate* the galvanometer, that is, to compare the electro-magnetic couple exerted by the multiplier when the needle is deflected through an angle θ with that when the needle is parallel to the windings. It is easy to see that this may be done by means of the arrangement described above for finding the constant of a galvanometer. If the object simply is to calibrate the galvanometer without reducing its indications to absolute measure, the standard coils may be replaced by a single coil of sufficient magnetic moment placed in the axis of the multiplier. Another method of calibration, which is simpler, and in some respects more satisfactory, although possibly more laborious, will be understood from fig. 9. The resistance a is equal to the resistance of the galvanometer, and they can be rapidly interchanged. By adjusting f the ratio of the currents in the branches of the multiple arc may be varied as we please, and by varying e the current in one of the branches can always be brought to a standard strength, say that which produces unit deflexion of the galvanometer needle. We can thus, by repeatedly interchanging a and b, compare the deflexions produced by a series of currents whose strengths are given multiples of the standard strength. If the experimenter has two galvanometers at his disposal the interchanges may of course be avoided.

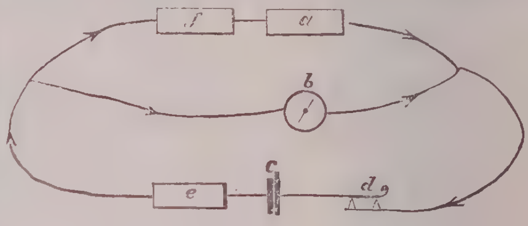

Fig. 9.

On the Use of the Galvanometer.—We may add a few remarks on the different uses to which a galvanometer may be put.

Detection of Currents.—One of the commonest of all the uses of a galvanometer is to indicate the currents sent through telegraph wires or cables. In the case of submarine cables, where the currents are often very feeble, dead-beat galvanometers of Thomson's or Varley's construction are used.

When a current is to be detected which produces a very small or quite insensible permanent deflexion, the following process, called the method of multiplication, is sometimes used. The period of oscillation of the needle is first found; then, the needle being at rest or only swinging through a very small arc, the current is applied through half the period of oscillation so as to urge the needle in the direction in which it is going, then intermitted for half a period, then applied again, and so on. If a current in the supposed direction really exist, the oscillations of the magnet will gradually increase, until the energy supplied by the intermittent action of the current is equal to that wasted by the damping of the needle.

It is obvious that this process is more effective the smaller the damping of the needle; it leads to no advantage whatever with a dead-beat instrument.

Resistance Measuring.—In comparing resistances, sensitive galvanometers of Sir William Thomson's construction[3] are by far the most convenient; the dead-beat arrangement is essential for rapid work.

If a differential galvanometer of given dimensions be used (see art. Electricity, p. 41), and if the resistance of the battery is negligible compared with the other resistances used, the wire with which it is wound should be chosen so that its resistance is one-third of the resistance to be measured.[4]

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[1] See for such calculations Maxwell, vol. ii., chaps. xiv. and xv.

[2] Or the piece to which the fibre is attached, if it is not rigidly attached to the multiplier.

[3] See Sir W. Thomson on resistance measurement, *Proc. R. S.*, 1862, p. 313.

[4] Schwendler, *Phil. Mag.*, 1872.

It is shown in the art. ELECTRICITY (p. 41) that, in arranging a Wheatstone's bridge to measure a given resistance, all the arms of the bridge and the battery and galvanometer should have equal resistances. As a rule, all these are not at our disposal. If the resistances of the arms and of the battery are given, and the resistance of the galvanometer (of given dimensions), is at our disposal, then the resistance of the galvanometer ought to be equal to that of the multiple arc which remains between the terminals of the galvanometer when the battery is disconnected from the bridge.[1] This may be deduced at once from the expression given in vol. viii. p. 42.

Again, the resistance to be measured and the battery and galvanometer resistance being given, we may inquire what is the best arrangement of the arms of the bridge.

Differentiating the expression given in vol. viii. p. 42 with respect to y and z, we get

$$\mathrm{BG} - y^2z^2\mathrm{R}^2 = z\{y^2(\mathrm{R}+\mathrm{G})\mathrm{R} - \mathrm{G}(\mathrm{R}+\mathrm{B})\}\,,$$
$$\mathrm{BG} - y^2z^2\mathrm{R}^2 = y\{z^2(\mathrm{R}+\mathrm{B})\mathrm{R} - \mathrm{B}(\mathrm{R}+\mathrm{G})\}\,;$$

the solution of which is obviously

$$y = \sqrt{\frac{\mathrm{G}(\mathrm{R}+\mathrm{B})}{\mathrm{R}(\mathrm{R}+\mathrm{G})}}\,, \qquad z = \sqrt{\frac{\mathrm{B}(\mathrm{R}+\mathrm{G})}{\mathrm{R}(\mathrm{R}+\mathrm{B})}}\,;$$

whence we have $\mathrm{S} = \sqrt{\mathrm{RG}\cdot\frac{\mathrm{R}+\mathrm{B}}{\mathrm{R}+\mathrm{G}}}$,

$$\mathrm{T} = \sqrt{\mathrm{RB}\cdot\frac{\mathrm{R}+\mathrm{G}}{\mathrm{R}+\mathrm{B}}}\,, \text{ and } \mathrm{U} = \sqrt{\mathrm{BG}}\text{—}$$

determining the resistances of the disposable arms.

It appears that, when B and G are given, the resistance of the arm opposite to the resistance to be measured ought always to be the geometric mean between B and G.[2]

In a certain class of observations a needle with large moment of inertia is used. The methods in use are mostly due to Gauss and Weber. For an account of these methods the reader is referred to Maxwell, chap. xvi. He should also consult a paper by Du Bois Reymond in *Monatsber. d. Berl. Acad.*, 1869–70. (G. CH.)

GALVESTON[*] (*copyright, 1879, by A. & C. Black*), a city and port of entry on the coast of Texas, United States of North America, situated about 340 miles to the westward of the mouth of the South Pass of the Mississippi River, on the south side of the entrance into Galveston Bay, in 29° 18′ N. lat. and 94° 47′ long. west from Greenwich. It is the principal port and the largest city in the State, is the seat of justice of Galveston County, and is located on the inner shore of Galveston Island, about 2 miles from its most north-easterly point, known as Fort Point. The city, therefore, faces the main Texas shore, being separated from it by West Bay, lying between the island and the mainland. The principal portion of the county lies on the mainland fronting the two bays above named, its general surface, like that of the island, being low and level, and the soil sandy.

Galveston Island is a low, sandy island, about 28 miles long and 1½ to 3½ miles wide, stretching along the coast of Texas in a north-easterly and south-westerly direction, and forming the gulf coast-line throughout its entire length. Its surface, which has an average height of 4 to 5 feet above tide level, is diversified by a number of freshwater ponds and intersected by several creeks and small bayous. The beach, on the Gulf side, furnishes a smooth and pleasant drive during low-water stage, and excellent surf-bathing at all times. To the northward of the entrance into the harbor, the coast-line is continued in the same general direction to the north-east by Bolivar Peninsula, a low, narrow sand-strip of the mainland, the width of the throat of the harbor between Fort Point and Bolivar Point being about 2 miles. There is a lighthouse on Bolivar Point.

Galveston Harbor is the finest in the State; and the bay of the same name, including certain outlying portions of it known severally as East Bay, West Bay, and Turtle Bay, covers an area of upwards of 450 square miles of tidal water. At the head of the bay, about 35 miles from the city in a northerly direction, it receives Trinity River, its largest tributary, while San Jacinto River and Buffalo Bayou enter it from the west 18 miles lower down.

The mean rise and fall of tide at Galveston is $1\frac{1}{10}$ feet, but spring-tides occasionally rise more than 3 feet above, and fall nearly 2 feet below the plane of mean low water, and fluctuations between much wider limits are not uncommon under the influence of heavy winds. During a storm which occurred in October, 1867, the water rose $6\frac{6}{10}$ feet above mean low-water stage, and in September, 1875, it rose in some portions of the bay 7 feet, and in others 9½ feet above the same level. Two years later there was a rise of $5\frac{2}{10}$ feet, produced by an on-shore wind which reached a maximum velocity of 60 miles per hour. The lowest tide of which we have any record fell $3\frac{2}{10}$ feet below mean low-water level, thus giving a difference of $12\frac{7}{10}$ feet between the highest and the lowest recorded tides.

A sand-bar, produced and maintained by the joint action of waves and currents, stretches across, bow-shaped, in front of the entrance into the bay, restricting the draught of vessels entering the harbor to from 12½ to 13 feet. The United States Government has undertaken the improvement of this entrance by means of two jetties, one starting from Fort Point and the other from near Bolivar Point, having an aggregate length of about 7 miles. It is the intention to carry them out to and beyond the crest of the bar on converging lines, so that their sea-ends, resting in about 18-feet water on the outer slope of the bar, will be about 1 mile apart. It is expected that these jetties will cost about $2,000,000, and that they will produce and maintain a practicable channel depth of 18 to 19 feet at mean low-water. Once inside this bar, a draught of fully 20 feet can be carried to the wharves of the city. The Bolivar Point Jetty in August, 1879, had reached a length of 8000 feet from the shore. That from Fort Point had not been carried out so far. The peculiar mode of construction adopted for these works by the superintending engineer, Major C. W. Howell, United States Corps of Engineers, merits some notice here. The jetties are formed with large gabions, or basket-work cylinders, plastered inside and out with hydraulic cement, so as to give a thickness of 5 to 6 inches to the cylindrical wall. The gabions are either circular, with a diameter of 6 feet, or of an oval cross-section, with diameters of 6 feet and 12 feet respectively. They are closed at the bottom, and are also provided with a tight-fitting wooden cover. After being sunk to their proper positions in the work, on their ends, arranged in a single or double row, they are filled with sand pumped up from the bottom and passed in through a hole left in the gabion cover. At first these gabions were placed directly upon the bottom, but the action of the sea and currents caused so much underscour and settlement, that a foundation of fascines formed into a mattress and weighted with stones was resorted to. On the most exposed portions of the works about one-sixth of the number of gabions put into position have been destroyed by heavy storm-waves, so that this method of construction cannot as yet be regarded as past the experimental stage.

Galveston was first settled in 1837. It is handsomely laid out upon ground elevated from 6½ to 10 feet above ordinary tide level, has wide and straight streets, and has several public squares, parks, and gardens. The streets running parallel to West Bay are known as avenues, and are designated by the letters of the alphabet, beginning at the bay, while those at right angles to the water are numbered. Special names are assigned to some of the streets. Avenue A, parallel and next to the wharf or channel front, is mostly occupied by wholesale houses. Next comes Avenue B, or "The Strand," and then Avenue C, or Mechanic Street, both devoted largely to the wholesale business. Avenue D, or Market Street, for a distance of seventeen squares, is occupied by retail stores, shops, restaurants, hotels, banks, etc. This is the main shopping street. Avenues E and F are of the same character. The post-office and United States court-house are at the intersection of Avenue F and 20th Street, and the custom-house is near by. Avenue J, or Broadway, is regarded as the most desirable locality for residences. It is 150 feet wide, including an esplanade 36 feet wide through the middle and a 16-foot sidewalk on either side. Bath Avenue, at right angles to Broadway, is 120 feet wide. Fremont, or 23d Street, is the principal drive in the city, and is maintained as a shell road from "The Strand" to the Gulf beach. With the exceptions named, the streets are 80 feet and the avenues 70 feet wide, including 16 feet sidewalks, and the blocks or squares are uniformly 260 feet wide and 300 long, with an alley 20 feet wide running lengthwise through the middle, along the rear of the lots. The portion of the city built over extends from about 6th to 40th Streets, and from Avenue A south to within two to three blocks of the Gulf beach. The only streets paved are four or five blocks on Avenues B, C, and D. They are paved with blocks of heart cypress. The same avenues are shelled from between 10th to 32d Streets, or thereabouts, with clam shells from 18 to 30 inches deep. Trees are planted very generally on the outer edge of the sidewalks, the oleander being the chief growth. It frequently attains a height of 20 to 25 feet, and grows rapidly from slips with great luxuriance, blooming the year round. The fig, orange, the black Hamburg and other kinds of grape, and many varieties of flowers and evergreen shrubbery, thrive and flourish. Throughout the most thickly-settled portions of the city the sidewalks are paved with either asphaltum, concrete, brick, or

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[1] Schwendler, *Phil. Mag.*, 1866.

[2] Heaviside, *ibid.*, 1873.

[*] This is reprinted here from the work entitled *Galveston*, by Maj.-Gen. Q. A. Gillmore, U. S. Engineers. New York, Charles Scribner's Sons, 1879. Copyright, 1879, by A. & C. Black.

German or English tiles. Oleander Park embraces 80 acres, and the city park about 25 acres, and there are three public gardens and six public squares. The business portion of the city is built up mostly with brick, and within certain defined fire limits the erection of wooden buildings is prohibited.

Among the public buildings, other than churches, are a post-office, custom-house, United States court-house, a county court-house, a county and city prison, a city hall, an opera house, 7 public halls, 2 libraries, 2 theatres, 13 hotels of different grades, and 3 market houses. There are 30 schools of all kinds, 15 church edifices, a Roman Catholic university or college (St. Mary's), a medical school, a convent, a house of refuge, an orphan asylum, and 3 hospitals. The St. Mary's university was founded in 1854, and in 1872 had 8 professors and 35 collegiate and 115 preparatory students. The medical school, founded in 1864, had ten years thereafter 6 professors. The convent (Ursuline) has 25 nuns and a female academy connected with it. There are two other female academies in the place. There are published in the town a number of daily, tri-weekly, and weekly papers. Galveston is a bishop's see of the Roman Catholic Church. The city is well connected by railroad with different parts of the State, and by regular steamship lines with Liverpool, New York, Havana, New Orleans, and the ports of Texas. The Galveston, Houston, and Henderson Railroad crosses West Bay on a wooden bridge 2 miles long, and by means of the Galveston Wharf Railroad delivers and receives freight at the several wharves of the city. The Gulf, Colorado, and Santa Fé Railroad, now building from Galveston to Belton, in Bell County, a distance of 220 miles, is finished (September, 1879) as far as Richmond, a distance of 63 miles, and 57 miles more to Brenham will be finished by January 1, 1880. The entire road to Belton is to be completed by September, 1881. This road crosses the Brazos River, below Richmond, on an iron bridge, and has a wooden bridge of its own across West Bay. There are no highway bridges connecting Galveston Island with the mainland.

The cotton business of the place is represented by six cotton presses and many immense brick warehouses, furnishing storage-room for nearly 200,000 bales of cotton, and covering an area of more than 50 acres. There are two national banks, with an authorized capital of $800,000, and a paid-up cash capital of $300,000,—the aggregate paid-up capital of all the banks being upwards of $2,000,000. The assessed value of real estate in 1878 was over $20,000,000, and the bonded debt $1,200,000.

Galveston is a healthy city, possesses a delightful climate, and has not been afflicted with an epidemic disease since 1867.

The following table, giving the temperature, the barometric pressure, and the rainfall at this place for five years ending June 30, 1878, has been compiled from the reports of the Chief Signal Office, United States Army :—

Year ending June 30.	Temperature, Fahr.			Mean Annual Barometric Pressure.	Annual Rainfall.
	Highest.	Lowest.	Annual Mean.		
				Inches.	Inches.
1874	98·5°	.....	72·8°	30·051	54·49
1875	98·5°	24°	69·6°	30·063	46·66
1876	97·0°	40°	70·9°	30·050	70·59
1877	96·0°	30°	68·7°	30·073	42·99
1878	97·0°	30°	70·2°	29·997	67·47

There was only one occasion during the five years, and that occurred on the 10th of January, 1875, when the temperature fell below 30° F.

The population of the city was more than trebled during the twenty years ending in 1870, and the local authorities claim that since 1870 the rate of increase has been more rapid still, and that in 1874 the population had reached between 25,000 and 30,000. A municipal census taken in 1876 made the population 35,000, which is believed to be too high. The past and estimated present population are given below :—

Year.	White.	Colored.	Total.
United States Census of 1850.........	3,469	708	4,177
United States Census of 1860.........	6,127	1,180	7,307
United States Census of 1870.........	10,810	3,008	13,818
Estimated for 1879.........................	...	...	31,000

In the business of receiving and shipping cotton, the leading production of the Southern States, Galveston ranks third in importance among the ports of the United States, New Orleans and Savannah standing before it, and Charleston, Norfolk, and Mobile after it in the order named. More than one-tenth of the cotton crop of the country finds a market through the port of Galveston. The following table shows the yearly receipts of bales of cotton at the six ports above named, for five years ending September 1, 1879 :—

Ports.	1878–79.	1877–78.	1876–77.	1875–76.	1874–75.
New Orleans ...	1,175,415	1,391,555	1,182,357	1,401,563	982,198
Savannah........	690,901	597,449	477,477	521,437	605,566
Galveston........	573,274	454,137	491,980	465,529	354,927
Norfolk...........	442,458	425,214	505,932	469,997	382,387
Charleston	449,888	423,128	442,515	389,698	413,101
Mobile............	362,522	414,332	357,879	371,298	319,263

The value of imports from foreign countries for the two years ending July 31, 1878, was as follows :—

	1877–78.	1876–77.
Imports of free commodities..............	$952,713	$1,155,808
Imports of dutiable commodities........	194,615	201,680
Total..........................	$1,147,328	$1,357,488

The leading importations comprise coffee from Brazil and Mexico, and manufactured cotton, woollen, and iron goods. The duties collected during the year ending July 31, 1878, amounted to $62,352.73, as against $95,980.49 during the previous year.

The value of domestic commodities, consisting largely of cotton, oil-cake, cattle, preserved meats, bone dust, cotton seeds, and lumber, exported to foreign countries during the year ending July 31, 1878, amounted to $11,963,132, as against $15,242,747 for the previous year.

The number and tonnage of vessels entered and cleared at the port of Galveston annually, for the six fiscal years ending June 30, 1878, are shown in the following tables :—

Coasting Trade.

Entered.			Cleared.		
Years.	Number of Vessels.	Tonnage.	Years.	Number of Vessels.	Tonnage.
1877–8	198	192,114	1877–8	291	291,264
1876–7	388	407,382	1876–7	301	263,792
1875–6	428	435,535	1875–6	311	290,956
1874–5	460	428,334	1874–5	531	285,970
1873–4	490	450,830	1873–4	315	274,919
1872–3	636	569,206	1872–3	422	424,848

Foreign Trade.

Entered.			Cleared.		
Years.	Number of Vessels.	Tonnage.	Years.	Number of Vessels.	Tonnage.
1877–8	130	72,585	1877–8	135	82,300
1876–7	167	99,386	1876–7	165	102,744
1875–6	177	85,598	1875–6	191	107,192
1874–5	167	99,175	1874–5	208	127,527
1873–4	206	124,316	1873–4	241	145,237
1872–3	156	79,170	1872–3	175	92,998

The decrease in the number of coasting vessels entered and cleared is accounted for in part by the fact that the Morgan line of steamers from New Orleans, which formerly entered here, now proceed up the bay to Clinton with original manifest, and make the entry there, merely touching at Galveston to land freight, passengers, and mails.

The number of documented vessels owned in the customs district of Galveston during the year ending June 30, 1878, was 197, with an aggregate tonnage of 9310 tons; built during the year, 9, with an aggregate tonnage of 239 tons; and lost at sea, wrecked, or abandoned, 16, with a total tonnage of 387 tons.

GALWAY, a maritime county in the province of Connaught, in the extreme west of Ireland, between 52° 54′ and 53° 43′ N. lat., and 7° 57′ and 10° 20′ W. long. It is bounded on the N. by Mayo and Roscommon; E. by Roscommon, King's County, and Tipperary; S. by Clare and the Bay of Galway; and W. by the Atlantic Ocean. The area comprises 2447 square miles, or 1,566,354 acres, of which 90,230 are under water.

Surface.—The county is naturally divided by Lough Corrib into two great divisions. The eastern, which comprehends all the county except the four western baronies, rests on a limestone base, and is, generally speaking, a level champaign country, but contains large quantities of wet bog. Its southern portion is partly a continuation of the Golden Vale of Limerick, so celebrated for its fertility, and partly occupied by the Slievebaughty Mountains. The northern portion of the division contains rich pasture and tillage ground, beautifully diversified with hill and dale. Some of the intermediate country is comparatively uncultivated, but forms excellent pasturage for sheep. The western division of the county has a substratum of granite, and is barren, rugged, and mountainous. It is divided into the three districts of Connemara, Jar-Connaught, and Joyce's

Country; the name of Connemara is, however, often applied to the whole district. Its highest mountains are the grand and picturesque group of Binabola, or the Twelve Pins, which occupy a space of about 25 square miles, the highest elevation being about 2400 feet. Much of this district is a gently sloping plain, from 100 to 300 feet above sea-level. Joyce's Country, further north, is an elevated tract, with flat-topped hills of from 1300 to 2000 feet high, and deep narrow valleys lying between them.

Coast.—Galway enjoys the advantage of a very extended line of sea-coast, indented by numerous harbors, which, however, are rarely used except by a few coasting and fishing vessels. Commencing at the coast of Mayo in the north are the Killeries, two bays which separate the counties of Galway and Mayo. The first bay on the western coast capable of accommodating large ships is Ballynakill, sheltered by Freaghillaun or Heath Island. Next in succession is Cleggan Bay, having Inishboffin in its offing. Streamstown is a narrow inlet, within which are the inhabited islands of Omey, Turbot, and Inishturk. Ardbear harbor divides itself into two inlets, the northern terminated by the town of Clifden, with excellent anchorage opposite the castle; the southern inlet has also good anchorage within the bar, and has a good salmon-fishery. Mannin Bay, though large, is much exposed, and but little frequented by shipping. From Slyne Head the coast turns eastward to Roundstone Bay, which has its entrance protected by the islands of Inishnee and Inishlacken. Next in order is Birterbuy Bay, studded with islets and rocks, but deep and sheltered. Kilkerrin Bay, the largest on this coast, has a most productive kelp shore of nearly 100 miles; its mouth is but 8 miles broad. Between Gorumna Island and the mainland is Greatman's Bay, and close to it Costello Bay, the most eastern of those in Connemara. The whole of the coast from Greatman's Bay eastward is comprehended in the Bay of Galway, the entrance of which is protected by the three limestone islands of Aran—Inishmore (or Aranmore), Inishmann, and Inisheer.

Rivers.—The rivers are few, and, except the Shannon, are of small extent. The Suck, which forms the eastern boundary of the county, rises in Roscommon, and passing by Ballinasloe, unites with the Shannon at Shannon bridge. The Shannon, which rises at the foot of Cuilcagh in the county of Cavan, forms the south-eastern boundary of the county, and passing Shannon Harbor, Banagher, Meelick, and Portumna, swells into the great expanse of water called Lough Derg, which skirts the county as far as the village of Mount Shannon. The Claregalway flows southward through the centre of the county, and enters Lough Corrib some 4 miles above the town of Galway. The Ballynahinch, considered one of the best salmon-fishing rivers in Connaught, rises in the Twelve Pins, passes through Ballynahinch Lake, and after a short but rapid course falls into Birterbuy Bay.

Lakes.—The lakes are numerous. Lough Corrib extends from Galway town northwards over 30,000 acres, with a coast of 50 miles in extent. It has now been made navigable to Lough Mask (which lies chiefly in Mayo county) and to the sea at Galway. The lake is studded with many islands, some of them thickly inhabited. Near it is Lough Ross, which receives a large supply of water from streams, but has no visible outlet. The district to the west of Lough Corrib contains in all about 130 lakes, about 25 of them more than a mile in length. Lough Rea, at the town of the same name, is more remarkable for scenic beauty than for extent. Besides these perennial lakes, there are several low tracts, called turloughs, which are covered with water during a great part of the year.

Geology and Minerals.—The boundary line between the limestone and granitic district is easily discernible by the diminution of the verdant hue which distinguishes the latter. The high road from Galway to Oughterard nearly marks the division. All the country to the north and east of this limit is limestone, all to the south and west granite, excepting some detached masses of primitive limestone between Oughterard and Clifden, and some scattered portions of other minerals, of great variety of appearance. The component rock of Binabola is quartz, in general distinctly stratified, or at least schistose. The position of its beds is various. Towards the western shore they are vertical, easily splitting by intervening mica plates, and affording good building stone. Limestone occurs in some places along the foot of these mountains. Round the base of this group are also gneiss and mica slate, with bands of hornblende and primitive mica. Along the north side of Lough Corrib to Ballynakill the mica slate and hornblende rise into mountains, and the limestone disappears. From Lough Mask to the Killeries is a transition country of greenstone and grauwacke slate covered by the Old Red Sandstone or conglomerate. The hill of Glan, on the shore of Lough Corrib, exhibits, in a small compass, all the formations which occur in the district. The western end is quartz, the north-eastern side mica slate; the middle is penetrated by beds of mica slate, containing hornblende and granular mica covered by thick beds of pyritous greenstone. On the south and east are granite and syenite, which runs under the sandstone conglomerate towards Oughterard, and this again passes under the flötz limestone, which, beyond Lough Corrib, occupies the greater part of Connaught and Leinster. Along the borders of the flötz limestone is a series of vast caverns, usually traversed by subterranean rivers. A fine gritstone, highly valued for making millstones, is raised near Dunmore. Crystalline sand, of a superior quality for scythe boards, occurs at Lough Coutra. Lead, zinc, copper, sulphur, and bismuth have been discovered in various parts of the western division of the county. Iron was raised at Woodford, and smelted until the timber was exhausted. The mountains of Slievebaughty, which separate Galway from Clare, are siliceous. In Connemara there is abundance of green variegated marble called serpentine; and a beautiful black marble, without spots or flaws, and susceptible of a high polish, is obtained near Oughterard. Mineral spas, mostly chalybeate, are abundant.

Climate and Agriculture.—The climate is mild and salubrious, but variable, and violent winds from the west are not uncommon. Frost or snow seldom remains long on the western coast, and cattle of every description continue unhoused during the winter. The eastern part of the county produces the best wheat. Oats are frequently sown after potatoes in moorish soils less adapted for wheat. The flat shores of the bays afford large supplies of seaweed for manure. Limestone, gravel, and marl are to be had in most other parts. When a sufficient quantity of manure for potatoes cannot be had, the usual practice is to pare and burn the surface. In many places on the sea-shore fine early potatoes are raised in deep sea-sand, manured with sea-weed, and the crop is succeeded by barley. Those parts of the eastern district less fitted for grain are employed in pasturage. Heathy sheep-walks occupy a very large tract between Monivea and Galway. An extensive range from Athenry, stretching to Galway Bay at Kinvarra, is also chiefly occupied by sheep.

The total area under crop in 1878 was 214,685 acres, as compared with 235,168 in 1853. The following tables show the acres under the principal crops, and also the numbers of the different domestic animals, during those years:—

	Wheat.	Oats.	Barley, Pease, etc.	Potatoes.	Turnips.	Other Green Crops.	Meadow and Clover.
1878	4,416	53,205	8,095	50,604	14,041	8,910	75,333
1853	16,817	83,840	15,751	46,134	18,788	10,764	45,780

	Horses.	Asses.	Cattle.	Sheep.	Pigs.	Goats.	Poultry.
1878	28,538	14,384	169,002	652.778	57,314	10,927	751,116
1853	25,916	13,714	139,497	466,430	41,403	16,632	410,199

According to the returns of 1875–6, the total value of land, exclusive of the town of Galway, was £437,686 15s., and the average value per acre was 5s. 11¾d., as compared with 6s. 9d. for the province, and 13s. 3d. for the whole of Ireland. The county was divided among 1235 proprietors, of whom 332, or 27 per cent., held less than one acre. The following possessed more than 20,000 acres, viz.: Richard Berridge, 159,898; Marquis of Clanricarde, 49,025; Lord Dunsandle, 33,543; Allan Pollok, 29,366; Lord Clonbrock, 28,246; Sir Thomas J. Burke, 25,258; Earl of Clancarty, 23,896.

Manufactures.—Manufactures are not carried on beyond the demand caused by the domestic consumption of the people. Coarse friezes, flannels, and blankets are made in all parts, and sold largely in Galway and Loughrea. Connemara has been long celebrated for its hand-knit woollen stockings. Coarse linen, of a narrow breadth, called bandle linen, is also made for home consumption. A linen-weaving factory has been established at Oughterard. The manufacture of kelp, formerly a great source of profit on the western shores, is still carried on to some extent. Feathers and sea-fowls' eggs are brought in great quantities from the islands of Aran, the produce of the puffins and other sea-fowl that frequent the cliffs. Fishing affords occupation to many of the inhabitants, but from want of capital is not prosecuted with sufficient vigor. In 1877 the number of vessels engaged was 451, with 1104 men and 58 boys.

Population.—The county includes one parliamentary borough, Galway; and three townships, Ballinasloe (part of which is, however, in the county of Roscommon), 4159; Loughrea, 3072; and Tuam, 4223. The largest of the villages are Gort, 1773; Clifden, 1313; Athenry, 1194; Headford, 870; Oughterard, 861; and Eyrecourt, 747. The population in 1831 was 414,684; in 1851, 321,684; and in 1871, 248,458, of whom 122,496 were males and 125,962 females. In 1871 the number of Catholics was 239,902, and of Protestants 8556, of whom 7464 were Episcopalians and 615 Presbyterians. Of persons five years and upwards 173,361 were illiterate, a proportion of 56·9 per cent.; and 30,239 could speak Erse only, as compared with 41,572 in 1861. Emigration from this county has drafted off a very large number of its inhabitants. From the 1st of May, 1851, to 31st December, 1877, there were 104,691 emigrants, or an annual average of 3950.

Representation and Administration.—Two members of parliament are returned for the county, and two for Galway borough. There are in the county 35 petty-sessions districts, and part of another. Quarter-sessions are held at Ballinasloe, Clifden, Galway, Gort, Loughrea, Oughterard, Portumna, and Tuam. There are five poor-law unions wholly within the county, Galway, Loughrea, Mount Bellew, Portumna, and Tuam; nearly the whole of Clifden, Gort, and Oughterard; and parts of five others—Ballinsaloe, Ballinrobe, Glennamaddy, Roscommon, and Scarriff. The county is within the Dublin military district, and there are barrack stations at Loughrea, Dunmore, Portumna, Galway, Gort, and Oughterard. It is divided into 18 baronies.

Antiquities.—Amongst these are the round towers of Ardrahan, Ballygaddy, Kilbannon, Kilmacduagh, Meelick and Murrough. Raths are numerous, and several cromlechs are still to be seen in good preservation. The ruins of monastic buildings are also numerous. That of Knockmoy, about 6 miles from Tuam, said to have been founded in 1180 by Cathal O'Connor, was adorned with rude fresco paintings, still discernible, which were considered valuable as being the best authentic representations existing of ancient Irish costumes. Ancient castles and square towers of the Anglo-Norman settlers are frequently met with; some have been kept in repair, but the greater number are in ruins. The castle of Tuam, built in 1161 by Roderick O'Connor, king of Ireland, at the period of the English invasion, is said to have been the first building of this description of stone and mortar in Ireland. The remains of a round castle, a form of building very uncommon in the military architecture of the country, are to be seen between Gort and Kilmacduagh.

GALWAY, the county town, and a parliamentary borough, is also a county in itself, with an exclusive jurisdiction extending two miles on every side except the south. It stands on the northern shore of the Bay of Galway, on both sides of the river Corrib, which connects Lough Corrib with the sea. The space within the walls formed an oval of about 3426 square perches. Some of the streets are very narrow, and contain several curious specimens of old buildings, chiefly in the antique Spanish style, being square, with a court in the centre, and a gateway opening into the street. The finest of these is the pile of buildings known as Lynch's Castle. During the last few years many large shops have been built in the principal streets, and several handsome residences have been erected in the suburbs. St. Nicholas church is the most remarkable building in the town. It is cruciform, 152 feet long by 126 broad, with a steeple rising over the nave, and the side aisles separated from the centre by Gothic pillars. It contains several antique monuments. The exchange, near the church, consists of an open corridor, 90 feet long by 28 broad, with a front of arches supporting an upper story, in which are apartments for holding the local courts, and for other public purposes. St. Augustine's church (Roman Catholic), an edifice in the First Pointed style, was erected in 1859. The county court-house is an elegant and commodious building; near it are the county and town prisons. The town also contains a county infirmary, a union workhouse, a fever hospital, three monasteries, five nunneries, and two barracks. A grammar-school is in the immediate neighborhood of the town. Queen's College, built of beautiful gray limestone, is an elegant and extensive quadrangular structure in the Tudor Gothic style. Near the college is a national school. The shipping trade of Galway has for some time been gradually increasing. In 1877 the number of British vessels that entered the port was 153, with a tonnage of 30,034; of foreign vessels 33, with a tonnage of 16,166. The number of British vessels that cleared was 136, with a tonnage of 29,827; of foreign vessels 27, with a tonnage of 13,225. The chief articles exported are agricultural produce, wool, and marble. There are a brewery, a distillery, a paper mill, a tannery, and several flour mills; and a company has recently been formed for the purpose of extracting iodine and marine salts from seaweed. The salmon fishery is of considerable value. Galway is divided into the old and new towns, and the maritime suburb of Claddagh, inhabited almost entirely by fishermen and their families, who have acquired or retained certain peculiar usages and habits of their own.

Little is known of the history of Galway until after the arrival of the English, at which time it was under the protection of O'Flaherty, who possessed the adjoining district to the west. On the extinction of the native dynasty of the O'Connors, the town fell into the hands of the De Burgos, the head of a branch of which, under the name of M'William Eighter, long governed it by magistrates of his own appointment. After it had been secured by walls, which began to be built in 1270, it became the residence of a number of enterprising settlers, through whom it attained a position of much commercial celebrity. Of these settlers the principal families, fourteen in number, were known as the tribes of Galway. They were of Norman, Saxon, or Welsh descent, and became so exclusive in their relationships that dispensations were frequently requisite for the canonical legality of marriages among them. The town rapidly increased from this period in wealth and commercial rank, far surpassing in this respect the rival city of Limerick. Richard II. granted it a charter of incorporation with liberal privileges, which was confirmed by his successor. It had the right of coinage by Act of Parliament, but there is no evidence to show that it exercised the privilege. Another charter, granted in 1545, extended the jurisdiction of the port to the islands of Aran, permitted the exportation of all kinds of goods except linens and woollens, and confirmed all the former privileges. Large numbers of Cromwell's soldiers are said to have settled in the town; and there are many traces of Spanish blood among the population. Its municipal privileges were extended by a charter from James I., whereby the town, and a district of two miles round in every direction, were formed into a distinct county, with exclusive jurisdiction and a right of choosing its own magistrates. During the civil wars of 1641 the town took part with the Irish, and was surrendered to the Parliamentary forces under Sir Charles Coote; after which the ancient inhabitants were mostly driven out, and their property was given to adventurers and soldiers, chiefly from England. On the accession of James II. the old inhabitants entertained sanguine hopes of recovering their former rights. But the successes of King William soon put an end to their expectations; and the town, after undergoing another siege, again capitulated to the force brought against it by General Ginkell. In the beginning of the present century the walls were thrown down, and buildings erected on their site.

Galway is governed by a high sheriff, a recorder, local magistrates, and a board of 24 commissioners elected triennially. The area of the municipal borough is 955 acres. The population in 1861 was 16,967, and in 1871, 15,597, of whom 14,424 were Roman Catholics. The parliamentary borough has an area of 22,493 acres, and a population of 19,843.

GAMA, VASCO DA (*c.* 1460–1524), the celebrated Portuguese navigator and discoverer, was born at Sines, a small sea-town in the province of Alemtejo. No one will deny that his name deservedly stands high in the roll of naval heroes; yet it cannot be doubted that he owes the brilliancy of his reputation to his country's illustrious poet, Luiz de Camoens, by whom his discoveries in India and their results have been assigned the foremost place in the great national epic *Os Lusiadas*. Of Vasco's early history little is known. His descent, according to the *Nobiliario* of Antonio de Lima, is derived from a noble family which is mentioned in the year 1166; but the line cannot be traced without interruption farther back than the year 1280, to one Alvaro da Gama, from whom was descended Estevão da Gama, Alcaide Mór of Sines, whose third son, the subject of this notice, was born probably about the year 1460. About this period died Prince Henry the Navigator, son of João I., who had spent his life in fostering the study of navigation, and to whose intelligence and foresight must be traced back all the fame that Portugal gained on the seas in the 15th and 16th centuries. Explorers sent out at his instigation discovered the Western Isles, and unknown regions on the African coast, whence continually came reports (which by and by affected Da Gama's history) of a great monarch, "who lived east of Benin, 350 leagues in the interior, and who held both temporal and spiritual dominion over all the neighboring kings," a story which tallied so remarkably with the accounts of "Prester John" which had been brought to the Peninsula by Abyssinian priests, that João II. steadfastly resolved that both by sea and by land the attempt should be made to reach the country of this potentate. In the hope of making this discovery, Pedro Covilham and Affonso de Payva were despatched eastward by land; while Bartholomeu Dias, in command of two vessels, was sent westward by sea. Neither of the landward travellers ever returned to his country; but Covilham, who, in his fruitless search for a mythical sovereign, reached the Malabar coast and the eastern shores of Africa, sent back to Lisbon along with the tales of the rich lands he had visited, this intelligence, "that the ships which sailed down the coast of Guinea ought to be sure of reaching the termination of the continent by persevering in a course to the south." King João was now seized with an ardent desire of reaching these eastern countries by the route indicated by Covilham. That there was in truth such an ocean highway was confirmed by Dias, who shortly after returned (in 1487) with the report that when sailing southward he was carried far to the east by a succession of fierce storms, past—as he discovered only on his return voyage—what he perceived to be the southern extremity of the African continent, and to which, on account of the fearful weather he had encountered, he gave the name of the Cape of Storms, an appellation which to the king, who was then elated with high hopes of enriching his kingdom by the addition of eastern possessions, appeared so inauspicious that he changed it to that of Cape of Good Hope. The state of João's health, however, and concerns of state, prevented the fitting out of the intended expedition; and it was not till ten years later, when Manoel had succeeded to the throne, that the preparations for the great voyage were completed—hastened, doubtless, by Columbus's discovery of America in the mean while. For the supreme command of this expedition the king selected Vasco da Gama, who had in his youth fought in the wars against Castile, and in his riper years gained distinction as an intrepid mariner. The fleet, consisting of four vessels specially built for this mission, sailed down the Tagus on the 8th July, 1497, after prayers and confession made by the officers and crews in the presence of the king and court, in a small chapel on the site where now stands the church of St. Maria de Belem, afterwards built to commemorate the event. Four months later it cast anchor in St. Helena Bay, South Africa, rounded the Cape in safety, and in the beginning of the next year reached Melinda. Thence, steering eastward, under the direction of a pilot obtained from Indian merchants met with at this port, Gama arrived at Calicut, on the Malabar coast, on the 20th May, 1498, and set up, according to the custom of his country, a marble pillar as a mark of conquest and a proof of his discovery of India. His reception by the zamorin, or ruler of Calicut, would have in all probability been favorable enough, had it not been for the jealousy of the Moorish traders, who, fearing for their gains, so incited the Hindus against the new comers that Gama, after escaping from enforced detention on shore, was obliged to fight his way out of the harbor. Having seen enough to assure him of the great resources of this new country, he returned home in September, 1499, with a glowing description of it. The king received him with every mark of distinction, created him a noble, and ordered magnificent fêtes to be held in his honor in the principal towns of the kingdom, "for he had brought back (not without severe loss in ships and in men) the solution of a great problem, which was destined to raise his country to the acme of prosperity." In prosecution of Gama's discoveries another fleet of 13 ships was immediately sent out to India by Manoel, under Alvarez Cabral, who, in sailing too far westward, by accident discovered Brazil, and on reaching his destination established a factory at Calicut. The natives, again instigated by the Moorish merchants, rose up in arms, and murdered all whom Cabral had left behind. To avenge this outrage a powerful armament of ten ships was fitted out at Lisbon, the command of which was at first given to Cabral, but was afterwards transferred to Gama on his urgent petition; for, "Sire," he said, "the king of Calicut arrested me and treated me with contumely, and because I did not return to avenge myself of that injury he has again committed a greater one, on which account I feel in my heart a great desire and inclination to go and make great havoc of him." In the beginning of 1502 the fleet sailed, and on reaching Calicut Gama immediately bombarded the town, enacting deeds of inhumanity and savagery too horrible to detail, and equalled only by the tortures of the Inquisition. Gama was naturally "very disdainful, ready to anger, and very rash;" but no peculiarities of disposition—nothing whatever—can excuse such acts as his, which have justly left a stain on his character that neither time nor the brightness of his fame as a navigator can in the slightest degree obliterate. From Calicut he proceeded in November to Cochin, "doing all the harm he could on the way to all that he found at sea," and having made favorable trading terms with it and with other towns on the coast, he returned to Lisbon in September, 1503, with richly laden ships. He and his captains were welcomed with great rejoicings; "but to Dom Vasco the king gave great favors, and all his goods free and exempt; he granted him the anchorage dues of India, made him admiral of its seas for ever, and one of the principal men of his kingdom." Soon after his return Vasco retired to his residence in Evora, and for twenty years took no part in public affairs, either from pique at not obtaining, as is supposed by some, so high rewards as he expected, or because he had in some way offended Manoel. During this time the Portuguese conquests increased in the East, and were presided over by successive viceroys. The fifth of these was so unfortunate that Gama was recalled from his seclusion by Manoel's successor, João III., created count of Vidigueira, and nominated viceroy of India, an honor which in April, 1524, he left Lisbon to fill. Arriving at Goa in September of the same year, he immediately set himself to correct, with vigor and firmness, the many abuses and evil practices which had crept in under the rule of his predecessors. He was not destined, however, to prosecute far the reforms he had inaugurated, for on the Christmas-eve following his arrival he died, while at Cochin, after a short illness, and was buried in the Franciscan monastery there. In 1538 his body was conveyed to Portugal and entombed in the town of Vidigueira, of which he was count, with all the pomp and honor due to one who had been the king's representative.

The important discoveries of Vasco da Gama had the immediate result of enriching Portugal, and raising her to one of the foremost places among the nations of Europe, and by degrees the far greater one of hastening the colonization and civilization of the East by opening its commerce to the great Western powers.

For further information the following works may be consulted:—*The Three Voyages of Vasco da Gama and his Viceroyalty*, by Gaspar Correa (Hakluyt Society); *Calcoen (i. e., Calicut), A Dutch Narrative of the Third Voyage of Vasco da Gama*, written by some unknown seaman of the expedition, printed at Antwerp about 1504, reprinted in facsimile, with introduction and translation, by J. Ph. Berjeau, London, 1875; *Discoveries of Prince Henry of Portugal*, by R. H. Major; *The Lusiads* of Camoens; Cooley, *History of Maritime Discovery*; Barros, *Decades*; Alvaro Velho, *Roteiro da viagem que em descobrimento da India pelo cabo de Bõa Esperança fez dom Vasco da Gama em 1479*, the manuscript of which is preserved at Coimbra, and a translation of which by Ferdinand Denis may be found in E. Charton's *Voyageurs Anciens et Modernes*, vol. iii. 1855; Castan Leda, *Historia do Descobrimento da India*, Coimbra, 1551 (largely based on Alvaro Velho's MSS.).

(H. O. F.)

GAMALIEL (גַּמְלִיאֵל, *i.e.*, God is a rewarder, Γαμαλιήλ), a Hebrew proper name, which occurs more than once in the Old Testament (Numb. i. 10; ii. 20), is repeatedly met with in the history of later Judaism. Of the persons designated by it the most important are enumerated below:—

1. GAMALIEL, or Rabban Gamliel the elder, as he is invariably called in the Talmud to distinguish him from his grandson, Rabban Gamaliel or Gamliel of Jabneh (Jamnia), was the son of Rabbi Simeon, and the grandson of Rabbi Hillel. Of his biography little is known beyond the facts that, early in the 1st century, he lived and taught in Jerusalem, where Saul of Tarsus was for some time his pupil; and that he was a member of the Sanhedrim, which body he successfully counselled to moderation in their treatment of the followers of Jesus.[1] He appears to have died before the destruction of the city. The Talmudists speak of him as having enjoyed the confidence of Cypros, the wife of Agrippa, and as having been president of the Sanhedrim during the reigns of Tiberius, Caligula, and Claudius; but the latter representation at least is certainly unhistorical, as may be learned from the New Testament and from Josephus, where it is invariably the high priest who presides over the council. Gamaliel the elder is also represented by Jewish tradition as having in some respects modified the provisions of the law with respect to divorce and marriages of widows, and as having made some

[1] The criticisms of Baur and others upon the speech, as recorded in Acts v. 34-39, do not affect the general fact as now stated.

new arrangements with regard to the calendar; but there is reason to believe that in this last statement he has been mistaken for Gamaliel of Jabneh. The fact that he is spoken of in the records of Judaism as having been the first of the seven "rabbans" (rabban being a honorific form of the title rabbi) is of itself almost conclusive against the late and otherwise improbable Christian tradition to the effect that he ultimately became a Christian and received baptism at the hands of Peter and John (*Clem. Recog.*, i. 65; Photius, cod. 171, p. 199). Compare Ewald, *Gesch. d. V. Isr.*, vi. 256 *sq.*; Derenbourg, *Hist. de Palestine*, p. 239 *sqq.*; Schürer, *NTliche Zeitgesch.*, p. 458.

2. GAMALIEL of Jabneh ranks with his grandfather, Gamaliel the elder, as one of the seven great rabbans of the Talmudists. His father also was named Simeon. On the death of Rabbi Johanan ben Zacai, Gamliel was chosen to succeed him as head of the famous school which had transferred itself to Jamnia or Jabneh shortly before the destruction of Jerusalem. For a considerable period after that event Jabneh became in some sense the metropolis of Judaism, and Gamliel, as head of the supreme judicial and legislative body which sat there, may be said to have been the first nasi or "prince" of the rabbinical period. An interesting account of his position as legislator will be found in chapter xx. of Derenbourg's *Histoire de Palestine*. As representing the Jewish nation and the Jewish faith, he visited Rome in the autumn of 95 A.D., and the Talmud abounds with references to the incidents of that journey. Gamliel was the friend of Rabbi Akiba, and the master of Aquila (the "Onkelos" of the Babylonian Talmud). He died about 115 A.D. (see Ewald, *Gesch. d. V. Isr.*, vii. 388).

3. A third GAMALIEL, son of Jehudah-ha-nasi, is mentioned in *Aboth*, ii. 2, as having specially insisted on the necessity of combining with the study of the law some active employment in order to the maintenance of a healthy moral tone.

GAMBIA, GAMBRA, BA DIMMA, or FURA, an important river of Western Africa, which enters the Atlantic about 13° 50′ N. lat. Its sources are in the central plateau of the Futa Jallon highlands, a tract of country about 240 miles inland, which also contains the head waters of the Senegal, the Faleme, the Rio Grande, and some tributaries of the Niger. Flowing almost due N. for the first 200 miles of its course, it turns somewhat abruptly to the W., and continues in that direction through a country of great fertility. Steamers can proceed up the river as far as Yaba Tenda; the channel remains navigable for boats 300 miles from the mouth to the falls of Barraconda; and above the falls it is again navigable, as was shown by Governor Macdonnell's expedition in 1851, for at least 160 miles farther. The principal affluent is the Neries, which, coming from the north, joins the main stream about 30 or 35 miles above the falls. At Fattatenda, a short distance below the falls, the river has a breadth, even in the dry season, of about 320 feet, with a depth of from 13 to 20 feet. In the rainy season it rises from 20 to 50 feet, and the whole country downwards to the sea is laid under water, and receives a rich alluvial deposit.

The British colony of Gambia comprises a considerable territory mainly on the left bank at the mouth of the river, Elephant's Island about 100 miles from the sea, and Macarthy's Island still further inland. The whole area under British authority is 21 square miles. The population in 1851 was stated at 5693, in 1861 at 6939, and in 1871 at 14,190 (7306 males and 6884 females). In the 15 years from 1860 to 1874 the total gross revenue was £268,232, making an annual average of £17,802; and the gross amount of public expenditure in the same period was £255,291, making an annual average of £17,019, or a total surplus of revenue over expenditure of £2941. In 1862, 1863, and 1864 the liabilities exceeded the assets by £3638, £4817, and £5492, respectively, but there is no funded debt. The Gambia settlement, which formerly cost the imperial revenue from £20,000 to £25,000 per annum, now provides for its own defence,—an armed police force, recruited mainly from the Mahometan tribe of the Houssas, having been substituted since 1869 for the imperial troops. The parliamentary grant, which had averaged about £4200 per annum from 1860 to 1867, was reduced to £1500 in 1868, and finally withdrawn in 1871, and all expenses are met by the local revenue. The Gambia district was originally united with Sierra Leone on the dissolution of the African Company in 1822; in 1843 it was made a separate colony, the first governor being Henry Frowd Seagram; in 1868 it was reunited to Sierra Leone; and it is now governed by an administrator. The capital of the colony is Bathurst, a town on the eastern side of St. Mary's Island.

St. Mary's Island lies at the mouth of the river on the south side, close to the mainland, from which it is separated by a stretch of mangrove swamp and a narrow arm of the river called Oyster Creek. It is about 15 miles in length by less than a mile in breadth, and consists of a slightly elevated plain of sandy soil, which in the dry season becomes a bed of hot and shifting dust. There are naturally not many trees on the island, though a few cocoa-nuts, palms, papaws, willows, bananas, oleanders, and guavas manage to maintain a precarious existence. The Barbados pride, however, flourishes luxuriantly (Captain Hewitt). Bathurst is on the whole a well-built town, the principal material employed being a dirty red sandstone coated with whitewash. It lies about 12 or 14 feet above the level of the river. The market house is built of iron, and the market place was planted with trees in 1869. Besides the Government house and the barracks, there is a hospital founded by General Macdonnell, a court-house, and an Episcopal church completed about 1869. The population of the town is of a very motley description, including, besides the white officials, and traders to the number of about 50, half-castes of all shades, liberated negroes, Jolloffs, Barras, and other local tribes. The part of the mainland immediately contiguous to St. Mary's is known as British Combo, an area of about 6 miles long by from 2 to 3 miles broad having been secured by treaty with the king of Combo in 1853.

M'Carthy's Island lies about 180 or 200 miles above St. Mary's. It is about 5½ miles in length and 1 in breadth. There are two or three "factories," a considerable trading town, peopled partly by liberated Africans, a fort, a Methodist church, and a schoolhouse. Though this was the last spot actually in British possession, it was long understood by Gambia traders that they were under British protection much farther up the stream; but, according to the despatches of Lord Carnarvon in 1877, they must proceed at their own risk as soon as they advance beyond British territory. St. James's Island, which was the seat of the British factory in the 18th century, is about 17 miles from St. Mary's. It still bears traces of European occupation, but is gradually being washed away by the river.

The chief exports are ground-nuts, wax, hides, ivory, gold-dust, palm-oil, and gum-arabic; but even these are obtained in quantities that look ridiculously small when the natural richness of the country through which the Gambia flows is considered. At the close of the 18th century only two or three ships were employed in the trade; in 1839 no fewer than 239 merchant vessels visited the river; and in 1871, 75 British and 154 foreign vessels entered, with a total tonnage of 51,853 tons. During the four rainy months, from July to October, the native trader conveys his employer's rice or corn up the river, and receives in exchange the pagnes or country cloths; in November he barters these same cloths for ground-nuts, hides, and wax; and for the rest of the year, till the rainy season comes round again, he supplies the natives with arms, powder, rum, Madras handkerchiefs, and other European productions. The French traders, however, who are gradually getting a large share of the commerce into their hands, have introduced the custom of money transactions, and the innovation is well received by the natives.

The trade in ground-nuts is of comparatively recent development. In 1836 the value exported was only £838; in 1837 it reached £8053, and in 1840 no less than £15,209. In 1860 the value was £79,611, and in 1861 £101,060. The average quantity between 1850 and 1860 was 11,196 tons; between 1870 and 1877 it was 14,000 tons. The supply is greatly affected by the political state of the country in which the nuts are grown. Most of the necessary tillage is performed by the tribe of the Sera-Woullis, who come down from the interior in great numbers, and return home when they have earned what they desire. The French markets are the principal destination of the nuts. American traders deal mainly in hides, horns, and beeswax; and the honey is chiefly purchased for the German market. The Roman Catholics maintain a mission and a small convent in the Gambia, and the Wesleyans have long had a number of stations. The latter have done great service to education in the colony, their 10 schools, as far back as 1860, being attended by 1273 scholars. It was not till 1869 that, even at Bathurst, a Government school was established; but there are now several schools in connection with the Episcopal church. The Roman Catholics began the erection of a large schoolhouse in 1873.

The Gambia was visited by the Carthaginian explorer Hanno, and it became early known to the Portuguese discoverers; but it was not till 1618 that English traders began to turn their attention to this quarter. In that year a company was formed for the exploration of the river. Richard Thompson was sent out in the "Catherine," and succeeded in reaching Kassan, a Portuguese trading town, but he never returned, and his fate is not known. Two years afterwards, Richard Jobson advanced beyond the falls of Barraconda; and he was followed about 40 years later, by Vermuyden, a Dutch merchant. In 1723 Captain Stibbs was sent out by the African Company to verify Vermuyden's reports of gold; he proceeded 60 miles above the falls. The treaty of Versailles in 1783 assigned the right of trade in the Gambia to Britain, reserving the single port of Albreda for the French; while at the same time it assigned the Senegal to France, and reserved the port of Portendic for the British. By the treaty of Paris in 1851 this arrangement was re-established, and it remained in force till 1857, when an exchange of possessions was effected, and the Gambia became a purely British river. In 1870 there was a proposal to transfer the colony to the French; but it led to nothing more than a voluminous diplomatic correspondence.

See Astley's *Collection*, vol. ii.; R. R. Madden's Report to the Government in 1841; T. E. Poole, *Life in Sierra Leone and the Gambia*, 1850; L. Borel, *Voyage à la Gambie*, 1865; and the Parliamentary Papers relating to Her Majesty's Colonial Possessions.

GAMBIER, GAMBIR, or PALE CATECHU. See CATECHU.

GAMBIER, JAMES, BARON (1756–1833), English admiral, was born on the 13th October, 1756, at the Bahamas, of which his father, John Gambier, was at that time lieutenant-governor. He entered the navy in 1767 as a midshipman on board the "Yarmouth," under the command of his uncle; and, his family interest obtaining for him rapid promotion, he was raised in 1778 to the rank of post-captain, and appointed to the "Raleigh," a fine 32-gun frigate. At the peace of 1783 he was placed on half-pay; but, on the outbreak of the war of the French Revolution, he was appointed to the command of the 74-gun ship "Defence," under Lord Howe; and in her he had an honorable share in the action off Ushant, on the 1st June, 1794. In recognition of his services on this occasion, Captain Gambier received the gold medal, and was made a colonel of marines; the following year he was advanced to the rank of rear-admiral, and appointed one of the lords of the Admiralty. In this office he continued for six years, till, in February, 1801, he, a vice-admiral of 1799, hoisted his flag on board the "Neptune," of 98 guns, as third in command of the Channel Fleet under Admiral Cornwallis, where, however, he remained for but a year, when he was appointed governor of Newfoundland and commander-in-chief of the ships on that station. In May, 1804, he returned to the Admiralty, and, with a short intermission in 1806, continued there during the naval administration of Lord Melville, of his uncle, Lord Barham, and of Lord Mulgrave. In November, 1805, he was raised to the rank of admiral; and in the summer of 1807, whilst still a lord of the Admiralty, he was appointed to the command of the fleet ordered to the Baltic, which, in concert with the army under Lord Cathcart, reduced Copenhagen, and enforced the surrender of the Danish navy, consisting of nineteen ships of the line, besides frigates, sloops, gunboats, and naval stores. This service was considered by the government as worthy of special acknowledgment; the naval and military commanders, officers, seamen, and soldiers received the thanks of both Houses of Parliament, and Admiral Gambier was rewarded with a peerage.

In the spring of the following year he gave up his seat at the Admiralty on being appointed to the command of the Channel Fleet; and in that capacity he witnessed the partial, and prevented the total, destruction of the French fleet in Basque Roads, on the 12th April, 1809. It is in connection with this event, which might have been as memorable in the history of the British navy as it is in the life of Lord Dundonald (see DUNDONALD), that Lord Gambier's name is now best known. A court-martial, assembled by order of a friendly Admiralty, and presided over by a warm partisan, "most honorably acquitted" him on the charge "that, on the 12th April, the enemy's ships being then on fire, and the signal having been made that they could be destroyed, he did, for a considerable time, neglect or delay taking effectual measures for destroying them;" but this decision was in reality nothing more than a party statement of the fact that a commander-in-chief, a supporter of the government, is not to be condemned or broken for not being a person of brilliant genius or dauntless resolution. No one now doubts that the French fleet should have been reduced to ashes, and might have been, had Lord Gambier had the talents, the energy, or the experience of many of his juniors. He continued to hold the command of the Channel Fleet for the full period of three years, at the end of which time—in 1811—he was superseded. In 1814 he acted in a civil capacity as chief commissioner for negotiating a treaty of peace with the United States; for his exertions in which business, he was honored with the Grand Cross of the Bath. In 1830 he was raised to the high rank of admiral of the fleet, and he died 19th April, 1833.

Although he had the good fortune to attain the very highest service rank, Lord Gambier is assuredly not one of those admirals whose memory the British navy treasures or idolizes. His predilection was for a life on shore; and during the great war he so utilized his family interest that he remained for nearly half the time a member of the Admiralty. And whether afloat or ashore, he had neither the genius nor the strength of mind fitted for high command or high office. Personally he was a man of earnest, almost morbid, religious principle, and of undoubted courage; but the administration of the Admiralty has seldom given rise to such flagrant scandals as during the time when Lord Gambier was a member of it; and through the whole war, the self-esteem of the navy suffered no such wound as during Lord Gambier's command in the Bay of Biscay.

The so-called *Memorials, Personal and Historical, of Admiral Lord Gambier*, by Lady Chatterton (1861), has no historical value. The life of Lord Gambier is to be read in Marshal's *Royal Naval Biography*, in Ralfe's *Naval Biography*, in Lord Dundonald's *Autobiography of a Seaman*, in the Minutes of the Courts-Martial, and in the general history of the period.

GAMBOGE, the drug *Cambogia*, a gum-resin procured from *Garcinia Morella*, Desrous., var. *pedicellata*, a diœcious tree with leathery, laurel-like leaves, small yellow flowers, and usually square-shaped and four-seeded fruit (see R. Jamie, *Pharm. Journ.*, 3d ser., vol. iv., p. 802), a member of the natural order *Guttiferæ*, and indigenous to Camboja (see CAMBODIA, vol. iv., p. 641), and parts of Siam and of the south of Cochin China, formerly comprised in Cambojan territory. The juice, which when hardened constitutes gamboge, is contained in the bark of the tree, chiefly in numerous ducts in its middle layer, and from this it is procured by making incisions, bamboo joints being placed to receive it as it exudes. Gamboge occurs in commerce in cylindrical pieces, known as pipe or roll gamboge, and also, usually of inferior quality, in cakes or amorphous masses. It is of a dirty orange externally; is hard and brittle, breaks with a conchoidal and reddish-yellow, glistening fracture, and affords a brilliant yellow powder; is odorless, and has a taste at first slight, but subsequently acrid; forms with water an emulsion; and consists of from 20 to 25 per cent. of gum soluble in water, and from 70 to 75 per cent. of a resin, *gambogic acid*, soluble in alcohol and ether, and, according to Johnston, of the formula $C_{20}H_{23}O_4$, together with moisture about 5 per cent., and a trace of ligneous fibre. Its commonest adulterations are rice-flour and pulverized bark. Some quantity of gamboge is shipped from Kâmpot in Camboja, but the principal places of export are Bangkok in Siam, and Saigon in Cochin China. Gamboge is a powerful hydragogue purgative, less drastic only than elaterium and croton oil. Like aloes, it appears to exert its chief influence on the lower bowel (*Brit. and For. Med.-Chir. Rev.*, i., 1853, p. 128), and in combination with compound colocynth pill it has been recommended by Dr. Symonds as one of the most efficient purgatives in torpor of the colon. The researches of Christison, Pabo, and Daraszkiewicz go to prove that gambogic acid alone is less cathartic than the same weight of gamboge; according to the last-mentioned experimenter and Schaur, the presence of bile in the intestines is requisite for the development of its action. In cerebral affections, as apoplexy, when great debility is not present, gamboge has proved to be a valuable counter-irritant purgative. It is sometimes employed as an anthelmintic, but appears to be devoid of any specific influence on entozoa. Some authorities regard it as decidedly diuretic in action. By Christison and others it has been found highly serviceable in dropsy. Abeille (quoted in *Brit. and For. Med.-Chir. Rev.*, 1853, ii. p. 279) administered it for that disease, in alcoholic solution, in divided doses of 6 grains per diem, increased by 2 grains daily, and given two hours prior or subsequent to meals. With the relief of the dropsy he observed that the patient's toleration of these large quantities ceased. As gamboge is apt to occasion vomiting and griping, it is usually administered in combination with milder remedies. It is an ingredient of the *pilula cambogiæ composita* of pharmacy. In overdoses it acts as an acrid poison, provoking violent emesis and catharsis, and abdominal pain, coldness of the extremities, and ulceration and mortification of the intestines, eventuating in death. Gamboge is used as a pigment, and as a coloring matter for varnishes. It appears to have been first brought into Europe by merchants from the East, at the close of the 16th century. Bontius, writing in the year 1658, mentions it under the name of *guttagemou*, a word derived by Rost from the Malay *gutáh*, gum, and Javanese *jamu*, medicinal. By the Chinese gamboge (*tang-hwang* and *shié-hwang*) is understood to be "serpent-bezoar," a substance vomited up by serpents, or the product of a species of ratan, analogous to the tabasheer of the bamboo (F. P. Smith, *Contrib. towards the Mat. Med. . . . of China*, 1871). Varieties of gamboge are yielded by *Garcinia Morella*, Desrous., a native of S. India and Ceylon, and by the Indian species *G. pictoria*, Roxb., and *G. travancorica*, Beddome.

See Christison, "Obs. on a new variety of Gamboge from Mysore," *Pharm. Journ.*, ser. i. vol. vi. pp. 60, 69, and "On the Gamboge Tree of Siam," *ib.*, vol. x. p. 235; F. Mason, "On the Gamboge of the Tenasserim Provinces," *ib.*, vol. vii. p. 398; Pereira, *Materia Medica*, vol. ii. pt. ii.; D. Hanbury, "On the Species of *Garcinia* which affords Gamboge in Siam," *Trans. Linn. Soc.*, xxiv., 1864, 487–490; E. J. Waring, *Man. of Pract. Therapeutics*, 3d ed., 1871; J. L. de Lanéssan, "Étude sur le Genre Garcinia (Clusiacées) et sur l'Origine et les Propriétés de la Gomme Gutte," *Coll. des Thèses soutenues à la Faculté de Médecine de Paris*, 1872, vol. x., No. 63; Flückiger and Hanbury, *Pharmacographia*, 1874; H. C. Wood, *A Treatise on Therapeutics*, 1874; Bentley and Trimen, *Medicinal Plants*, pt. xxx., pl. 33.

GAME LAWS. This expression is applied in England to a series of statutes of modern date, establishing a peculiar kind of property in wild animals. These statutes, it is well known, are regarded with great dislike by a large and important section of the people—partly on account of their alleged injurious economic effects, and partly on account of their harsh and exceptional character. It will be well to state first the principles of the common law, and then to show how far they have been superseded by recent legislation. By the very nature of the case, wild animals cannot be made the subject of that absolute kind of ownership which is generally signified by the term property. The substantial basis of the law of property is physical possession, the actual power of dealing with things as we see fit, and we can have no such power over animals in a state of nature. Accordingly, the common law recognized nothing like property in wild animals, until they had, as it were, been reduced into possession. Wild animals reclaimed or confined become property, but the moment they escape from confinement the property is gone, and the rights of the owner are lost. Even bees, which might well be described as domesticated and not wild animals, do not become property until they are hived. "Though a swarm lights on any tree," says Bracton, "I have no more property therein than I have in the birds which make their nests thereon." The owner of a confined animal which escapes does indeed retain his property while he is in pursuit of the fugitive; *i.e.*, no other person can, in the mean time, establish a right of property against him by capturing the animal, just as a swarm of bees "which fly from and out of my hive are mine so long as I can keep them in sight, and have power to pursue them." Again the law recognized a right in wild animals *propter impotentiam*, *i.e.*, when they were young and unable to move from place to place. With these exceptions wild animals were *res nullius*, capable of being made the property of any person reducing them into possession. A prior right to acquire property in such animals was, however, allowed to the owner (or occupier) of the soil. Thus it is said that "if A starts a hare in the ground of B, and hunts it and kills it there, the property continues all the while in B." B is said to have a right of property in the wild animals on his land *ratione soli*. But "if A starts a hare on the ground of B, and hunts it into the ground of C and kills it there, the property is in A, and not in B or C." That is to say, the so-called property in wild animals *ratione soli* consists in this, that if one of them is started and killed by a trespasser it belongs to the owner (or occupier) of the soil. If the animal goes to another man's land this inchoate right is transferred to the other man. And the inchoate right of the owner becomes an actual right of property only when the animal is both started and killed by the trespasser on the same man's land. Such right as the owner has belongs to the occupier when the land is given without reserve to a tenant for a term.

These principles, it will be observed, apply to all wild animals, and no distinction is made between game and other animals. The laws of the forest, however, established in derogation of the common law a different kind of property in certain classes of wild animals. For an account of these see Forest Law (vol. ix. pp. 359, 360). The forest code affected definite districts of the country, and the right which they protected was the exclusive right of hunting the animals of the forest within those districts.

The game laws as above defined have virtually taken the place of the forest laws. The latter protected the privilege of the king and his favorites to hunt certain animals in certain districts; the former have extended and protected the right of an owner of the soil to the chase of certain animals on his own estate. The means adopted have been to make trespass (in itself only a civil wrong) a criminal offence punishable with great severity, and to restrict, by a system of licenses, the right as well of killing as of selling game. The principal Acts are 1 & 2 William IV. c. 32 (the Game Act), 9 Geo. IV. c. 69 (the Night Poaching Act), 23 & 24 Vict. c. 90 (Game Licenses Act), and the Hares Killing Act, 11 & 12 Vict. c. 29. The Game Act repeals a large number of statutes on the subject, most of them passed in the 18th century. Game is defined to include "hares, pheasants, partridges, grouse, heath or moor game, black game, and bustards," and the same definition is found in the Night Poaching Act. A close time is fixed for certain birds of game:—for partridges from 1st February to 1st September; pheasants, 1st February to 1st October; black game, 10th December to 20th August; grouse, 10th December to 12th August; bustard, 1st March to 1st September; and the possession of such game after 10 days in dealers, and 40 days in other persons, from the expiration of the season is made illegal. The Act makes no difference in the effect of a game certificate (now "game license"); that is to say, the license authorizes the holder to kill game, subject to the law of trespass as modified by this Act. A temporary section reversed, as to all existing leases, the presumption of law that the game, unless specially reserved, belongs to the tenant; but the presumption remains as to all future leases. But when the game has been reserved to the landlord, or any assignee of his, then the occupier shall be punished for killing it, or for authorizing any other person to do so. This section no doubt was rendered necessary by the fact that the law of trespass, which is the pivot of the Game Act, could not be made to include the case of a farmer shooting game on his own ground; but it is open to the remark that in effect it converts a mere breach of contract into a crime. Persons holding game certificates (licenses) may sell game to persons licensed to deal therein. Various sections of the Act define the penalties to which persons killing or selling game without a license shall be subject, and it should be noticed that it is a punishable offence even to buy game except from a licensed dealer.

The section relating to trespass (§ 30 of the Game Act) enacts that "if any person whatsoever shall commit any trespass by entering or being in the day time upon any land in search or pursuit of game, or woodcocks, snipes, quails, landrails, or conies,[1] such person shall, on conviction thereof before a justice of the peace, forfeit and pay such sum of money, not exceeding two pounds, as to the justice shall seem meet, together with the costs of the conviction;" and that if any persons, to the number of five or more together, shall commit any trespass by entering or being in the day time upon any land in search of or pursuit of game or woodcock, etc., "each shall, on conviction, forfeit a sum not exceeding five pounds. The leave of the occupier shall be no defence when the game belongs to the landlord or other person; and by § 31, trespassers in pursuit of game, etc., may be required to leave the land, to tell their names and abodes, and if they refuse may be arrested. The owner of the right of shooting may take from them any game found in their possession. The sections against trespassers, however, do not include any person hunting or coursing upon any land with hounds or greyhounds." This act applies only to England.

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[1] These animals, although not included in the statutory definition of game, are by this section partially admitted to the benefit of the Act.

The Poaching Acts are still more severe. The Night Poaching Act enacts that, "if any person shall, after the passing of this Act, by night unlawfully take or destroy any game or rabbits in any land, whether open or enclosed, or shall by night unlawfully enter or be on any land, whether open or enclosed, with any gun, net, engine, or other instrument for the purpose of destroying game, such offender shall, upon conviction thereof before two justices of the peace, be committed for the first offence to the common gaol or house of correction for any period not exceeding three calendar months, there to be kept to hard labor, and at the expiration of such period shall find sureties" for his not so offending again. For a second offence the punishment is six months with hard labor, etc., with one year's further imprisonment in default of sureties; a third offence is a misdemeanor, and the punishment is penal servitude for not more than seven years, or imprisonment for not more than two years. A later Act, 7 & 8 Vict. c. 29, § 1, applies the penalties to the unlawful taking or destroying game on a highway by night. "Night" is declared to commence at the expiration of the first hour after sunset and to conclude at the beginning of the last hour before sunrise. Finally, the Poaching Prevention Act (25 & 26 Vict. c. 114) gives power to a constable, "on any highway, street, or public place, to search any person whom he may have good cause to suspect of coming from any land where he shall have been unlawfully in search or pursuit of game, or any persons aiding or abetting such person, and having in his possession any game unlawfully obtained, or any gun, part of gun, or nets or engines used for the killing or taking game; and also to stop and search any cart or other conveyance in or upon which such constable or peace officer shall have good cause to suspect that any such game, or any such article or thing, is being carried by any such person." If any such thing be found the constable is to detain it, and apply for a summons against the offender, summoning him to appear before two justices, where, on conviction, he may be fined not more than £5, and shall forfeit the game, guns, etc., found in his possession. This act is available by night as well as day. It should be noted in all cases where the unlawful taking or destroying of game is mentioned, that such taking is made unlawful only by the provisions of the Acts relating to certificates, or by the law relating to trespass. A person provided with a certificate can still kill game where he pleases, unless he commits a trespass—the only exception being that of the tenant whose landlord has reserved the game in his lands. Thus it may be inferred that a poacher provided with a certificate could not be brought within the limits of the Act relating to poaching on highways.

Game certificates are now regulated by 23 & 24 Vict. c. 90. Section 4 enacts that "any person, before he shall in Great Britain take, kill, or pursue, or aid or assist in any manner in the taking, killing, or pursuing, by any means whatever, or use any dog, gun, net, or other engine for the purpose of taking, killing, or pursuing any game, or any woodcock, snipe, quail, landrail, or any coney, or any deer, shall take out a proper license to kill game under this Act"—subject to a penalty of £20. There are, however, certain exceptions and exemptions. As to licenses to deal in game, any person who shall have obtained a license to deal in game from the justices of the peace under the provisions of 1 & 2 Will. iv. c. 32, and 2 & 3 Vict. c. 35, shall annually and during the continuance of such license, and before he shall be empowered to deal in game under such license, obtain a further license to deal in game under this Act, and only those who have obtained license from the justices shall be licensed under the Act, *i. e.*, by the Inland Revenue. By 11 & 12 Vict. c. 29 any occupier or owner having the right of killing game may, by himself or by any person authorized by him in writing, kill hares without paying duty or taking out license.

Most of the Acts cited above apply to Scotland as well as England, and when they do not there are special enactments for Scotland having substantially the same effect. The more important statutes specially affecting Scotland are the 13 Geo. III. c. 54, which fixes a close time for killing, selling, buying, etc., muirfowl, heathfowl, partridge, and pheasant; the 2 & 3 Will. IV. c. 68 (the Trespass Act); the 11 & 12 Vict. c. 30 (Hares Killing Act); and the 40 & 41 Vict. c. 28. The last is to some extent a departure from the general policy of the game laws, being an attempt to provide compensation to tenants for damage caused by game. In effect it will be found to belong to the class of "permissive" statutes. The important section is the 4th:

> "Where, under any lease made subsequently to the commencement of this Act, or where, by presumption of common law, upon any land occupied under a lease made subsequently to the commencement of this Act, the lessor shall reserve or retain the sole right of hunting, killing, or taking rabbits, hares, or other game, or any of them, the lessee shall be entitled to compensation for the damage done to his crops in each year by the rabbits and hares, or other game, to which the lessor may have reserved or retained the whole right, in excess of such sum as may have been set forth in the lease as the amount of annual damage for which it is agreed no compensation shall be due; and if no such sum shall be set forth, then in excess of the sum of forty shillings."

Scotch law, differing in this respect from English law, infers that, when the lease contains no stipulations as to game, the landlord reserves the right of killing game to himself. The Act contains provisions for settling claims of damage either by arbitration or by action at law. Leases made before the Act are not to be affected thereby. The old Act of 1621, "anent hunting and haulking," is cited in the schedule of the last-mentioned Act; it "ordaines that no man hunt nor haulk at any time hereafter who hath not a plough of land in heritage, under the pain of £100." It is, of course, practically obsolete. (E. R.)

GAMES. The public games of Greece and Rome were athletic contests and spectacles of various kinds, generally connected with and forming part of a religious observance. Probably no institution exercised a greater influence in moulding the national character, and producing that unique type of physical and intellectual beauty which we see reflected in Greek art and literature, than the public contests of Greece. For them each youth was trained in the gymnasium, they were the central mart whither poet, artist, and merchant each brought his wares, and the common ground of union for every member of the Hellenic race. It is to Greece, then, that we must look for the earliest form and the fullest development of ancient games, and we propose in the present article to treat principally of the Greek ἀγῶνες. The shows of the Roman circus and amphitheatre were at best a shadow, and in the later days of the empire a travesty, of the Olympia and Pythia, and require only a cursory notice. "Corruptio optimi fit pessima." From the noblest spectacle in the world, the Greek Olympia, the downward course of public games can be traced, till we reach the ignoblest, the Roman amphitheatre, of whose horrors we may still form a faint picture from its last survival—the Spanish bull-fight.

Greek games.

The earliest games of which we have any record are those at the funeral of Patroclus, which form the subject of the twenty-third Iliad. They are noticeable both as showing that the belief that the dead would be appeased or gratified by the same exhibitions which pleased them in life was a common heritage of Greeks and Romans from their Aryan progenitors, and as already including all the distinctive competitions which we find in historical times,—the chariot-race, archery, boxing, wrestling, and putting the weight. Each of the great Grecian games was held near some shrine or consecrated spot, and is connected by myth or legend with some hero, demigod, or local deity.

The Olympian games were the earliest, and to the last they remained the most celebrated of the four national festivals. Olympia was a naturally enclosed spot in the rich plain of Elis, bounded on the N. by the rocky heights of Kronos, and on the S. and W. by the Alpheus and its tributary, the Kladeus. There was the grove of Altis, in which were ranged the statues of the victorious athletes, and the temple of Olympian Zeus with the chryselephantine statue of the god, the masterpiece of Phidias. There Hercules (so ran the legend which Pindar has introduced in one of his finest odes), when he had conquered Elis and slain its king Augeas, consecrated a temenos and instituted games in honor of his victory. A later legend, which probably embodies historical fact, tells how, when Greece was torn by dissensions and ravaged by pestilence, Iphitus inquired of the oracle for help, and was bidden restore the games which had fallen into desuetude; and there was in the time of Pausanias, suspended in the temple of Hera at Olympia, a bronze disk whereon were inscribed, with the regulations of the games, the names of Iphitus and Lycurgus. From this we may safely infer that the games were a primitive observance of the Eleians and Pisans, and first acquired their celebrity from the powerful concurrence of Sparta. In 776 B. C. the Eleians engraved the name of their countryman Corœbus as victor in the foot-race, and thenceforward we have an almost unbroken list of the victors in each succeeding Olympiad or fourth recurrent year. For the next fifty years no names occur but those of Eleians or their next neighbors. After 720 B. C. we find Corinthians and Megareans, and later still Athenians and extra-Peloponnesians. Thus, what at first was nothing more than a village bout became a bond of union for all the branches of the Doric race, and grew in time to be the high feast to which every Greek gathered, from the mountain fastnesses of Thessaly to the remotest colonies of Cyrene and Marseilles. It survived even the extinction of Greek liberty, and had nearly completed twelve centuries when it was abolished by the decree of the Christian emperor Theodosius, in the tenth year of his reign. The last Olympian victor was a Romanized Armenian named Varastad.

Let us attempt to call up the scene which Olympia in its palmy days must have presented as the great festival approached. Heralds had proclaimed throughout Greece the truce of God, which put a stop to all warfare, and ensured to all a safe conduct during the sacred month. So religiously was this observed that the Spartans chose to risk the liberties of Greece, when the Persians were at the gates of Pylæ, rather than march during the holy days. Those white tents which stand out against the sombre gray of the olive groves belong to the Hellanodicæ, or ten judges of the games, chosen one for each tribe of the Eleians. They have been here already ten months, receiving instruction in their duties. All, too, or most of the athletes must have arrived, for they have been undergoing the indispensable training in the gymnasium of the Altis. But along the "holy road" from the town of Elis there are crowding a motley throng. Conspicuous in the long train of pleasure-seekers are the *θεωροί* or sacred deputies, clad in their robes of office, and bearing with them in their carriages of state offerings to the shrine of the god. Nor is there any lack of distinguished visitors. It may be Alcibiades, who, they say, has entered no less than seven chariots; or Gorgias, who has written a famous *ἐπίδειξις* for the occasion; or the sophist Hippias, who boasts that all he bears about him, from the sandals on his feet to the dithyrambs he carries in his hand, are his own manufacture; or Aetion, who will exhibit his picture of the Marriage of Alexander and Roxana—the picture which gained him no less a prize than the daughter of the Hellanodices Praxonides; or, in an earlier age, the poet-laureate of the Olympians, Pindar himself. Lastly, as at the mediæval tournament, there are "store of ladies whose bright eyes rain influence;" matrons, indeed, are excluded on pain of death, but maidens, in accordance with Spartan manners, are admitted to the show.

At daybreak the athletes presented themselves in the Bouleuterion, where the presidents were sitting, and proved by witnesses that they were of pure Hellenic descent, and had no stain, religious or civil, on their character. Laying their hands on the bleeding victim, they swore that they had duly qualified themselves by ten months' continuous training in the gymnasium, and that they would use no fraud or guile in the sacred contests. Thence they proceeded to the stadium, where they stripped to the skin and anointed themselves. A herald proclaimed—"Let the runners put their feet to the line," and called on the spectators to challenge any disqualified by blood or character. If no objection was made, they were started by the note of the trumpet, running in heats of four, ranged in the places assigned them by lot. The presidents seated near the goal adjudged the victory. The foot-race was only one of twenty-four Olympian contests which Pausanias enumerates, though we must not suppose that these were all exhibited at any one festival. Till the 77th Olympiad all was concluded in one day, but afterwards the feast was extended to five. The order of the games is for the most part a matter of conjecture, but, roughly speaking, the historical order of their institution was followed. We will now describe in this order the most important.

(1.) The *foot-race*. For the first 13 Olympiads the *δρόμος*, or single lap of the stadium, which was 200 yards long, was the only contest. The *δίαυλος*, in which the course was traversed twice, was added in the 14th Olympiad, and in the 15th the *δόλιχος*, or long race, of 7, 12, or, according to the highest computation, 24 laps, over 3 miles in length. We are told that the Spartan Ladas, after winning this race, dropped down dead at the goal. There was also, for a short time, a race in heavy armor, which Plato highly commends as a preparation for active service. (2.) *Wrestling* was introduced in the 18th Olympiad. The importance attached to this exercise is shown by the very word *palæstra*, and Plutarch calls it the most artistic and cunning of athletic games. The practice differed little from that of modern times, save that the wrestler's limbs were anointed with oil and sprinkled with sand. The third throw, which decided the victory, passed into a proverb, and struggling on the ground, such as we see in the famous statue at Florence, was not allowed, at least at the Olympia. (3.) In the same year was introduced the *πένταθλον*, a combination of the five games enumerated in the well-known pentameter ascribed to Simonides:—

ἅλμα, ποδωκείην, δίσκον, ἄκοντα, πάλην.

Only the first of these calls for any comment. The only leap practised seems to have been the long jump. The leapers increased their momentum by means of *ἁλτῆρες* or dumb-bells, which they swung in the act of leaping. By the help of them, and of the spring-board, enormous distances were covered, though the leap of 55 feet with which Phayllus is credited is simply incredible. It is disputed whether a victory in all five contests, or in three at least, was required to win the *πένταθλον*. (4.) *Boxing* was added in the 23d Olympiad. The rules were much the same as those of the modern ring, except that the boxer's fists and wrists were armed with straps of leather. The force of the blow was thereby increased; but no arm so terrible as the cestus of the Romans can ever have been admitted in Greek contests, seeing that the death of an antagonist not only disqualified a combatant, but was severely punished. In the *pancratium*, a combination of wrestling and boxing, the use of these straps, and even of the clenched fist, was disallowed. (5.) The *chariot-race* had its origin in the 23d Olympiad. It was held in the hippodrome, a race-course 1200 feet long by 400 broad, laid out on the left side of the hill of Kronos. The whole circuit had to be traversed twelve times. In the centre near the further end was the pillar or goal (the *spina* of the Romans), round which the chariots had to turn. "To shun the goal with rapid wheels" has been well selected by Milton as the most graphic feature of the Olympian games. So dangerous indeed was the manœuvre that, according to Pausanias, a mysterious horror attached to the spot, and horses when they passed it would start in terror without visible cause, upsetting the chariot and wounding the driver. The number of chariots that might appear on the course at once is uncertain. Pindar (*Pyth.* v. 46) praises Arcesilaus of Cyrene for having brought off his chariot uninjured in a contest where no fewer than forty took part. The large outlay involved excluded all but rich competitors, and even kings and tyrants eagerly contested the palm. Thus in the list of victors we find the names of Cylon, the would-be tyrant of Athens, Pausanias the Spartan king, Archelaus of Macedon, Gelon and Hiero of Syracuse, and Theron of Agrigentum. Chariot-races with mules, with mares, with two horses in place of four, were successively introduced, but none of these present any special interest. Races on horseback date from the 33d Olympiad. As the course was the same, success must have depended on skill as much as on swiftness. Lastly, there were athletic contests of the same description for boys, and a competition of heralds and trumpeters, introduced in the 93d Olympiad.

The prizes were at first, as in the Homeric times, of some intrinsic value, but after the 6th Olympiad the only prize for each contest was a garland of wild olive, which was cut with a golden sickle from the kallistephanos, the sacred tree brought by Hercules "from the dark fountains of Ister in the land of the Hyperboreans, to be a shelter common to all men and a crown of noble deeds" (Pindar, *Ol.*, iii. 18). Greek writers from Herodotus to Plutarch dwell with complacency on the magnanimity of a race who cared for nothing but honor and were content to struggle for a corruptible crown. But though the Greek games present in this respect a favorable contrast to the greed and gambling of the modern race-course, yet to represent men like Milon and Damoxenus as actuated by pure love of glory is a pleasing fiction of the moralists. The successful athlete received in addition to the immediate honors very substantial rewards. A herald proclaimed his name, his parentage, and his country; the Hellanodicæ took from a table of ivory and gold the olive crown and placed it on his head, and in his hand a branch of palm; as he marched in the sacred revel to the temple of Zeus, his friends and admirers showered in his path flowers and costly gifts, singing the old song of Archilochus, τήνελλα καλλίνικε, and his name was canonized in the Greek calendar. Fresh honors and rewards awaited him on his return home. If he was an Athenian he received, according to the law of Solon, 500 drachmæ, and free rations for life in the Prytaneum; if a Spartan, he had as his prerogative the post of honor in battle. Poets like Pindar, Simonides, and Euripides sung his praises, and sculptors like Phidias and Praxiteles were engaged by the state to carve his statue. We even read of a breach in the town walls being made to admit him, as if the common road were not good enough for such a hero; and there are well-attested instances of altars being built and sacrifices offered to a successful athlete. No wonder then that an Olympian prize was regarded as the crown of human happiness. Cicero, with a Roman's contempt for Greek frivolity, observes with a sneer that an Olympian victor receives more honors than a triumphant general at Rome, and tells the story of the Rhodian Diagoras, who, having himself won the prize at Olympia, and seen his two sons crowned on the same day, was addressed by a Laconian in these words:—"Die, Diagoras, for thou hast nothing short of divinity to desire." Alcibiades, when setting forth his services to the state, puts first his victory at Olympia, and the prestige he had won for Athens by his magnificent display. But perhaps the most remarkable evidence of the exaggerated value which the Greeks attached to athletic prowess is a casual expression which Thucydides employs when describing the enthusiastic reception of Brasidas at Scione. The government, he says, voted him a crown of gold, and the multitude flocked round him and decked him with garlands, *as though he were an athlete.*

The above description of the Olympian games will serve generally for the other great festivals of Greece. Without entering on any detailed account of these, it will be sufficient here to glance at the most prominent characteristics of each.

The *Pythian* games, second only to the Olympian in importance, were founded after the first Sacred War out of the spoils of Cirrha, 595 B. C. Originally a local festival held every eighth year in honor of the Delphic god, with no other contests but in the harp and the pæan—in fact a sort of Greek Eisteddfod—they developed into a common ἀγών for all Greece (so Demosthenes calls them), with all the games and races of Olympia, from which they were distinguished only by their musical and poetical competitions. They were held under the superintendence of the Amphictyones in the autumn or first half of every third Olympian year. The prizes were a wreath of laurel and a palm.

The *Nemean* games, originally a warlike gathering and review, were held in honor of Nemean Zeus at the grove of Nemea, between Cleonæ and Phlius, in the second and fourth year of each Olympiad. They date from about 570 B. C. The prize was a chaplet of parsley.

The *Isthmian* games, founded a little earlier than the Nemean, partook at first of the nature of mysteries. They were held on the narrowest part of the Isthmus of Corinth in honor of Poseidon in the first and third year of each Olympiad. Their prize was a wreath of pine leaves. The importance of the Isthmian games in later times is shown by the fact that Flamininus chose the occasion for proclaiming the liberation of Greece, 196 B. C. That at a later anniversary (67 A. D.) Nero repeated the proclamation of Flamininus, and coupled with it the announcement of his own infamous victory at Olympia, shows alike the hollowness of the first gift and the degradation which had befallen the Greek games, the last faint relic of Greek worth and independence.

Roman Games.

The *Ludi Publici* of the Romans included feasts and theatrical exhibitions as well as the public games with which alone we are concerned. As in Greece, they were intimately connected with religion. At the beginning of each civil year it was the duty of the consuls to vow to the gods games for the safety of the commonwealth, and the expenses were defrayed by the treasury. Thus, at no cost to themselves, the Roman public were enabled to indulge at the same time their religious feelings and their love of amusement. Their taste for games naturally grew till it became a passion, and under the empire games were looked upon by the mob as one of the two necessaries of life. The ædiles who succeeded to this duty of the consuls were expected to supplement the state allowance from their private purse. Political adventurers were not slow to discover so ready a road to popularity, and what at first had been exclusively a state charge devolved upon men of wealth and ambition. A victory over some barbarian horde or the death of a relation served as the pretext for a magnificent display. But the worst extravagance of private citizens was eclipsed by the reckless prodigality of the Cæsars, who squandered the revenues of whole provinces in catering for the mob of idle sight-seers on whose favor their throne depended. But though public games played as important a part in Roman as in Greek history, and must be studied by the Roman historian as an integral factor in social and political life, yet, regarded solely as exhibitions, they are comparatively devoid of interest, and we sympathize with Pliny, who asks his friend how any man of sense can go day after day to view the same dreary round of fights and races.

It is easy to explain the different feelings which the games of Greece and of Rome excite. The Greeks at their best were actors, the Romans from first to last were spectators. It is true that even in Greek games the professional element played a large and ever-increasing part. As early as the 6th century B. C. Xenophanes complains that the wrestler's strength is preferred to the wisdom of the philosopher, and Euripides, in a well-known fragment, holds up to scorn the brawny swaggering athlete. But what in Greece was a perversion and acknowledged to be such, the Romans not only practised but held up as their ideal. No Greek, however high in birth, was ashamed to compete in person for the Olympic crown. The Roman, though little inferior in gymnastic exercises, kept strictly to the privacy of the palæstra; and for a patrician to appear in public as a charioteer is stigmatized by the satirist as a mark of shameless effrontery.

Roman games are generally classified as *fixed, extraordinary,* and *votive*; but for our present purpose they may be more conveniently grouped under two heads according to the place where they were held, viz., the circus or the amphitheatre.

For the Roman world the circus was at once a political club, a fashionable lounge, a rendezvous of gallantry, a betting ring, and a playground for the million. Juvenal, speaking loosely, says that in his day it held the whole of Rome; and there is no reason to doubt the precise statement of P. Victor, that in the Circus Maximus there were seats for 350,000 spectators. Of the various *Ludi Circences* it may be enough here to give a short account of the most important, the *Ludi Magni* or *Maximi.*

Initiated according to legend by Tarquinius Priscus, the *Ludi Magni* were originally a votive feast to Capitoline Jupiter, promised by the general when he took the field, and performed on his return from the annual campaign. They thus presented the appearance of a military spectacle, or rather a review of the whole burgess force, which marched in solemn procession from the Capitol to the forum and thence to the circus, which lay between the Palatine and Aventine. First came the sons of patricians mounted on horseback, next the rest of the burghers ranged according to their military classes, after them the athletes, naked save for the girdle round their loins, then the company of dancers with the harp and flute players, next the priestly colleges bearing censers and other sacred instruments, and lastly the simulacra of the gods, carried aloft on their shoulders or drawn in cars. The games themselves were fourfold: (1) the chariot race; (2) the *ludus Troiæ;* (3) the military review; and (4) gymnastic contests. Of these only the first two call for any comment. (1.) The chariot employed in the circus was the two-wheeled war car, at first drawn by two, afterwards by four, and more rarely by three horses. Originally only two chariots started for the prize, but under Caligula we read of as many as twenty-four heats run in the day, each of four chariots. The distance traversed was fourteen times the length of the circus or nearly five miles. The charioteers were apparently from the first professionals, though the stigma under which the gladiator lay never attached to their calling. Indeed a successful driver may compare in popularity and fortune with a modern jockey. The drivers were divided into companies distinguished by the colors of their tunics, whence arose the faction of the circus which assumed such importance under the later emperors. In republican times there were two factions, the white and the red; two more, the green and the blue, were added under the empire, and for a short time in Domitian's reign there were also the gold and the purple. Even in Juvenal's day party spirit ran so high that a defeat of the green was looked upon as a second Cannæ. After the seat of empire had been transferred to Constantinople these factions of the circus were made the basis of political cabals, and frequently resulted in sanguinary tumults, such as the famous Nika revolt (532 A. D.), in which 30,000 citizens lost their lives. (2.) The Ludus Troiæ was a sham fight on horseback in which the actors were patrician youths. A spirited description of it will be found in the 5th Æneid. See also CIRCUS.

The two exhibitions we shall next notice, though occasionally given in the circus, belong more properly to the amphitheatre. *Venatio* was the baiting of wild animals who were pitted either with one another or with men—captives, criminals, or trained hunters called *bestiarii*. The first certain instance on record of this amusement is in 186 B. C., when M. Fulvius exhibited lions and tigers in the arena. The taste for these brutalizing spectacles grew apace, and the most distant provinces were ransacked by generals and proconsuls to supply the arena with rare animals—giraffes, tigers, and crocodiles. Sulla provided for a single show 100 lions, and Pompey 600 lions, besides elephants, which were matched with Gætulian hunters. Julius Cæsar enjoys the doubtful honor of inventing the bull-fight. At the inauguration of the Colosseum 5000 wild and 4000 tame beasts were killed, and to commemorate Trajan's Dacian victories there was a butchery of 11,000 beasts. The *naumachia* was a sea fight, either in the arena, which was flooded for the occasion by a system of pipes and sluices, or on an artificial lake. The rival fleets were manned by prisoners of war or criminals, who often fought till one side was exterminated. In the sea fight on Lake Fucinus, arranged by the emperor Claudius, 100 ships and 19,000 men were engaged.

But the special exhibition of the amphitheatre was the *munus gladiatorium*, which dates from the funeral games of Marcus and Decimus Brutus, given in honor of their father, 264 B. C. It was probably borrowed from Etruria, and a refinement on the common savage custom of slaughtering slaves or captives on the grave of a warrior or chieftain. Nothing so clearly brings before us the vein of coarseness and inhumanity which runs through the otherwise noble character of the Roman, as his passion for gladiatorial shows. We can fancy how Pericles, or even Alcibiades, would have loathed a spectacle that Augustus tolerated and Trajan patronized. Only after the conquest of Greece we hear of their introduction into Athens, and they were then admitted rather out of compliment to the conquerors than from any love of the sport. In spite of numerous prohibitions from Constantine downwards, they continued to flourish even as late as St. Augustine. To a Christian martyr, if we may credit the story told by Theodoret and Cassiodorus, belongs the honor of their final abolition. In the year 404 Telemachus, a monk who had travelled from the East on this sacred mission, rushed into the arena and endeavored to separate the combatants. He was instantly despatched by the prætor's orders; but Honorius, on hearing the report, issued an edict abolishing the games, which were never afterwards revived. See GLADIATORS. (F. S.)

GAMES, GAMING. Looking here at these in their legal aspects, it will be seen that from very early times the law of England has attempted to exercise some control over the sports and pastimes of the people—particularly those involving an element of gambling. Certain games were either prohibited altogether, or reserved for people of some position in society. The Act 33 Henry VIII. c. 9, increasing the severity of still older enactments, deals with the whole subject in great detail, and it is interesting to notice that the reason assigned for prohibiting unlawful games was that they interfered with other exercises more useful to the state. The Act is entitled a "Bill for the maintaining artillery and the debarring unlawful games;" and it recites that, since the last statutes, "crafty persons have invented many and sundry new and crafty games and plays, as loggetting in the fields, slide-thrift, otherwise called shove-groat, as well within the city of London as elsewhere in many other and divers parts of this realm, keeping houses, plays, and alleys for the maintenance thereof, by reason whereof archery is sore decayed, and daily is like to be more and more minished, and divers bowyers and fletchers, for lack of work, gone and inhabit themselves in Scotland and other places out of this realm, there working and teaching their science, to the pursuance of the same, o the great comfort of estrangers and detriment of this realm." Accordingly penalties are declared against all persons keeping houses for unlawful games, and all persons resorting thereto. It is further provided that "no manner of artificer or craftsman of any handicraft or occupation, husbandman, apprentice, laborer, servant at husbandry, journeyman or servant of artificer, mariners, fishermen, watermen, or any serving man, shall play at the tables, tennis, dice, cards, bowls, clash, coyting, loggetting, or any other unlawful game out of Christmas under the pain of xxs. to be forfeit for every time; and in Christmas to play at any of the said games in their masters' houses or in their masters' presence; and also that no manner of person shall at any time play at any bowl or bowls in open places out of his garden or orchard" (§ 16). The social evils of gambling (impoverishment, crime, neglect of divine service) are incidentally alluded to in the preamble, but only in connection with the main purpose of the statute—the maintenance of archery. Blackstone, commenting on this and subsequent statutes, declares that "the principal ground of modern complaint is the gambling in high life" (vol. iv. c. 13), and he cites the various statutes which, up to his time, had been passed against this pernicious vice. Some of these went so far as to make the mere winning or losing of money at play a criminal offence. By the Act 18 Geo. II. c. 34 (repealed by 8 and 9 Vict. c. 109), if any man be convicted upon information or indictment of winning or losing at play or by betting at any one time £10 or £20 within 24 hours, he shall be fined five times the sum for the benefit of the poor of the parish. And the evil of gambling, *i. e.*, betting or wagering, is the ostensible object against which the later statutes on gaming are directed. A bet or wager was, however, at common law as valid as any other kind of contract, and the distinction between bets depending on gaming and bets depending on other contingencies was long retained, and has, in fact, not yet entirely disappeared. Besides the Act last mentioned, the Acts 9 Anne c. 14, 2 Geo. II. c. 28, and 13 Geo. II. c. 34 prohibited particular games.

The modern statutes are the following—8 and 9 Vict. c. 109, 16 and 17 Vict. c. 119, and 17 and 18 Vict. c. 38.

The 8 and 9 Vict. c. 109 (Act to amend the law relating to games and wagers) repeals, *inter alia*, so much of the old law of Henry VIII. as makes it unlawful to play at any mere games of skill. And it provides that, to prove any house to be a common gaming-house, it "shall be sufficient to show that it is kept or used for playing therein at any unlawful game, and that a bank is kept there by one or more of the players exclusively of the others, or that the chances of any game played therein are not alike favorable to all the players, including among the players the banker or other person by whom the game is managed, or against whom the other players stake, play, or bet." Gambling, it will be noticed, is still in this definition connected with some kind of game; the later Act, 16 and 17 Vict. c. 119 (for the suppression of betting-houses), enacts that any house used for the purpose of "betting with persons resorting thereto" shall be deemed to be a common gaming-house. To return to the former Act, it provides that proof that the gaming was for money shall not be required, and that the presence of cards, dice, and other instruments of gaming shall be *prima facie* evidence that the house was used as a common gaming-house. The keeping of houses for the game of billiards is to be authorized under license from the justices to be granted at the general licensing sessions, and the conditions are in general the same as to time of opening, etc., as those of the victuallers' licenses. Any persons winning money by cheating at any game or wager shall be deemed guilty of obtaining money by false pretences. The 16 and 17 Vict. c. 119, besides bringing betting-houses within the statutory definition of gaming-houses, makes it a specific offence to publish advertisements, handbills, placards, etc., showing that any house is kept or opened for the purpose of betting. With reference to the definition of betting-house in this statute, "a place opened, kept, or used for the purpose of *the owner, occupier, etc., thereof*, betting with persons resorting thereto," it may be mentioned that it was avowedly framed for the purpose of hitting houses open to all and sundry, as distinguished from large but legally private betting-clubs like Tattersall's. The reason for this distinction, of course, is that the former are frequented mainly by a poorer class of persons, who cannot afford the luxury of gambling, and will be tempted by their losses to defraud their employers. The Act of 17 and 18 Vict. gives additional facilities for enforcing the preceding Acts, and increases the severity of the penalties. The keeper of a gaming-house may be fined up to £50 and costs, and on default of payment may be sent to jail for twelve months. Finally, the Vagrant Act, 1873 (36 and 37 Vict. c. 38), contains the following clause: "Every person playing or betting by way of wagering or gaming on any street, road, highway, or other open and public place, or in any open place to which the public have, or are permitted to have, access, at or with any table or instrument of gaming, or any coin, card, token, or other article used as an instrument or means of gaming, at any game or pretended game of chance, shall be deemed a rogue and vagabond." The original Act of 1868, of which this is an amendment, was passed to repress the practice of playing pitch and toss in the streets, which, it seems, had grown to the dimensions of a nuisance in the colliery districts.

The general result of all these enactments may be briefly stated thus. Apart from statute, no games are unlawful in themselves. Games were originally made unlawful in the interest of the more useful military exercises which they threatened to supplant. The prohibition has been retained and extended on account of the vice of gambling, and severe penalties have been enacted against houses at which persons can play unlawful games. Betting-houses in general were brought within the definition of gaming-houses, and finally betting or gaming was prohibited in any public place. It must be admitted that these distinctions are based on a most invidious principle. Practically gambling is forbidden to the poor and connived at in the rich.

It may be asked, What games, as such, are lawful under these various statutes, and what are unlawful? The author of an excellent and amusing little work on *Gaming and Gamesters' Law*,[1] gives the following as the result of a careful examination of all the Acts. The following are lawful games:—backgammon, bagatelle, billiards, boat-races, bowls, chess, cricket, croquet, curling, dominoes, draughts, fives, football, foot-races, golf, knurr and spell, putting the stone, quoits, rackets, rowing, skittles, tennis, whist, wrestling. The following are doubtful—boxing, cudgel-playing, and single-stick. The following are absolutely unlawful—ace of hearts, basset, dice (except backgammon), hazard, lotteries (except art-union lotteries), Pharaoh (or faro), boulet (or roly poly). An Act of Geo. II., which prohibited horse-racing for prizes under £50 value, has since been repealed.

To turn now to the civil aspects of the case. Gambling apart from gaming, *i. e.*, simple wagering or betting, was not at common law illegal, and the Act of Anne did not affect wagers other than gaming wagers. In fact, the courts were constantly being called upon to enforce contracts by way of wagers, and were as constantly exercising their ingenuity to discover excuses for refusing. A writer on the law of contracts[2] discovers here the origin of that principle of "public policy" which plays so important a part in English law. Wagering contracts were rejected because the contingencies on which they depended tended to create interests hostile to the common weal. A bet on the life of the emperor Napoleon was declared void because it gave one of the parties an interest in keeping the king's enemy alive, and also because it gave the other an interest in compassing his death by unlawful means. A bet as to the amount of the hop-duty was against public policy, because it tended to expose the condition of the king's revenue to all the world. A bet between two hackney coachmen, as to which of them should be selected by a gentleman for a particular journey, was void, because it tended to expose the customer to their importunities. When no such subtlety could be invented, the law, however reluctantly, was compelled to enforce the fulfilment of a wager. Now, however, by the Act 8 and 9 Vict. c. 109, cited *supra*, all agreements by way of wager are void, and money lost on them cannot be recovered by action at law. There still remains, as hinted above, a distinction between gaming and other wagers. The 5 and 6 Will. IV. c. 41 treats securities (*e. g.*, promissory notes) given for money lost at gaming as being given for an illegal consideration; under the 8 and 9 Vict. c. 109, securities given for betting are held to be given for a *void*, or for no consideration. Thus a third person, coming into possession of a note given for a bet, would have to prove that he gave value for it if the bet was a gaming bet under the statute of Anne; if it was not a gaming bet, he would be presumed to have given consideration for it until it was actually proved that he had not.

The 8 and 9 Vict. c. 109 exempts all subscriptions, or contributions, or agreements to subscribe or contribute towards any plate, prize, or sum of money to be awarded to the winner of any lawful game. (E. R.)

GANDERSHEIM (in Eberhard's Chronicle, Gandersem), a town of Germany at the head of a circle in the duchy of Brunswick, situated on the Gande, a sub-tributary of the Weser, about 48 miles S. W. of Brunswick. It is a small place numbering, according to the census of 1875, only 2454 inhabitants; but it carries on the manufacture of linen, cigars, beet-root sugar, and beer, and possesses not only an old palace built by the dukes of Brunswick in the 16th century, but an abbey which ranks among the most famous in Germany.

The abbey of Gandersheim was founded in 856, according to Eberhard's Chronicle, by the duke Ludolf of Saxony and his wife Oda, who removed to the new domicile the nuns whom they had shortly before established at Brunshausen. Their own daughter, Hathumoda, was the first abbess, who was succeeded on her death by her sister Gerberga. Under Gerberga's government King Louis III. granted a privilege, by which the office of abbess was to continue in the ducal family as long as any member was found competent and willing to accept the same. Otto III. gave the abbey a market, a right of toll, and a mint; and after the bishop of Hildesheim and the archbishop of Mainz had long contested with each other about its supervision, Pope Innocent III. declared it altogether independent of both. The abbey was ultimately recognized as holding directly of the empire, and the abbess had a vote in the diet as a member of the Rhenish bench of bishops. The conventual estates were of great extent, and among the feudatories who could be summoned to the court of the abbess were the elector of Hanover and the king of Prussia. Protestantism was introduced in 1568, and Magdalena, the last Roman Catholic abbess, died in 1589; but Protestant abbesses were appointed to the foundation, and continued to enjoy their imperial privileges till 1802, when Gandersheim was incorporated with Brunswick. The last abbess was a princess of the ducal house, and kept her rank till her death. The memory of Gandersheim will long be preserved by its literary memorials. Hroswitha, the author of the famous ecclesiastical dramas, was a member of the sisterhood in the 9th century; and the rhyming Chronicle of Eberhard of Gandersheim ranks as in all probability the earliest historical work composed in Low German. The Chronicle, which contains an account of the first period of the monastery, is edited by Wieland in *Monumenta Germ. historica* (Vernacular section, vol. ii., 1877), and has been the object of a special study by Paul Hasse, Göttingen, 1872. See also "Agii vita Hathumodæ abbatissæ Gandershemensis primæ," in J. G. von Eckhart's *Veterum monumentorum quaternio*, Leipsic, 1720; and Hase, *Mittelalterliche Baudenkmäler Niedersachsens*, 1870.

GANDIA, an ancient wall-encircled city of Spain in the province and archbishopric of Valencia, is beautifully situated in the fertile huerta or garden of Gandia, about 3 miles from the mouth of the river Alcoy. Its most prominent buildings are a large collegiate church, a college of the Escuelas Pias, and a palace of the dukes of Gandia. There is some trade in the produce of the district, especially in fruit; and linen and silk are manufactured to a limited extent. St. Francis de Borgia or Borja, third general of the Jesuit order, was duke of Gandia, and spent some years of his life there. Population about 7000.

GANDO, a kingdom of north-western Africa in the Sudan, comprising that part of the territory watered by the Quorra, or Niger, which extends from the Birni and Say in the N. to Idda in the S. It was established by the Fulah or Fulatah on the dissolution of the Houssa kingdom of Katchena by the death in 1817 of Sheik Othman dan Foddie. The political unity of the various parts of the kingdom is with difficulty maintained, and the process of disintegration has begun. Among the separate districts or provinces are Libtako in the north, Yaga, Saberma, Gurma, Dendima, a great part of Yoruba with the town of Ilori, Yauri, part of Nupe or Nyffe, and part of Borgu. The chief town is Gando, situated on the Sokoto, the first considerable affluent of the Niger from the east, not far from the town of Sokoto, which is the capital of the powerful kingdom of that name. Rabba, Egga, Busah, Igbegbo, and Bida are among the more important towns. The whole Gando territory is estimated at 81,500 square miles, and its population at 5,800,000. See Barth's *Travels in Central*

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[1] By F. Brandt, London, 1872.

[2] F. Pollock, *Principles of the Law of Contract.*

Africa, and Baikie, "Journey from Bidà to Kano," in *Journ. Roy. Geog. Soc.*, 1867.

GANGANELLI. See CLEMENT XIV.

GANGES, a river of northern India, formed by the drainage of the southern ranges of the Himálayas. This mighty stream, which in its lower course supplies the great river system of Bengal, rises in the Garhwál state, and falls into the Bay of Bengal after a course of 1500 miles. It issues, under the name of the Bhágirathí from an ice cave at the foot of an Himálayan snow bed near Gangotri, 10,300 feet above the level of the sea. During its earlier passage through the southern spurs of the Himálayas, it receives the Jahnavi from the north-west, and subsequently the Alaknandá, after which the united stream takes the name of the Ganges. Deo Prayág, their point of junction, is a celebrated place of pilgrimage, as is also Gangotri, the source of the parent stream. At Sukhi it pierces through the Himálayas, and turns south-west to Hardwár, also a place of great sanctity. It proceeds by a tortuous course through the districts of Dehra Dún, Saháranpur, Muzaffarnager, Bulandshahr, and Farrukhabad, in which last district it receives the Rámgangá. Thus far the Ganges has been little more than a series of broad shoals, long deep pools, and rapids, except, of course, during the melting of the snows and throughout the rainy season. At Allahábád, however, it receives the Jumna, a mighty sister stream, which takes its rise also in the Himálayas to the west of the sources of the Ganges. The combined river winds eastward by south-east through the North-Western Provinces, receiving the Gumti and the Gográ. The point of junction of each of these streams has more or less pretension to sanctity. But the tongue of land at Allahábád, where the Jumna and the Ganges join, is the true Prayág, *the* place of pilgrimage, to which hundreds of thousands of devout Hindus repair to wash away their sins in the sacred river. Shortly after passing the holy city of Benares, the Ganges enters Behar, and after receiving an important tributary, the Son, from the south, passes Patná, and obtains another accession to its volume from the Gandak, which rises in Nepál. Further to the east, it receives the Kusí, and then, skirting the Rájmahál hills, turns sharply to the southward, passing near the site of the ruined city of Gaur. By this time it has approached to within 240 miles, as the crow flies, from the sea. About 20 miles further on, it begins to branch out on the level country, and this spot marks the commencement of the delta, 220 miles in a straight line, or 300 by the windings of the river, from the Bay of Bengal. The main channel takes the name of the Padma or Padda, and proceeds in a south-easterly direction, past Pábná to Goalandá, above which it is joined by the Jamuná or main stream of the Brahmaputra. The vast confluence of waters rushes towards the sea, receiving further additions from the hill country on the east, and forming a broad estuary known under the name of the Meghná, which enters the Bay of Bengal near Noákháli. This estuary, however, is only the largest and most easterly of a great number of mouths or channels. The most westerly is the Húglí or Hooghly, which receives the waters of a number of distributary channels that start from the parent Ganges in the neighborhood of Murshidábád. Between the Húglí on the west and the Meghná on the east lies the delta. The upper angle of it consists of rich and fertile districts, such as Murshidábád, Nadiyá, Jessor, and the 24 Parganás. But towards its southern base, resting on the sea, the country sinks into a series of great swamps, intercepted by a net-work of innumerable channels. This wild waste is known as the Sundarbans, from the sundari tree, which grows in abundance in the sea-board tracts. The most important channel of the Ganges for commerce is the Húglí, on which stands Calcutta, about 90 miles from the mouth. Beyond this city, the navigation is conducted by native craft—the modern facilities for traffic by rail, and the increasing shoals in the river, having put an end to the previous steamer communication, which plied until about 1860 as high up as Allahábád. Below Calcutta important boat routes through the delta connect the Húglí with the eastern branches of the river, both for native craft and steamers. The Ganges is essentially a river of great cities: Calcutta, Monghyr, Patná, Benares, and Allahábád, all lie on its course below its junction with the Jumna; and the ancient capitals, Agra and Delhi, are on the Jumna, higher up. The catchment basin of the Ganges is bounded on the N. by a length of about 700 miles of the Himálayan range, on the S. by the Vindhyá mountains, and on the E. by the ranges which separate Bengal from Burmah. The vast river basin thus enclosed embraces 432,480 square miles. The flood discharge of the Ganges at Rájmahál, after it has received all its important tributaries, was formerly estimated at 1,350,000 cubic feet per second. According to the latest calculations, the length of main stream of Ganges is 1540 miles, or with its longest affluent, 1680; breadth at true entrance, 20 miles; breadth of channel in dry season, 1¼ to 2¼ miles; depth in dry season, 30 feet; flood discharge, 1,800,000 cubic feet per second; ordinary discharge, 207,000 cubic feet; longest duration of flood, about 40 days. The average descent of the river from Allahábád to Benares is 6 inches per mile; from Benares to Calcutta, between 4 and 5 inches; from Calcutta to the sea, 1 to 2 inches. Great changes take place from time to time in the river bed, which alter the face of the country. Extensive islands are thrown up, and attach themselves to the mainland, while the river deserts its old bed and seeks a new channel, it may be many miles off. Such changes are so rapid and on so vast a scale, and the corroding power of the current on the bank so irresistible, that in Lower Bengal it is considered perilous to build any structure of a large or permanent character on the margin. Many decayed or ruined cities attest the changes in the river bed in ancient times; and within our own times the main channel which formerly passed Rájmahál has turned away from it, and left the town high and dry, 7 miles from the bank.

GANGI, a town of Italy, in the province of Palermo, and circondario of Cefalu, about 22 miles inland from the town of Cefalu. It occupies the slope of a hill on the southern flanks of the Nebrode or Monte Marone, and the ridge of the hill is crowned by a striking fortress with three towers, only one of which, however, is entire. The inhabitants, who in 1871 numbered 12,921, cultivate grain and manufacture cheese in sufficient quantities to maintain a moderate trade. Gangi Vetere or Old Gangi, in the vicinity, is identified, according to a conjecture of Cluverius, with the ancient Enguium or Engyum. The foundation of Enguium was ascribed by Diodorus Siculus and Plutarch to a Cretan settlement, and Plutarch relates that relics of Meriones and Ulysses were exhibited in his time in the town. Having sided with the Carthaginians in the Second Punic War, it was saved from the vengeance of Marcellus by the entreaties of a certain Nicias. At the close of the republic it was a municipal town, with considerable celebrity on account of the temple of the Great Mother, as Cicero calls her.

GANGOTRI, a celebrated place of Hindu pilgrimage, situated among the Himálaya Mountains, in the State of Gárhwal, on the Ganges, which is here not above 15 or 20 yards broad, with a moderate current, and not in general above 3 feet deep. The course of the river runs N. by E.; and on the bank near Gangotri there is a small temple about 8 or 10 feet high, in which are two images representing the Ganges and Bhágirathí rivers. The bed of the river adjoining the temple is divided off by the Brahmans into three basins, where the pilgrims bathe. One of these portions is dedicated to Brahma, another to Vishnu, and the third to Siva. The pilgrimage to Gangotri is considered efficacious in washing away the sins of the devotee, and ensuring him eternal happiness in the world to come. The water taken from this sacred spot is exported by pilgrims to India, and sold at a high price. It is drawn under the inspection of a Brahman, to whom a trifling sum is paid for the privilege of taking it, and the vessels are then sealed. The elevation of the temple above the sea is 10,319 feet. Long. 78° 59′ E., lat. 30° 59′ N.

GANGPUR, a tributary State of Chutiá Nágpur, Bengal, situated between 21° 47′ 5″ and 22° 32′ 20″ N. lat., and 85° 10′ 15″ and 85° 34′ 35″ E. long. It is bounded on the N. by Lohárdagá district and Jashpur state; on the E. by Singbhum district; on the S. by Bonái and Bámrá States and Sambalpur district; and on the W. by Ráipur district. Gangpur State consists of a long undulating table-land about 700 feet above the sea, sloping downwards from the higher plateau of Chutiá Nágpur to the N., and dotted with detached ranges and isolated peaks rising to a height of 2240 feet. The area is 2484 square miles. The chief products are rice, sugar-cane, oil-seeds, and tobacco, besides lac, *tasar* silk, resin, and catechu, yielded by the jungles. Diamonds and gold are occasionally found in the bed of the river Ib. Coal is known to exist, but is not worked. The population in 1872 numbered 73,637, viz., 37,751 males and 35,886 females.

Of the total population 45,208, or 61·3 per cent., belong to various aboriginal hill tribes, such as Bhuiyás, Uráons, etc.; 9843, or 13·4 per cent., are semi-Hinduized aborigines; 18,349, or 24·9 per cent., are Hindus; and 231 are Mahometans. The state yields the rájá an estimated annual revenue of £2000, and pays an annual tribute to the British government of £50.

GANGRENE. See MORTIFICATION.

GANILH, CHARLES (1758–1836), a distinguished political economist, was born at Allanche in Cantal, on the 6th January, 1758. He was educated for the profession of law, and practised as *avocat.* During the troubled period which culminated in the taking of the Bastile on 14th July, 1789, he came prominently forward in public affairs, and was one of the seven members of the permanent Committee of Public Safety which sat at the Hôtel de Ville. He was imprisoned during the Reign of Terror, and was only released by the counter-revolution of the 9th Thermidor. During the first consulate he was called to the tribunate, but was excluded in 1802. In 1815 he was elected deputy for Cantal, and finally left the chamber on its dissolution in 1823. He died in 1836. Ganilh is best known as the most vigorous defender of the mercantile school in opposition to the views of Adam Smith and the English economists. His works, though interesting from the clearness and precision with which these peculiar opinions are presented, do not now possess much value for the student of political economy. The most important are the treatises, *Des Systèmes d'Économie Politique* (1st ed., 1809; 2d ed., 1821, 2 vols.), in which the rival doctrines of economics are stated and compared, and *Théorie de l'Économie Politique, fondée sur les faits,* which introduces largely the element of statistical detail. Other works are—*Essai politique sur le revenu public des peuples de l'antiquité et du moyen âge* (2 vols., 1st ed., 1806; 2d ed., 1823); *De la Législation* (1817); and *Dictionnaire Analytique d'Économie Politique* (1st vol., 1826)—"a work," says Blanqui, "unworthy of him." A considerably higher estimate of Ganilh's merits than that given by Blanqui will be found in Kantz's laborious *Geschichtliche Entwick. d. National-Œkonomik* (sec. 85, pp. 598, 599).

GANJAM, a district of Madras, situated between 18° 18′ and 19° 40′ 30″ N. lat., and between 83° 51′ 30″ and 83° 10′ 30″ E. long., bounded on the N. by Purí district in Orissa; on the E. by the Bay of Bengal, on the S. by Vizagapatam district, and on the W. by the estates of Kalahandi, Patná, and Jáipur. The district is exceedingly mountainous and rocky, but is interspersed with open valleys and fertile plains. Pleasant groves of trees in the plains give to the scenery a greener and less Indian appearance than is usually met with in the districts to the south. The mountainous tract known as the Máliyás, or chain of the eastern *ghâts,* has an average height of about 2000 feet,—its principal peaks being Singhháráj (4976 feet), Mahendragiri (4923), and Deodanga (4534). The chief rivers are the Rushikuliyá (with its tributary the Mahánadi), the Vamsadári, and the Lánguliyá; besides numerous mountain streams and torrents. The sea and river fisheries afford a livelihood to a considerable section of the population. The hilly region abounds in forests consisting principally of *sál,* with satin wood, ebony, and sandal-wood in smaller quantities. The district abounds in game both large and small.

Ganjam formed part of the ancient kingdom of Kalinga. Its early history is involved in obscurity, and it was not till after the Gajapati dynasty ascended the throne of Orissa, that this tract became even nominally a part of their dominions. Owing to the nature of the country, the rising Mahometan power was long kept at bay; and it was not till nearly a century after the first invasion of Orissa that a Mahometan governor was sent to govern the Chikakol Sarkárs, which included the present district of Ganjam. In 1753 Chikakol, with the Northern Sarkárs, was made over to the French by Salabat Jang for the maintenance of his French auxiliaries. In 1759 Masulipatam was taken by an English force sent from Bengal, and the French were compelled to abandon Ganjam and their other factories in the north. In 1765 the Northern Sarkárs (including Ganjam) were granted to the English by imperial firman, and in August, 1768, an English factory was founded at Ganjam, protected by a fort. The present district of Ganjam was constituted in 1802. In the earlier years of British rule considerable difficulty was experienced in administering the district. The country was continually in a state of confusion and disturbance; and on more than one occasion, the refractory large landholders had to be coerced by means of regular troops. In 1816 Ganjam was overrun by the Pindáris; and in 1836 occurred the Gúmsur campaign, when the British first came into contact with the aboriginal Kandhs, the suppression of whose practice of human sacrifice was successfully accomplished. A petty rising of a section of the Kandhs occurred in 1865, which was, however, suppressed without the aid of regular troops.

The census of 1872 gives the area at 8500 square miles, including 3359 square miles occupied by the Máliyá or mountain-region, and the population at 779,112 males and 740,976 females,—total, 1,520,088 (with 4562 villages and 341,404 houses), classified thus according to religion:—Hindus, 1,513,673; Mahometans, 4826; Christians, 1043; Buddhists or Jains, 45; "others," 501. The Kandhs and Sauras are the aboriginal tribes inhabiting the mountains. Of the plains population two-thirds are estimated as belonging to the Urugá race, the remainder being mostly Telegus. Of the plains country, with an area of 5141 square miles, or 3,290,240 acres, about one-third is under cultivation, one-third cultivable, and one-third waste. A considerable extent of land is under cultivation in the Máliyás, but no revenue is derived from this tract. Rice forms the staple product, and is largely exported. The other crops are cereals of various sorts, pulses and oilseeds, fibres, sugar-cane (said to be the best in India), tobacco, indigo, chilies, etc. Holdings are small, and the peasantry are generally poor and in debt to the village money-lender. Five towns contain a population exceeding 5000: Berhampur, 21,670; Parla Kimidi, 15,958; Chikakol, 15,587; Báruvá, 6739; Takkali Raghunandapuram, 5206. Ganjam town, the former administrative headquarters of the district, has a population of only 4163. The means of internal communication consist of 661 miles of road in the plains, and 323 miles of hill roads, besides a short tidal canal 9 miles long, connecting the Chilká lake with the Rushikuliyá river. Salt manufacture is a Government monopoly, yielding about £200,000 annually. The revenue has rapidly increased of late years, having advanced from £216,196 in 1860–61 to £238,705 in 1875–76. The chief receipts are the salt and land revenue, which yielded £196,396 and £117,348 respectively in 1875–76. The expense of administering the district amounted to £23,970 in 1860–61, and to £28,123 in 1875–76. For the protection of persons and property there were, in 1875–76, 27 magisterial and 13 civil and revenue courts. Murder is unusually prevalent in Ganjam, no less than 26 cases having occurred in 1875. Education is backward, only about 3·3 per cent. of the population of the plains being able to read and write. In 1875 there were 334 Government or aided schools in the plains, attended by 6909 pupils, besides 17 schools in the hills, with 860 pupils.

GANNAL, JEAN NICOLAS (1791–1852), a distinguished French technical chemist, was born at Sarre-Louis, July 28, 1791. At the age of fourteen he was placed in a druggist's establishment, where he acquired a knowledge of chemical manipulation. In 1808 he entered the medical department of the French army, and in the campaign of 1812 he witnessed the disastrous retreat from Moscow. After the downfall of the empire he obtained a situation at the École Polytechnique in Paris, and subsequently acted as chemical assistant to Thénard. Having commenced research in industrial chemistry, he devised a method for the refining of borax, by which the price of that salt was reduced from 6 francs to 60 centimes per ℔. He was the first to introduce into printing the use of elastic rollers, which he formed of a mixture of gelatin and sugar, and his process for the melting of tallow and hardening it with acids prepared the way for the manufacture of wax-candles. In 1823 he took out a patent for the making of glue and gelatin. His experiments with the latter substance demonstrated the incorrectness of the opinion, held by Darcet and others, that it possessed highly nutritive properties. He obtained one of the Montyon prizes of the Institute in 1827 for the employment of chlorine in the treatment of catarrh and phthisis, and again in 1835 for his discovery of the efficacy of injections of solutions of acetate and chloride of aluminium in preserving anatomical preparations. Turning his attention next to embalmment, he showed that it could be accomplished without mutilation of the body, and with greater economy than after the old methods, by injecting into one of the carotid arteries solutions of aluminium salts. Gannal died at Paris in 1852. The following are among his works:—

Du Chlore employé comme Remède contre la Phthise pulmonaire, 1832, 8vo; *Sur la Gélatine,* 1834 and 1836, 2 pts. 8vo; *Sur la Conservation des Parties animales,* 1836, 8vo; *Mémoire . . . sur l'Application d'un nouveau Système d'Inhumation dans les Cimitières,* 1842, 4to; *Histoire des Embaumements et de la Pré-*

paration des Pièces d'Anatomie normale, 1837 and 1841, 8vo; *M. Gannal et M. le Docteur Pasquier,*—a pamphlet relative to the embalmment of the duke of Orleans, in which Gannal's process was not employed, 1842, 8vo; and *Lettre à l'Institut,* 1843, and *Nouvelle Lettre aux Médecins,* 1844, on embalming, 8vo.

GANNAT, a town of France, capital of an arrondissement in the department of Allier, is situated on the Andelot, an affluent of the Allier, 33 miles S. by W. of Moulins. The vicinity is very pleasant, but the town is badly built and the streets are crooked and narrow. It possesses a tribunal of primary instance, a hospital, and a secondary school. There are limeworks, tanneries, cutleries, and some trade in corn, fruits, wine, and cattle. The town was formerly surrounded by walls, and what remains of its old castle is now used as a prison. The church of Sainte-Croix possesses a choir in the pure Auvergne style of the 11th century, and also some fine paintings. The population in 1876 was 5042.

GANNET (Anglo-Saxon, *ganot*) or SOLAN GOOSE,[1] the *Pelecanus bassanus* of Linnæus and the *Sula bassana* of modern ornithologists, a large sea-fowl long known as a numerous visitor, for the purpose of breeding, to the Bass Rock at the entrance of the Firth of Forth, and to certain other islands off the coast of Britain, of which four are in Scottish waters—namely, Ailsa Craig, at the mouth of the Firth of Clyde; the group known collectively as St. Kilda; Suleskerry, some 40 miles north-east of the Butt of Lewis; and the Stack and Skerry, about the same distance westward of Stromness. It appears also to have two stations off the coast of Ireland, the Skellig Islands and the Stags of Broadhaven, and it resorts besides to Lundy Island in the Bristol Channel—its only English breeding-place. Further to the northward its settlements are Myggenæs, the most westerly of the Faroes, and various small islands off the coast of Iceland, of which the Vestmannaeyjar, the Reykjanes Fuglaskér, and Grimsey are the chief. On the western side of the Atlantic it appears to have but five stations, one in the Bay of Fundy, and four rocks in the Gulf of St. Lawrence. On all these seventeen places the bird arrives about the end of March or in April and departs in autumn when its young are ready to fly; but even during the breeding-season many of the adults may be seen on their fishing excursions at a vast distance from their home, while at other times of the year their range is greater still, for they not only frequent the North Sea and the English Channel, but stray to the Baltic, and, in winter, extend their flight to the Madeiras, while the members of the species of American birth traverse the ocean from the shores of Greenland to the Gulf of Mexico.

Apparently as bulky as a Goose, and with longer wings and tail, the Gannet weighs considerably less. The plumage of the adult is white, tinged on the head and neck with buff, while the outer edge and principal quills of the wing are black, and some bare spaces round the eyes and on the throat reveal a dark blue skin. The first plumage of the young is of a deep brown above, but paler beneath, and each feather is tipped with a triangular white spot. The nest is a shallow depression, either on the ground itself or on a pile of turf, grass, and seaweed,—which last is often conveyed from a great distance. The single egg it contains has a white shell of the same chalky character as a Cormorant's (vol. vi. p. 361). The young are hatched blind and naked, but the slate-colored skin with which their body is covered is soon clothed with white down, replaced in due time by true feathers of the dark color already mentioned. The mature plumage is believed not to be attained for some three years. Towards the end of summer the majority of Gannets, both old and young, leave the neighborhood of their breeding-place, and, betaking themselves to the open sea, follow the shoals of herrings and other fishes (the presence of which they are most useful in indicating to fishermen) to a great distance from land. Their prey is almost invariably captured by plunging upon it from a height, and a company of Gannets fishing presents a curious and interesting spectacle. Flying in a line, each bird, when it comes over the shoal, closes its wings and dashes perpendicularly into the waves, whence it emerges after a few seconds, and, shaking the water from its feathers, mounts in a wide curve, and orderly takes its place in the rear of the string, to repeat its headlong plunge so soon as it again finds itself above its prey.[2]

Gannet, or Solan Goose.

Structurally the Gannet presents many points worthy of note, such as its closed nostril, its aborted tongue, and its toes all connected by a web—characters which it possesses in common with most of the other members of the group of birds (*Steganopodes*) to which it belongs. But more remarkable still is the system of subcutaneous air-cells, some of large size, pervading almost the whole surface of the body, communicating with the lungs, and capable of being inflated or emptied at the will of the bird. This peculiarity has attracted the attention of several writers—Montagu, Professor Owen (*Proc. Zool. Soc.*, 1831, p. 90), and Macgillivray; but a full and particular account of the anatomy of the Gannet is still to be desired.

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[1] The phrase *Ganotes bæð* (Gannet's bath), a periphrasis for the sea, occurs in the *Anglo-Saxon Chronicle*, in reference to events which took place 975 A. D., as pointed out by Prof. Cunningham, whose learned treatise on this bird (*Ibis*, 1866, p. 1) nearly exhausts all that can be said of its history and habits. A few pages further on (p. 13) this writer remarks:—"The name Gannet is intimately connected with our modern English Gander, both words being modifications of the ancient British 'gan' or 'gans,' which is the same word with the modern German 'Gans,' which in its turn corresponds with the old High German 'Kans,' the Greek χήν, the Latin *anser*, and the Sanskrit 'hansa,' all of which possess the same signification, viz., a Goose. The origin of the names Solan or Soland, Sulan, Sula, and Haf-sula, which are evidently all closely related, is not so obvious. Martin [*Voy. St. Kilda*] informs us that 'some imagine that the word Solan comes from the Irish Souler, corrupted and adapted to the Scottish language, *qui oculis irretortis e longinquo respiciat prædam.*' The earlier writers in general derive the word from the Latin *solea*, in consequence of the bird's supposed habit of hatching its egg with its foot; and in a note intercalated into Ray's description of the Solan Goose in the edition of his Itineraries published by the Ray Society, and edited by Dr. Lankester, we are told, though no authority for the statement is given, that 'the Gannet, *Sula alba*, should be written Solent Goose, *i. e.*, a channel goose.'" Hereon an editorial note remarks that this last statement appears to have been a suggestion of Yarrell's, and that it seems at least as possible that the "Solent" took its name from the bird.

[2] The large number of Gannets, and the vast quantity of fish they take, has been frequently animadverted upon, but the computations on this last point are perhaps fallacious. It seems to be certain that in former days fishes, and herrings in particular, were at least as plentiful as now, if not more so, notwithstanding that Gannets were more numerous. Those frequenting the Bass were reckoned by Macgillivray at 20,000 in 1831, while in 1869 they were computed at 12,000, showing a decrease of two-fifths in 38 years. On Ailsa in 1869 there were supposed to be as many as on the Bass, but their number was estimated at 10,000 in 1877 (*Report on the Herring Fisheries of Scotland*, 1878, pp. xxv. and 171),—being a diminution of one-sixth in eight years, or nearly twice as great as on the Bass.

In the southern hemisphere the Gannet is represented by two nearly allied but somewhat smaller forms—one, *Sula capensis*, inhabiting the coast of South Africa, and the other, *S. serrator*, the Australian seas. Both much resemble the northern bird, but the former seems to have a permanently black tail, and the latter a tail the four middle feathers of which are blackish-brown with white shafts.

Apparently inseparable from the Gannets generically are the smaller birds well known to sailors as Boobies from the extraordinary stupidity they commonly display. They differ, however, in having no median stripe of bare skin down the front of the throat; they almost invariably breed upon trees, and are inhabitants of warmer climates. One of them, *S. cyanops*, when adult has much of the aspect of a Gannet, but *S. piscator* is readily distinguishable by its red legs, and *S. leucogaster* by its upper plumage and neck of deep brown. These three are widely distributed within the tropics, and are in some places exceedingly abundant. The fourth, *S. variegata*, which seems to preserve throughout its life the spotted suit characteristic of the immature *S. bassana*, has a much more limited range, being as yet only known from the coast of Peru, where it is one of the birds which contribute to the formation of guano. (A. N.)

GANS, Edward (1798–1839), a distinguished jurist, was born at Berlin, on the 22d March, 1798. His father, a banker in Berlin, was of Jewish descent. He was educated first at Berlin, then at Göttingen, and finally at Heidelberg, where he met Thibaut, the celebrated lawyer, and Hegel, by whom he was much attracted. He attended Hegel's lectures at Berlin and became thoroughly imbued with the principles of the Hegelian philosophy. In 1825 he travelled for some months in England and France, and on his return was named professor extraordinarius at Berlin. At this period the historical school of jurisprudence was coming to the front, and Gans, already, from his Hegelian tendencies, predisposed to treat law historically, applied the method to one special branch of legal relations—the right of succession. His great work, *Erbrecht in weltgeschichtlichen Entwicklung* (4 vols. 1825, 1825, 1829, and 1835), is still of permanent value, not only on account of its extensive survey of facts, but through the admirable manner in which the general theory of the slow evolution of legal relations is presented. In 1830, and again in 1835, Gans visited Paris, and formed an intimate acquaintance with the knot of brilliant writers and lecturers, Cousin, Villemain, Michelet, and Quinet, who then made Paris the centre of literary culture and criticism. The liberality of his views, especially on political matters, drew upon Gans the displeasure of the Prussian Government, and in 1835 his course of lectures on the history of the last fifty years, afterwards published (*Vorlesungen über d. Geschichte d. letzten fünfzig Jahre*), was prohibited. He died at Berlin in 1839. In addition to the works above mentioned, there may be noted the treatise on the right of possession (*Ueber die Grundlage des Besitzes*, 1829), a portion of a systematic work on the Roman civil law (*System der Römischen Civil-rechts*, 1827), and a collection of his miscellaneous writings (*Vermischte Schriften*, 1832). Gans edited the *Philosophie der Geschichte* in Hegel's *Werke*, and contributed an admirable preface.

See on the life and works of Gans, *Revue des Deux Mondes*, Dec., 1839.

GÄNSBACHER, Johann Baptist (1778–1844), a musical composer of repute, was born in 1778 at Sterzing in Tyrol. His father, a schoolmaster and teacher of music, undertook his son's early education, which the boy continued under various masters till 1802, when he became the pupil of the celebrated Abbate Vogler. To his connection with this artist and with his fellow pupils, more perhaps than to his own merits, Gänsbacher's permanent place in the history of music is due; for it was during his second stay with Vogler, then (1810) living at Darmstadt, that he became acquainted with Weber and Meyerbeer, who had also been attracted by the abbate's reputation, and the close friendship which sprang up among the three young musicians, and was dissolved by death only, has become celebrated in the history of their art. But although Gänsbacher owes the greater part of his reputation to this circumstance, he was himself by no means without merit. He creditably filled the responsible and difficult post of director of the music at St. Stephen's Cathedral, Vienna, from 1823 till his death (July 13, 1844); and his compositions betray the musician of high gift and accomplishment. They consist chiefly of church music, not less than 17 masses, besides litanies, motets, offertories, etc., being amongst the number. He also wrote several sonatas, a symphony, and one or two minor compositions of a dramatic kind.

GANYMEDE (Greek, Γανυμήδης, Latin, *Ganymedes*) affords a typical example of the manner in which myth-making continued as a living process through the whole of Greek history. In the thought of the primitive Indo-Germanic race, occupied with the simplest cares of living, a very frequent subject was naturally the rain; and their thought has been preserved to us in the form of mythology. As the rain descends to earth it is the chief blessing to men, while in the clouds it gladdens the dwellers there. Hence arises the idea of a drink for the gods—the soma of the Hindus, the meth of the Norsemen, and the nectar of the Greeks—which plays such an important part in the *Rig Veda*, the *Edda*, and the Homeric poetry. The guardian and giver of the divine drink occurs in many forms, sometimes as a bird, sometimes as a divine being. Just as the eagle brings nectar to Zeus in Crete, so Odin takes the form of an eagle to steal the meth from Guttung for the use of the gods. The same divinity that in heaven distributes the drink to the gods is on earth the genius that presides over the due supply of water. Hence among the Greeks Ganymede, as this genius is called, exists in heaven as the Aquarius of the zodaic (Hyginus, fab. 224), while on earth he is, as Pindar (fr. 267 [110]) tells us, the genius of the fountains of the Nile, which was *par excellence* the life-giving and fertilizing river of the earth.

But the form under which the Ganymede myth most commonly appears has its origin in Asia Minor and in Crete. Homer (*Il.*, xx. 232) says that Ganymede was a son of Tros, and that the gods on account of his beauty carried him off to heaven to dwell among the immortals and pour out the wine for Zeus. The *Little Iliad* again makes him the son of Laomedon, and says that Zeus gave his father a golden vine in exchange for him. In the Trojan Ganymede there is not much trace left of the old kindly genius who distributes the blessing out of the clouds. We may, indeed, when we remember that the Greeks admired personal beauty as almost divine (*cf.* Hdt., v. 47), be able to see in this translation the good genius returning alive to heaven after his sojourn on earth, an idea that occurs in the mythology of almost every race. But now he seems rather to represent the everlasting youth and beauty that attend on the gods, and to be the male counterpart of Hebe, who was worshipped in Phlius under the name Ganymeda (Pausanias, ii. 13). More and more the myth grows away from its earliest form, and as Greek manners altered the darkest side of their social system attached itself to it. Through the Ionian Greeks the Asiatic custom of secluding women had spread to the mother country and superseded the old heroic manners. The presence of women at meal-times, customary in the time of Homer (*Od.*, iv. 221), was now discontinued. Beautiful young male slaves waited at banquets, and the feeling grew that the gods also observed this custom. Ganymede was now conceived as the favorite of Zeus. So early as the hymn to Aphrodite, Zeus himself carries off Ganymede on account of his beauty; and Theognis (about 500 B. C.) speaks of the love of Zeus for Ganymede as a well-known tale. In Crete especially, where the love of boys was systematized and legalized, and from which the habit spread over the whole of Greece, does the myth find nourishment and growth. On the one hand, Zeus was represented to have himself, in the form of an eagle, carried off Ganymede; on the other hand, it was said that Minos, the primitive ruler and law-giver of Crete, had been the ravisher of Ganymede. In this way it was attempted to give dignity and antiquity to a borrowed and loathsome custom. The rapidity with which the habit spread all over Greece makes the mythical embodiment of it fill an important place in the painting, sculpture, and literature of Greece in its decline. Thus it comes that the name which once denoted the good genius that gives the best gifts to man was adopted in the vulgar Latin under the form Catamitus to signify the most degraded of men (on this subject *v.* Böttiger, *Kunst-Mythol.*, ii. 35, 61).

It is significant that in Greek art not one very early representation of the myth occurs (Overbeek, *Kunst-Myth-*

ologie, p. 515); but in the middle and later periods it becomes a favorite subject. Two moments especially are represented—(1) Ganymede carried off by the eagle, where the eagle is sometimes Zeus's messenger, but at other times obviously Zeus himself, as is shown by the sensual passion apparent in both figures (Jahn, *Archæolog. Beiträge*, p. 20), and (2) Ganymede feeding or caressing the eagle.

Besides Preller's and Jacobi's elaborate works, see Kuhn, *Herabkunft des Feuers*; Braun, *Naturgesch. der Sage*; Hartung, *Religion u. Myth. der Griechen*; Schwartz, *Ursprung der Myth.*; and on the derivation of the name see Kuhn's *Zeitsch.*, ii. and v.

GAP (the ancient *Vapincum*), a town of France, capital of an arrondissement and also of the department of Hautes-Alpes, is situated on the right bank of the Luye, 46 miles S. E. of Grenoble. It stands in a wide valley about 2400 feet above sea-level, and is surrounded by an amphitheatre of hills, over which tower the snow-covered mountains of the Alps. In the vicinity are fine walnut avenues and vineyards, but the town, with the exception of a few modern houses, is badly built and has a somewhat miserable appearance. The chief public buildings are the Gothic cathedral, containing the tomb of the celebrated Constable de Lesdiguières, the court-house, the town-hall, the bishop's palace, the barracks, and the theatre. In 1866 a statue in black marble was erected in front of the barracks to Baron de Ladoucette, a former prefect of the Hautes-Alps. Gap is the seat of a court of primary jurisdiction, and has a communal college, a diocesan seminary, a public library, and a museum of antiquities, natural history, botany, and geology. The manufactures comprise woollen, linen, and silk goods, leather, and dressed skins. In the vicinity are some marble quarries, which were known to the Romans. The town became the seat of a bishopric in the 4th century, and its bishops were for a long period styled princes and counts of Gap. In former times it suffered greatly from the devastations of the Lombards and Moors, from the plague, and from earthquakes; and in 1692 it was almost burned to the ground by Duke Victor Amadeus of Savoy. The population in 1876 was 7249.

GARAT, Dominique Joseph (1749–1833), was born at Bayonne, 8th September, 1749. After receiving a good education under the direction of a relation who was a curé, he came to Paris, where he obtained introductions to the most distinguished writers of the time, and became a contributor to the *Encyclopédie Méthodique* and the *Mercure de France*. He gained considerable reputation by an éloge on L'Hôpital in 1778, and was afterwards three times crowned by the Academy for éloges on Suger, Montausier, and Fontenelle. In 1785 he was named professor of history at the Athenæum, where his lectures enjoyed an equal popularity with those of Laharpe on literature. Being chosen a deputy to the states-general in 1789, he rendered important service to the popular cause by his narrative of the proceedings of the Assembly contributed to the *Journal de Paris*. Possessing strongly optimist views, a mild and irresolute character, and indefinite and changeable convictions, he played a somewhat undignified part in the great political events of the time, and became a pliant tool in carrying out the designs of others. He succeeded Danton as minister of justice in 1792, and in this capacity had entrusted to him what he called the *commission affreuse* of communicating to Louis XVI. his sentence of death. In 1793 he became minister of the interior, and during the Reign of Terror he was imprisoned, but he received his liberty after the revolution of the 9th Thermidor, and was named minister of public instruction. In 1798 he was appointed ambassador to Naples, and in the following year he became a member of the Council of the Ancients. After the revolution of the 18th Brumaire, he was chosen a senator by Napoleon and created a count. During the Hundred Days he was a member of the chamber of representatives, and strongly opposed the recall of the Bourbons. In 1803 he was chosen a member of the Institute of France, but after the restoration of Louis XVIII. his name was, in 1816, deleted from the list of members. After the revolution of 1830 he was named a member of the new Academy of Moral and Political Science. He died at Ustaritz near Bayonne, April 25, 1833. His writings are characterized by elegance, grace, and variety of style, and by the highest kind of rhetorical eloquence; but his grasp of his subject is superficial, and as his criticisms have no root in fixed and philosophical principles they are not unfrequently whimsical and inconsistent. He must not be confounded with his elder brother Dominique (1735–1799), who was also a deputy to the states-general.

The works of Garat include, besides those already mentioned *Considérations sur la Révolution française*, Paris, 1792; *Mémoires sur la Révolution, ou Exposé de ma conduite*, 1795; *Mémoires sur la vie de M. Suard, sur ses écrits, et sur le XVIII*^{me} *siècle*, 1820; éloges on Joubert, Kléber, and Desaix; several notices of distinguished persons; and a large number of articles in periodicals.

GARAT, Pierre-Jean (1764–1823), one of the most famous singers of his time, nephew of the former, was born at Ustaritz, 25th April, 1764. Gifted with a voice of exceptional timbre and compass, he devoted himself, from an early age, to the cultivation of his musical talents. On account of his manifesting a distaste for the legal profession, for which his father wished him to study, he was deprived of his allowance, but he obtained through the patronage of a friend the office of secretary to Comte d'Artois, and was afterwards engaged to give musical lessons to the queen of France. After the Revolution he became a professional singer, and on account of a song which he had composed in reference to the misfortunes of the royal family he was thrown into prison. On regaining his liberty he went to Hamburg, where he at once achieved extraordinary success; and by his subsequent appearances in Paris, and his visits to Italy, Spain, Germany, and Russia, he made for himself a reputation as a singer unequalled by any other of his own time. He was a keen partisan of the composer Gluck in opposition to Handel. On the institution of the Conservatoire de Musique, he became its professor of singing. He is also the composer of a number of songs, many of which have considerable merit. He died 1st March, 1823.

GARAY, János (1812–1853), Hungarian poet and author, was born 10th October, 1812, at Szegszárd, in the county of Tolna. From 1823 to 1828 he studied at Fünfkirchen, and subsequently, in 1829, at the university of Pesth. Here, having become acquainted with the works of the best German authors, he devoted himself to literary pursuits, and in 1834 brought out an heroic poem, in hexameters, under the title *Csatár*. After this he issued in quick succession various historical dramas, among which the most successful were *Arbócz*, *Országh Ilona*, and *Báthori Erzsébet*,—the first two published at Pesth in 1837, and the last in 1840. From 1833 to 1836 Garay was, moreover, associated with the literary journal *Regélö* (Taleteller), and in 1837 assisted in the editorship of the periodical *Rajzolatok* (Sketches). At the beginning of 1838 he removed to Presburg, where he was for some time engaged in editing the political journal *Hirnök* (Herald). He returned to Pesth in 1839, when he was elected a corresponding member of the Hungarian Academy of Sciences. In 1842 he was admitted into the Kisfaludy Society, of which he became second secretary. Garay enriched Hungarian literature with numerous lyrical poems, ballads, and tales. The first collection of his poems was published at Pesth in 1843; and his prose tales appeared in 1845, under the title of *Tollrajzok* (Sketches with the Pen). His historical ballads and legends, styled *Arpádok*, Pesth, 1847 (2d ed. 1848), showed him to be a master in the art of ballad writing. Some of his lyrical poems also are excellent, as for example, *Balatoni Kagylók* (Shells from the Balaton Lake), Pesth, 1848. His legend *Bosnyák Zsófia*, Pesth, 1847, as also his poetical romance *Frangepán Kristófné* (Christopher Frangepan's Wife), Pesth, 1846, gained the prize of the Kisfaludy Society. His last and most famous work was an historical poem in 12 cantos, with the title *Szent László* (Saint Ladislaus), Eger, 1852 (2d ed. Pesth, 1853, 3d ed. 1863). In 1848 Garay was nominated professor of Hungarian language and literature to the university of Pesth, but in the following year he resigned that post. In 1850 he became enfeebled in health, and at length unfit for further literary efforts. After about four years' illness, he died on the 5th November, 1853, in great want, in the forty-second year of his age. A collective edition of his poems was published at Pesth the year after his death by F. Ney (2d ed. 1860), and several of his poems have been translated by Kertbeny.

See *Garay János összes költeményei*, 2d ed., Pesth, 1860; and *Dichtungen von Johann Garay*, 2d ed., Vienna, 1856.

GARBO, Raffaellino del (1466–1524), a Florentine painter. His real name was Raffaello Capponi; Del Garbo was a nickname, bestowed upon him seemingly from the graceful nicety (*garbo*) of his earlier works. He was a scholar of Filippino Lippi, with whom he remained till 1490, if not later. He showed great facility in design, and excited hopes which the completed body of his works fell short of. He married and had a large family; embarrassments and a haphazard manner of work ensued; and finally he lapsed into a very dejected and penurious condition. Three of his best tempera pictures are in the Berlin Gallery; one of the Madonna standing with her Infant between two musician-angels is particularly attractive. We may also name the oil-painting of the Resurrection done for the church of Monte Oliveto, Florence, now in the Academy of the same city, ordinarily reputed to be Raffaellino's masterpiece; the ceiling of the Caraffa Chapel in the church of the Minerva, Rome; and a Coronation of the Virgin in the Louvre, which is a production of much merit, though with somewhat over-studied grace. Angelo Allori was his pupil.

GARÇAO, PEDRO ANTONIO CORREA (1724–1772), Portuguese lyric and dramatic poet, was born in the neighborhood of Lisbon on the 24th of April, 1724. Almost nothing of his biography is known except that he lived a life of quiet domesticity and learned leisure, in a rural retreat at Fonte-Santa near the capital, till about his thirty-sixth year, when he was imprisoned on an obscure charge which is believed to have arisen out of some expressions in his writings that had given offence to a despotic Government. After languishing in confinement for eighteen months, he was released by death on the 10th of November, 1772. His works, which include sonnets, odes, satires, and epistles, as well as dramatic pieces, were published for the first time in a collected form in 1778 (*Obras poeticas de P. A. C. Garçao*), and are regarded by the Portuguese as having marked a period of revival in their national literature. While, however, in an age of great degeneracy he succeeded in exhibiting purity and refinement of taste, he cannot be said to have given any indications of an original or powerful genius. His dramas are confessedly imitations from foreign models; while his odes, epistles, and satires, which have earned for him the title (shared by Ferreira) of "the Portuguese Horace," at once reveal the source of their inspiration. His endeavor, moreover, occasionally to approach the classic style more nearly by substituting quantity for rhyme can hardly be regarded as very successful.

GARCIA, MANOEL (1775–1832), or, in full, Manoel Garcia del Popolo Vicente, was born in 1775 at Seville. He began artistic life as chorister at the cathedral of Seville, and simultaneously studied music under the best masters of his native city. At the age of seventeen he made his début on the stage at Cadiz, in an operetta of his own composition. Soon afterwards he appeared at Madrid in his twofold capacity of singer and composer. His reputation being thus established, he proceeded to Paris, where he appeared for the first time, in 1808, in Paer's opera *Griselda*. Here also he was received with great applause, his style of singing being especially appreciated. This he further improved by careful study of the Italian method in Italy itself, where he continued his successes. His opera, *The Caliph of Bagdad*, was favorably received at Naples in 1812, but his chief successes were again due to his perfection as a vocalist. In 1824 he went to London, and thence proceeded to America (1825) with a company of excellent artists, amongst whom were his son Manoel and his daughter Maria, better known under her subsequent name of Malibran. He extended his artistic tour as far as Mexico, and was on the point of returning to Europe in order to retire from public life, when he was robbed of his well-earned wealth by brigands on his way to Vera Cruz. Settled again in Paris he soon retired from the stage, and devoted himself exclusively to teaching. He died in 1832. His method of teaching was unsurpassed, and some of the most celebrated singers of the early part of the century were amongst his pupils. He also wrote an excellent book on the art of singing called *Metodo di canto*. Amongst his pupils were his children (already mentioned), who, as well as his daughter Paulina, worthily continued his name in the musical world.

GARCILASO DE LA VEGA (1503–1536), soldier and poet, was born at Toledo in 1503. His father, Garcilaso (Garcias Laso or Garcilasso) de la Vega, was counsellor of state to Ferdinand and Isabella, and for some time their ambassador at the court of Rome; by his mother he was descended from the illustrious house of Guzman. At the age of seventeen he received a military appointment as a "contino" or guardsman to Charles V., and in that capacity took part in the war against the insurgent comuneros, having been present at the battle of Olias near Toledo, where he received a wound in the face. He afterwards served in the north of Italy, and gained great distinction by his bravery, particularly at the battle of Pavia in 1525. His marriage with a lady of the household of Queen Eleanor, which took place in the following year, suspended only for a very short time his activity in military and diplomatic employments; he took part in the repulse of the Turks from Vienna in 1529, was present at the splendid ceremonial connected with the coronation of the emperor at Bologna in 1530, and was charged with a secret mission to Paris in autumn of the same year. In 1531 he accompanied the duke of Alva to Vienna, where, for having been in some way privy to the clandestine marriage of his nephew to one of the ladies of the court, he was imprisoned for some months on an island in the Danube. It was during this captivity that he composed the fine "cancion" commencing "Con un manso ruido de agua corriente y clara." Released and restored to favor in June, 1532, he at once went to Naples on the staff of Don Pedro de Toledo, the newly-appointed viceroy, by whom he was twice sent on public business of importance to Barcelona, in 1533 and in 1534. After having accompanied the emperor on his Tunis expedition in 1535, where he fought bravely and received two severe wounds, he was employed as a confidential agent at Milan and Genoa in negotiations connected with the proposed invasion of Provence, and afterwards joined the expedition itself when it took the field. Being with Charles in the neighborhood of Fréjus during the retreat from Marseilles, Garcilaso de la Vega was ordered to silence a small fort at the village of Muy, which had been harassing the movements of the army. In the successful discharge of this duty he received a wound on the head which twenty-one days afterwards, at Nice, proved fatal (October 14, 1536). His literary remains, few in number, but destined to exert a powerful influence on the subsequent development of the poetry and general literature of his native country, were committed to the charge of his friend Boscan, who was preparing them for publication along with his own when death overtook him in 1540. The volume ultimately appeared at Barcelona in 1543, and has often been reprinted. Garcilaso's share in it consisted principally of three *eglogas* or pastorals, which the Spaniards regard as among the finest works of the kind in their language, and which for sweetness of versification and delicacy of expression take a high rank in modern European literature. In addition to the pastorals, there are thirty-seven sonnets, five canciones, two elegies, and an epistle in *versi sciolti*, in all of which the influence of Boscan is plainly felt, as well as that of the Italian models whom both poets avowedly imitated, Petrarch, Bembo, Ariosto, and Sannazaro. The poems rapidly gained a wide popularity; and within a century of their appearance they had been edited and commented on as classics by Sanchez, Herrera, and Tamayo de Vargas. "Imitated by Lope de Vega in every possible way, praised more and cited oftener than any other poet by the genius of Cervantes, Garcilaso de la Vega has come down to us enjoying a general national admiration such as is given to hardly any other Spanish poet, and to none that lived before his time" (Ticknor). An English translation of his works was published by Wiffen in 1823.

GARCILASO INCA DE LA VEGA (1540–1616), historian of ancient Peru, was born at Cuzco in 1540. His father was a cadet of the illustrious family of La Vega, who had gone to Peru in the suite of Pedro de Alvaredo, soon after the conquests of Pizarro; his mother was of the Peruvian blood-royal, a circumstance of which he was not a little proud, as giving a right to the title which he claimed by invariably subscribing himself "Inca." In 1560 he removed to Spain, and, having entered the military service, was engaged in the wars against the Moors and Turks. Disappointed in the inadequate recognition of his services by the crown, he retired while still a young man into private life at Cordova, where he gave himself to literature, and produced the learned historical work by which he is now known, the *Comentarios Reales que tratan del Origen de los Yncas reyes que fueron del Peru, de su Idolatria, Leyes, etc., con la Historia general de Peru*. The first part was published in 1609, and the second within a few months of his death, which occurred in 1616. His thorough acquaintance with the language and traditions of his maternal ancestors gave his work an altogether peculiar value. It is, accordingly, the source from which all subsequent writers on the subject have most largely drawn, and still continues to be the chief original authority upon ancient Peru. An inaccurate English translation was published by Sir Paul Rycaut, in 1688. There is also a French translation, which was published in 1727.

GARD, a department in the south of France, consisting of part of the old province of Languedoc, is bounded N. by the departments of Lozère and Ardèche, E. by the Rhone, which separates it from Vaucluse and Bouches-du-Rhône, S. by Hérault and the Mediterranean, and W. by Aveyron. It lies between 43° 27′ 25″ and 44° 27′ 20″ N. lat., and between 3° 15′ 39″ and 4° 50′ 44″ E. long. The western and northern districts of the department are occupied by the range of the Cévennes, which on the frontier of Lozère attain a height of 5120 feet. The whole of this region is celebrated for its fruitful valleys, its gorges, its beautiful streams, its vines, and its chestnut, mulberry, and other fruit trees, with which the mountains are often clothed to their summits. From the Cévennes the land gradually declines to the Rhone and Mediterranean. The southern portion, which extends to the sea, and was probably at one time covered by it, is a low plain with numerous lakes and marshes. Besides the Rhone, which bounds the department on the E., and the Ardèche, the lower portion of which forms part of its boundary on the N., the principal rivers are the Cèze, Gard, Vidourle, and Hérault. The most northern of these is the Cèze, which rises in the Cévennes, and after a course of about 50 miles in an E. S. E. direction falls into the Rhone below Bagnols. The Gard, or Gardon, from which the department takes its name, is also an affluent of the Rhone, and rising in the Cévennes from several sources, traverses the centre of the department, having a length of about 60 miles. In the upper part of its course it flows through a succession of deep mountain gorges, and from the melting of the snows on the Cévennes is subject to inundations, which often cause great damage. Its waters not unfrequently rise 18 or 20 feet in a few hours, and its bed is sometimes increased in width to nearly a mile. The Vidourle flows in a S. S. E. direction from its source near Le Vigan, and after a course of about 50 miles falls into the sea. Below Sommières it forms the western boundary of the department. The Hérault has its source and part of its course in this department. The Canal de Beaucaire extends from the Rhone at the town of that name to Aigues Mortes, which communicates with the Mediterranean by means of the Grand-Roubine canal. The climate is generally very mild, but is rather changeable, and cold and violent storms of wind are not uncommon. The department is rich in minerals, which constitute one of the chief sources of its wealth. Iron, coal, and argentiferous lead mines are extensively worked; and manganese, zinc, and antimony are found. Great quantities of salt are obtained from the salt marshes along the coast. The gypsum and other quarries employ a considerable number of workmen. The fisheries are very productive. The manufactures are extensive, and include silk, cotton, and woollen fabrics, ironware, hats, gloves, paper, leather, earthenware, and glass. The chief grain crops are wheat, oats, rye, and barley. Lentils, pease, and potatoes are also grown. Gard is famed for its cattle, its breed of small horses, and its sheep, the wool of which is of a very fine quality. The principal fruit trees are the olive and mulberry. The vine is extensively cultivated, and yields excellent red and white wines. Gard is divided into the arrondissements of Nîmes, Alais, Uzès, and Le Vigan, with 38 cantons and 347 communes. The chief town is Nîmes. The total area is 2256 square miles, and the population in 1866 was 429,747, and in 1876 423,804.

GARDA, LAKE OF, the Italian LAGO DI GARDA and ancient *Benacus*, the largest and most eastern of the great lakes of northern Italy. It is enclosed by Alpine ridges on both sides, except towards the south, where it widens out into the Lombard plain. The northern extremity belongs to the Austrian district of Tyrol, while the remainder is divided between the two old Italian provinces of Venetia and Lombardy. The length of the lake is about 38 miles; its width varies from 2 or 3 miles in the north, to 11 or 12 in the south; and its area is estimated at 135 square miles. The ordinary elevation of the surface above the level of the sea is 320 feet, but this is increased by 3 or 5 feet by the melting of the Alpine snows at the beginning of summer. The greatest depths are about 900 or 1000 feet. At the northern extremity it receives the waters of the Sarca, a comparatively small Tyrolese stream, and at the south-eastern corner, at Peschiera, its surplus is conveyed by the Mincio to the Po. Navigation on the one hand is frequently rendered dangerous by sudden bursts of storm, while on the other hand it is facilitated by the two regular winds called the Ora or Andar and the Sover, of which the former blows from the south from midday to midnight, and the latter from the north from midnight to midday. Especially in its southern quarters, the lake is very rich in fish, the more important species being the salmon-trout, the carpione (*Salmo punctatus*), the trout, the sardina (*Alausa vulgaris*), the eel, and the arvole. The principal towns and villages along the Riviera or western side of the lake are —Desenzano, in the south; Salo, with 4500 inhabitants; Maderno, with 1500 inhabitants; Toscolano, with 2000, famous for its paper-mills, introduced in 1386; Gargnano, with 4000; Limone; and Riva, at the northern extremity, with about 6000. Proceeding south along the eastern side we find Torbole, Malcesine, Torri, Garda, which gives its name to the lake, Lacize, and Peschiera. Desenzano and Torri are the chief seats of the fish trade. Steamers ply regularly from Desenzano to Riva, and from Riva to Peschiera. The scenery of the Garda is not so fine as that of the Lake of Como, but it is remarkable for the luxuriance of the vegetation, especially on the beautiful promontory of Sirmione, which projects from the southern shore, and still contains the ruins of the villa once inhabited by Catullus. The lemon ripens its fruit at several places round the lake, though the trees require to be carefully covered, and even artificially warmed, during the frosts. The whole number is estimated at about 18,000, and each may produce about 1000 lemons.

The lake was well known to the Romans as Benacus (Βήνακος), and its storms are described by Virgil in the familiar line—

“*Fluctibus et fremitu assurgens, Benace, marino.*”

In several ancient inscriptions the name Benacenses occurs; and some antiquaries on no more authority have supposed that there must have been a town of its own name on the lake. According to a not improbable hypothesis there was formerly a navigable channel from the Adriatic to the Benacus; and we know from inscribed stones preserved in the Museo Filarmonico of Peschiera (the ancient *Ardelica*) that a rich corporation of shipowners existed in the town (*Collegium naviculariorum Ardelicensium*). If such a passage to the sea was available in the later Roman period, it must at least have disappeared before the end of the 15th century; for when in 1438 the Venetians wished to bring their vessels from the Adige to the lake they conveyed them overland from the neighborhood of Mori to Torbole. This Herculean undertaking was proposed by Blasio de Arboribus and Nicolo Sorbolo, and it was successfully accomplished at a cost of 15,000 ducats. As early as 1827 a steamboat of 28 horse-power, the “Arciduca Ranieri,” was launched on the lake at Desenzano by a Milan company; and in 1834 it was superseded by another of 18 horse-power. In 1830 Francesco Montagni of Riva built a boat, the “Manubrio,” the machinery of which was moved by 8 horses going round and round on the deck; but in 1839 he gave it up as unprofitable. In 1873 there were four steamboats on the lake in the service of the railway company of Upper Italy, besides thirty-one vessels with a total tonnage of about 400 tons, and about 500 fishing boats. The Italian Government also maintained four gunboats at Peschiera.

See Dal Pozzo, *Lago, Fortezza, e Rocca di Garda e Gardesana*, Verona, 1678; Volta Serafino, *Descrizione del Lago di Garda*, Mantua, 1828; Ercolani, *Guida al Lago di Garda*, Milan, 1846; Bignami, *Il Lago di Garda*, Milan, 1873.

GARDAIA, or GHARDAYA (in the local documents Taghardeit), a town of North Africa in the Algerian Sahara, situated on a hill in the middle of the Wadi Mezab, on the route between Morocco and Tripoli, about 36 miles W. N. W. of Wargla, in 32° 28′ N. lat., and 4° 39′ E. long., at a height of 1755 feet above the sea-level. Gardaia is well built of limestone, and defended by a bastioned wall pierced with seven gates. There is a Jewish quarter inhabited by about 200 families, who hold a large part of the industry of the town in their hands; but the principal inhabitants are the Beni Mezab, who speak the *awal domsab*, a dialect of the Berber language slightly modified by Arabic. According to native accounts the town was founded in 952 of the Hegira. In modern times the Turks under Raiss Salah Bey attempted to subjugate the inhabitants, but their invasion was successfully repulsed. Aghrem Baba Saád, a small ruined town to the west of Gardaia, is the fortified post in which the Beni Mezab took refuge. At the time of Duveyrier's visit in 1859, Gardaia paid a tribute of 45,000 francs to the French. The population is estimated at from 13,000 to 14,000.

GARDELEGEN (formerly Gardeleben and Gardleben), the chief town of a circle in the government district of Magdeburg, Prussian Saxony, is situated on the right bank of the Milde, 28 miles N. N. W. of Magdeburg. The inhabitants are employed in agriculture, linen and woollen manufacture, button-making, calico-printing, and brewing. The chief buildings are the hospital founded in 1285, and the higher borough school. The population in 1875 was 6389.

Gardelegen is a place of great antiquity. In 633 it was destroyed by Dervan, duke of the Wends, but it was rebuilt in 924 by King Henry I. For a long time it was the seat of a line of margrave princes. It remained a free town until 1478. It suffered considerably in the Thirty Years' War, and in 1775 it was burned by the French. On the neighboring heath Margrave Louis I. gained in 1343 a victory over Otto the Wild of Brunswick.

GARDENING. See Horticulture.

GARDINER, a city of the United States in Kennebec county, State of Maine, is situated at the junction of the Kennebec and Cobosse rivers, 10 miles S. by E. of Augusta. The water-power of the Cobosse river is much utilized for manufactures, and the town has saw-mills, paper-mills, iron foundries, a woollen factory, a tannery, a pottery, and manufactories of sashes and blinds, and is the headquarters of the ice business on the Kennebec. It is connected with Pittston, on the other side of the river, by a bridge 900 feet in length. The population in 1870 was 4497.

GARDINER, Colonel James (1687–1745), a Scottish soldier, was born at Carriden in Linlithgowshire, January 10, 1687. At the age of fourteen he entered a Scottish regiment in the Dutch service, and was afterwards present at the battle of Ramillies, where he was wounded. He subsequently served in different cavalry regiments, and in 1730 was advanced to the rank of lieutenant-colonel, and in 1743 to that of colonel. He fell at the battle of Prestonpans, September 1, 1745. The circumstances of his death are described in Sir Walter Scott's *Waverley*. In his early years he was distinguished for his recklessness and profligacy, but in 1719, a supernatural vision, as he regarded it, led to his conversion; and from that time he lived a life of great devoutness and of thorough consistency with his Christian profession. His life was written by Dr. Philip Doddridge.

GARDINER, Stephen (1483–1555), bishop of Winchester and lord chancellor of England, was born at Bury St. Edmunds in 1483. He is believed to have been the illegitimate son of Dr. Woodville, bishop of Salisbury, brother of Elizabeth Woodville, queen of Edward IV. If so, he lost his father when he was only one year old; but his education seems to have been carefully provided for. He was sent to Cambridge and studied at Trinity Hall, where he greatly distinguished himself in the classics, especially in Greek. He afterwards devoted himself to the canon and civil law, in which subjects he attained so great a proficiency that no one could dispute his pre-eminence. He received the degree of doctor of civil law in 1520, and of canon law in the following year. Ere long his abilities attracted the notice of Cardinal Wolsey, who made him his secretary, and in this capacity he is said to have been with him at More Park in Hertfordshire, when the conclusion of the celebrated treaty of the More brought Henry VIII. and the French ambassadors thither. It is stated, and with great probability, that this was the occasion on which he was first introduced to the king's notice, but he does not appear to have been actively engaged in Henry's service till three years later. In that of Wolsey, he undoubtedly acquired a very intimate knowledge of foreign politics, and in 1527 he and Sir Thomas More were named commissioners on the part of England in arranging a treaty with the French ambassadors for the support of an army in Italy against the emperor. That year he accompanied Wolsey on his important diplomatic mission to France, the splendor and magnificence of which are so graphically described by Cavendish. Among the imposing train who went with the cardinal—including, as it did, several noblemen and privy councillors—Gardiner alone seems to have been acquainted with the real heart of the matter which made this embassy a thing of such peculiar moment. Henry was then particularly anxious to cement his alliance with Francis I., and gain his co-operation as far as possible in the object on which he had secretly set his heart—a divorce from Catherine of Aragon. In the course of his progress through France he received orders from Henry to send back his secretary Gardiner, or, as he was called at court, Master Stevens, for fresh instructions; to which he was obliged to reply that he positively could not spare him, as he was the only instrument he had in advancing the king's "secret matter." Next year Gardiner, though still nominally in the service of Wolsey, was sent to Italy along with Edward Fox, provost of King's College, Cambridge, to promote the same business with the pope. His despatches on this occasion are still extant, and whatever we may think of the cause on which he was engaged, they certainly give a wonderful impression of the zeal and ability with which he discharged his functions. Here his perfect familiarity with the canon law gave him an advantage over all with whom he had to negotiate. Clement VII., who was then at Orvieto, and had just recently escaped from captivity at St. Angelo at the hands of the imperialists, did not wish to offend the king of England, but was still more in dread of the emperor. He only desired to temporize. But Gardiner would not allow him to take refuge in an evasive policy. What was to be thought, he said, of a spiritual guide who either could not or would not show the wanderer his way? The king and lords of England would be driven to think that God had taken away from the Holy See the key of knowledge, and that pontifical laws which were not clear to the pope himself might as well be committed to the flames.

In short, it was owing to Gardiner's vigorous advocacy that the celebrated commission was issued to Cardinals Wolsey and Campeggio to try the cause in England. After obtaining it he was recalled, but early in the following year, 1529, as Campeggio delayed proceeding, he was sent once more to Rome. This time, however, his efforts were unavailing. The pope would make no further concessions, and would not even promise not to revoke the cause to Rome, as he did very shortly after. Gardiner's services, however, were fully appreciated. He was appointed the king's secretary. He had been already some years archdeacon of Taunton, and the archdeaconry of Norfolk was added to it in March, 1529, which two years later he resigned for that of Leicester. In 1530 he was sent to Cambridge to procure the decision of the university as to the unlawfulness of marriage with a deceased brother's wife, in accordance with the new plan devised for settling the question without the pope's intervention. In this he succeeded, though not without a good deal of artifice, more creditable to his ingenuity than to his virtue. In November, 1531, the king rewarded him for his services with the bishopric of Winchester, vacant by Wolsey's death. The promotion was unexpected, and was accompanied by expressions from the king which made it still more honorable, as showing that if he had been in some things too subservient, it was from no abject, self-seeking policy of his own. Gardiner had, in fact, ere this remonstrated boldly with his sovereign on some points, and Henry now reminded him of the fact. "I have often *squared* with you, Gardiner," he said familiarly, "but I love you never the worse, as the bishopric I give will convince you." It must be owned, however, that his next distinguished service was not a very creditable one; for he was, not exactly, as is often said, one of Cranmer's assessors, but according to Cranmer's own expression, "assistant" to him as counsel for the king, when the archbishop, in the absence of Queen Catherine, pronounced her marriage with Henry null and void, on the 23d May, 1533. Immediately afterwards he was sent over to Marseilles, where an interview between the pope and Francis I. took place in September, of which event Henry stood in great suspicion, as Francis was ostensibly his most cordial ally, and had hitherto maintained the justice of his cause in the matter of the divorce. Here he intimated the appeal of Henry VIII. to a general council in case the pope should venture to proceed to sentence against him. He also made a like appeal in behalf of Cranmer. Next year he and other bishops were called upon to vindicate the king's new title of "Supreme Head of the Church of England." The result was his celebrated treatise *De Vera Obedientia*, the ablest, certainly, of all the vindications of royal supremacy. In 1535 he had an unpleasant dispute with Cranmer about the visitation of his diocese. During the next few years he was engaged in various embassies in France and Germany. He was indeed so much abroad that he had little influence upon the king's councils. But in 1539 he was much concerned in the drawing up and passing through the House of Lords of the severe statute of the Six Articles, which led to the resignation of Bishops Latimer and Shaxton and the persecution of the whole Protestant party. In 1540, on the death of Cromwell, earl of Essex, he was elected chancellor of the university of Cambridge. A few years later he attempted, in concert with others, to fasten a charge of heresy upon Archbishop Cranmer in connection with the Act of the Six Articles; and but for the personal intervention of the king he would probably have succeeded. He was, in fact, though he had supported the royal supremacy, a thorough opponent of the Reformation in a doctrinal point of view, and it was suspected that he even repented his advocacy of the royal supremacy. He certainly had not approved of Henry's general treatment of the church, especially during the ascendency of Cromwell, and he was frequently visited with storms of royal indignation, which he schooled himself to bear with patience. In 1544 a relation of his own, named German Gardiner, whom he employed as his secretary, was put to death for treason in reference to the king's supremacy, and his enemies insinuated to the king that he himself was of his secretary's way of thinking. But being warned of his danger, he sought an interview with Henry, in which he succeeded in clearing himself of all injurious imputations. That he was party to a design against Queen Catherine Parr, whom the king was at one time on the point of committing to the Tower, rests only upon the authority of Foxe, and seems a little doubtful. It is certain, however, that his name was omitted at the last in Henry VIII.'s will, though the king was believed to have intended making him one of his executors.

Under Edward VI. Gardiner was completely opposed to the policy of the dominant party both in ecclesiastical and in civil matters. The religious changes he objected to both on principle and on the ground of their being moved during the king's minority, and he resisted Cranmer's project of a general visitation. His remonstrances, however, were met by his own committal to the Fleet, and the visitation of his diocese was held during his imprisonment. Though soon afterwards released, it was not long before he was called before the council, and, refusing to give them satisfaction on some points, was thrown into the Tower, where he continued during the whole remainder of the reign, a period slightly over five years. During this time he in vain demanded his liberty, and to be called before parliament as a peer of the realm. His bishopric was taken from him and given to Dr. Poynet, a chaplain of Cranmer's who had not long before been made bishop of Rochester. At the accession of Queen Mary, the duke of Norfolk and other state prisoners of high rank were in the Tower along with him; but the queen, on her first entry into London, set them all at liberty. Gardiner was restored to his bishopric and appointed lord chancellor, and he set the crown on the queen's head at her coronation. He also opened her first parliament, and for some time was her leading councillor. He was now called upon, at the age of seventy, to undo not a little of the work in which he had been instrumental in his earlier years,—to vindicate the legitimacy of the queen's birth and the lawfulness of her mother's marriage, to restore the old religion, and to recant what he himself had written touching the royal supremacy. At least this, it may be presumed, was the time when he wrote, if, as we are told, he really did write, a *Palinodia* or retractation of his book *De Vera Obedientia*, which, however, does not seem to be now extant, so that how far he had changed his sentiments we cannot very well judge. That he should have really changed them to some extent is not at all unnatural; and in relation to the divorce of Catherine of Aragon, we may well believe that it was his earlier and not his later action that ever troubled his conscience. Yet as to the royal supremacy, it seems that he would have advised Queen Mary to retain it; but her own desire was so great to give up ecclesiastical jurisdiction to the pope that he could not press the matter. A less agreeable task which fell to him was the negotiation of the queen's marriage treaty with Philip, to which he shared the general repugnance, though he could not oppose her will. In executing it, however, he took care to make the terms as advantageous for England as possible, and to make express provisions that the Spaniards should in nowise be allowed to interfere in the government of the country. After the coming of Cardinal Pole, and the reconciliation of the realm to the see of Rome, his influence suffered some eclipse, though he still remained in high favor. How far he was responsible for the persecutions which afterwards arose is a debated question. There is no doubt that he sat in judgment on Bishop Hooper, and on several other Protestants whom he condemned to the flames. But being placed on a commission along with a number of other bishops to administer a severe law, it does not appear that he could very well have acted otherwise. On the bench he is said to have used every effort to induce the accused to make concessions and accept a pardon; and a remarkable instance of his clemency is recorded by the church historian Fuller, who, notwithstanding his prejudices, acknowledges a debt of gratitude to him for preserving one of his own ancestors from the persecuting zeal of others. It would seem, moreover, that when he saw the results of the cruel proceedings against heretics, he very soon got tired of them. The persecutions raged with the greatest vehemence during his absence at the Calais peace conferences in 1555, and when he came back he declared he would have no further hand in them, so that those afterwards apprehended in his diocese were removed into that of London in order to be adjudged to the flames. In October, 1555, he again opened parliament as lord chancellor, but towards the end of the month he fell ill and grew rapidly worse till the 12th November, when he died, about the age of seventy-two.

Perhaps no celebrated character of that age has been the subject of so much ill-merited abuse at the hands of popular historians. That his virtue was not equal to every trial may be admitted, but that he was anything like the morose and narrow-minded bigot he is commonly represented there is nothing whatever to show. He has been called ambitious, turbulent, crafty, abject, vindictive, bloodthirsty, and a good many other things besides, not quite in keeping with each other; in addition to which it is roundly asserted by Bishop Burnet that he was despised alike by Henry and by Mary, both of whom made use of him as a tool. How such a mean and abject character submitted to remain five years in prison rather than change his principles is not very clearly explained; and as to his being despised, we have seen already that Henry VIII., at least, did not consider him despicable. The truth is, there is not a single divine or statesman of that day whose course throughout was so thoroughly consistent. He was no friend to the Reformation, it is true, but he was at least a conscientious opponent. In doctrine he adhered to the old faith from first to last, while as a question of church polity, the only matter for consideration with him was whether the new laws and ordinances were constitutionally justifiable.

His merits as a theologian it is unnecessary to discuss; it is as a statesman and a lawyer that he stands conspicuous. But his learning even in divinity was far from commonplace. The manual set forth in 1543 by royal and parliamentary authority, entitled *A Necessary Doctrine and Erudition for any Christian Man*, was chiefly from his pen; and at a later date he was the author of various tracts in defence of the Real Presence against Cranmer, some of which, being written in prison, were published abroad under a feigned name. Controversial writings also passed between him and Bucer, with whom he had several interviews in Germany, when he was there as Henry VIII.'s ambassador.

He was a friend of learning in every form, and took great interest especially in promoting the study of Greek at Cambridge. He was, however, opposed to the new method of pronouncing the language introduced by Sir John Cheke, and wrote letters to him and Sir Thomas Smith upon the subject, in which, according to Ascham, his opponents showed themselves the better critics, but he the superior genius. In his own household he loved to take in young university men of promise; and many whom he thus encouraged became distinguished in after life as bishops, ambassadors, and secretaries of state. His house, indeed, was spoken of by Leland as the seat of eloquence and the special abode of the muses.

He lies buried in his own cathedral at Winchester, where his effigy is still to be seen. (J. GA.)

GARE-FOWL[1] (Icelandic, *Geirfugl;* Gaelic, *Gearbhul*), the Anglicized form of the Hebridean name of a large sea-bird, formerly a visitor to certain remote Scottish islands, the GREAT AUK of most English book-writers, and the *Alca Impennis* of Linnæus. Of this remarkable creature mention has been already made at some length (BIRDS, vol. iii. p. 637), but since the species has a mournful history and several egregious misconceptions prevail concerning it, a few more details may not be unacceptable, particularly as many of them have been hitherto confined to works not easily accessible to the general reader, and the presumed extinction of the bird gives it especial interest. In size it was hardly less than a tame Goose, and in appearance it much resembled its smaller and surviving relative the Razor-bill (*Alca torda*); but the glossy black of its head was varied by a large patch of white occupying nearly all the space between the eye and the bill, in place of the Razor-bill's thin white line, while the bill itself bore eight or more deep transverse grooves instead of the smaller number and the ivory-like mark possessed by the species last named. Otherwise the coloration was similar in both, and there is satisfactory evidence that the Gare-fowl's winter-plumage differed from that of the breeding-season just as is ordinarily the case in other members of the family *Alcidæ* to which it belongs. The most striking characteristic of the Gare-fowl, however, was the comparatively abortive condition of its wings, the distal portions of which, though the bird was just about twice the linear dimensions of the Razor-bill, were almost exactly of the same size as in that species—proving, if more direct evidence were wanting, its inability to fly.

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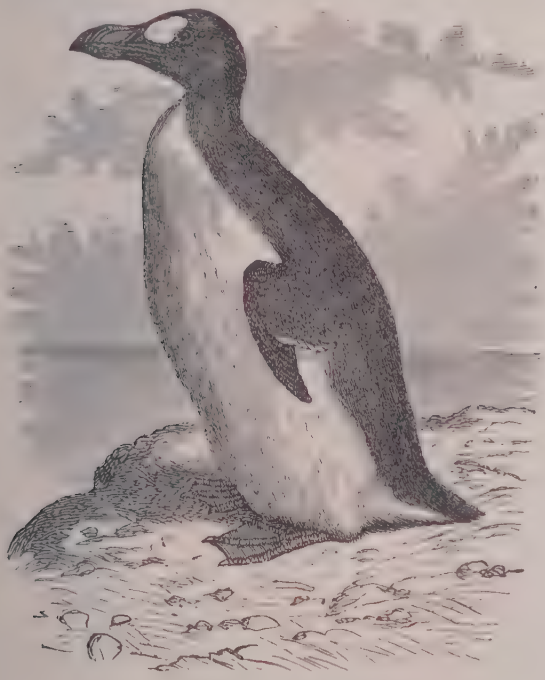
[1] The name first appears, and in this form, in the *Account of Hirta*



Gare-Fowl, or Great Auk.

The most prevalent misconception concerning the Gare-fowl is one which has been repeated so often and in books of such generally good repute and wide dispersal, that a successful refutation seems almost hopeless. This is the notion that it was a bird possessing a very high northern range, and consequently to be looked for by Arctic explorers. How this error arose would take too long to tell, but the fact remains indisputable that, setting aside general assertions resting on no evidence worthy of attention, there is but a single record deserving any credit at all of a single example of the species having been observed within the Arctic Circle, and this, according to Prof. Reinhardt, who has the best means of ascertaining the truth, is open to grave doubt.[1] It is clear that the older ornithologists let their imagination get the better of their knowledge or their judgment, and their statements have been blindly repeated by most of their successors. Another error which, if not so widely spread, is at least as serious, since Prof. Owen (*Encycl. Brit.*, ed. 8, xvii. p. 176; *Palæontology*, p. 400) has unhappily given it countenance, is that this bird "has not been specially hunted down like the dodo and dinornis, but by degrees has become more scarce." Now, if any reliance can be placed upon the testimony of former observers, the first part of this statement is absolutely untrue. Of the Dodo all we know is that it flourished in Mauritius, its only abode, at the time the island was discovered, and that some 200 years later it had ceased to exist—the mode of its extinction being open to conjecture, and a strong suspicion existing that though indirectly due to man's acts it was accomplished by his thoughtless agents (*Phil. Trans.*, 1869, p. 354). The extinction of the *Dinornis* lies beyond the range of recorded history. Supposing it even to have taken place at the very latest period as yet suggested—and there is much to be urged in favor of such a supposition—little but oral tradition remains to tell us how its extirpation was effected. That it existed after New Zealand was inhabited by man is indeed certain, and there is nothing extraordinary in the proved fact that the early settlers (of whatever race they were) killed and ate Moas. But evidence that the whole population of those birds was done to death by man, however likely it may seem, is wholly wanting. The contrary is the case with the Gare-fowl. In Iceland there is the testimony of a score of witnesses, taken down from their lips by one of the most careful naturalists who ever lived, the late John Wolley, that the latest survivors of the species were caught and killed by expeditions expressly organized with the view of supplying the demands of caterers to the various museums of Europe. In like manner the fact is incontestable that its breeding-stations in the western part of the Atlantic were for three centuries regularly visited and devastated with the combined objects of furnishing food or bait to the fishermen from very early days, and its final extinction, according to Sir Richard Bonnycastle (*Newfoundland* in 1842, i. p. 232) was owing to "the ruthless trade in its eggs and skin." No doubt that one of the chief stations of this species in Icelandic waters disappeared, as has been before said (BIRDS, *loc. cit.*), through volcanic action—

"A land, of old upheaven from the abyss
By fire, to sink into the abyss again"—

and that the destruction of the old Geirfuglaskér drove some at least of the birds which frequented it to a rock nearer the mainland, where they were exposed to danger from which they had in their former abode been comparatively free; yet on this rock (Eldey = fire-island) they were "specially hunted down" whenever opportunity offered, until the stock there was wholly extirpated in 1844, and whether any remain elsewhere must be deemed most doubtful.

A third misapprehension is that entertained by Mr. Gould, who, in his *Birds of Great Britain*, says that "formerly this bird was plentiful in all the northern parts of the British Islands, particularly the Orkneys and the Hebrides. At the commencement of the present century, however, its fate appears to have been sealed; for though it doubtless existed, and probably bred, up to the year 1830, its numbers annually diminished until they became so few that the species could not hold its own."

Now of the Orkneys, we know that Low, who died in 1795, says in his posthumously-published *Fauna Orcadensis* that he could not find that it was ever seen there; and on Bullock's visit in 1812 he was told, says Montagu (*Orn. Dict. App.*), that one male only had made its appearance for a long time. This bird he saw and unsuccessfully hunted, but it was killed soon after his departure, while its mate had been killed just before his arrival, and none have been seen there since. As to the Hebrides, St. Kilda is the only locality recorded for it, and the last example known to have been obtained there, or in its neighborhood, was that given to Fleming (*Edinb. Phil. Journ.*, x. p. 96) in 1821 or 1822, having been some time before captured by Mr. Maclellan of Glass. That the Gare-fowl was not plentiful in either group of islands is sufficiently obvious, as also is the im-

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[St. Kilda] *and Rona, etc.*, by the Lord Register, Sir George M'Kenzie, of Tarbat, printed by Pinkerton in his *Collection of Voyages and Travels* (iii. p. 730), and then in Sibbald's *Scotia Illustrata* (1684). Martin soon after, in his *Voyage to St. Kilda*, spelt it "Gairfowl." Prof. Owen has adopted the form "Garfowl," without, as would seem, any precedent authority.

[1] The specimen is in the Museum of Copenhagen; the doubt lies as to the locality where it was obtained, whether at Disco, which is within, or at the Fiskernäs, which is without, the Arctic Circle.

possibility of its continuing to breed "up to the year 1830."

But mistakes like these are not confined to British authors. As on the death of an ancient hero myths gathered round his memory as quickly as clouds round the setting sun, so have stories, probable as well as impossible, accumulated over the true history of this species, and it behoves the conscientious naturalist to exercise more than common caution in sifting the truth from the large mass of error. Americans have asserted that the specimen which belonged to Audubon (now at Vassar College) was obtained by him on the banks of Newfoundland, though there is Macgillivray's distinct statement (*Brit. Birds*, v. p. 359) that Audubon procured it in London. The account given by Degland (*Orn. Europ.*, ii. p. 529) in 1849, and repeated in the last edition of his work by M. Gerbe, of its extinction in Orkney, is so manifestly absurd that it deserves to be quoted in full: "Il se trouvait en assez grand nombre il y a une quinzaine d'années aux Orcades ; mais le ministre presbytérien dans le Mainland, en offrant une forte prime aux personnes qui lui apportaient cet oiseau, a été cause de sa destruction sur ces îles." The same author claims the species as a visitor to the shores of France on the testimony of Hardy (*Annuaire Normand*, 1841, p. 298), which he grievously misquotes both in his own work and in another place (*Naumannia*, 1855, p. 423), thereby misleading an anonymous English writer (*Nat. Hist. Rev.*, 1865, p. 475) and numerous German readers.

Since the former notice of this species in the general article Birds (*ut supra*) the only important contribution to our knowledge of it that has appeared is a paper by Mr. John Milne, published in *The Field* newspaper, and since reprinted for private circulation. This gentleman visited Funk Island, one of the former resorts of the Gare-fowl, or "Penguin," as it was there called, in the Newfoundland seas, a place where bones had before been obtained by Stuvitz, and natural mummies so lately as 1863 and 1864. Landing on this rock at the risk of his life, he brought off a rich cargo of its remains, belonging to no fewer than fifty birds, some of them in size exceeding any that had before been known. His collection has since been dispersed, most of the specimens finding their way into various public museums in this country.

A literature by no means inconsiderable has grown up respecting the Gare-fowl. Neglecting works of general bearing, few of which are without many inaccuracies, the following treatises may be especially mentioned:—J. J. S. Steenstrup, "Et Bidrag til Geirfuglens Naturhistorie og særligt til Kundskaben om dens tidligere Udbredningskreds," *Naturh. Foren. Vidensk. Meddelelser*. [Copenhagen], 1855, p. 33; E. Charlton, "On the Great Auk," *Trans. Tyneside Nat. Field Club*, iv. p. 111; "Abstract of Mr. J. Wolley's Researches in Iceland respecting the Gare-fowl," *Ibis*, 1861, p. 374; W. Preyer, "Ueber *Plautus impennis*," *Journ. für Orn.*, 1862, pp. 110, 337; K. E. von Baer, "Ueber das Aussterben der Thierarten in physiologischer und nicht physiologischer Hinsicht," *Bull. de l'Acad. Imp. de St. Pétersb.*, vi. p. 513; R. Owen, "Description of the Skeleton of the Great Auk," *Trans. Zool. Soc.*, v. p. 317; "The Gare-fowl and its Historians," *Nat. Hist. Rev.*, v. p. 467; J. H. Gurney, jun., "On the Great Auk," *Zoologist*, 2d ser. pp. 1442, 1639; H. Reeks, "Great Auk in Newfoundland," etc., *op. cit.*, p. 1854; V. Fatio, "Sur l'Alca impennis," *Bull. Soc. Orn. Suisse*, ii. pp. 1, 80, 147; "On existing Remains of the Gare-fowl," *Ibis*, 1870, p. 256; J. Milne, "Relics of the Great Auk," *Field*, 27 March, 3 and 10 April, 1875. Lastly, reference cannot be omitted to the happy exercise of poetic fancy with which the late Prof. Kingsley was enabled to introduce the chief facts of the Gare-fowl's extinction (derived from one of the above-named papers) into his charming *Water Babies*. (A. N.)

GARESSIO, Garesso, or Garezzo, in Latin *Garexium*, a town of Italy about 18 miles S. E. of Mondovi, in the valley of the Tararo. The Roman remains which are discovered from time to time bear witness to its high antiquity; during the Middle Ages it was the seat of a marquisate, which in 1509 was sold to the Spinola family, and its double walls gave it some importance as a defensible position. Besides a castle, it possesses three old monastic buildings, one of which, the Carthusian convent of Casotto, is an edifice of much magnificence. Population in 1870 nearly 7000.

GAR-FISH is the name given to a genus of fishes (*Belone*) found in nearly all the temperate and tropical seas, and readily recognized by their long, slender, compressed and silvery body, and by their jaws being produced into a long, pointed, bony, and sharply-toothed beak. About fifty species are known from different parts of the globe, some attaining to a length of 4 or 5 feet. One species is common on the British coasts, and is well known by the names of "long-nose," "green-bone," etc. The last name is given to those fishes on account of the peculiar green color of their bones, which deters many people from eating them, although their flesh is well flavored and perfectly wholesome. The Skipper (*Scomberesox*) and Half-beak (*Hemirhamphus*), in which the lower jaw only is prolonged, are fishes nearly akin to the gar-pikes. See Ichthyology.

GARGANEY[1] (North-Italian, *Garganello*), or Summer-Teal, the *Anas querquedula* and *A. circia* of Linnæus (who made, as did Willughby and Ray, two species out of one), and the type of Stephens's genus *Querquedula*. This bird is one of the smallest of the *Anatidæ*, and has gained its common English name from being almost exclusively a summer-visitant to this country, where nowadays it only regularly resorts to breed in some of the East-Norfolk waters called Broads, though possibly at one time found at the same season throughout the great Fen-district. About the same size as the common Teal (*A. crecca*), the male is readily distinguished therefrom by its peculiarly-colored head, the sides of which are nutmeg-brown, closely freckled with short whitish streaks, while a conspicuous white curved line descends backwards from the eyes. The upper wing-coverts are bluish-gray, the scapulars black with a white shaft-stripe, and the wing-spot (*speculum*) grayish-green bordered above and below by white. The female closely resembles the hen Teal, but possesses nearly the same wing-spot as her mate. In Ireland or Scotland the Garganey is very rare, and though it is recorded from Iceland, more satisfactory evidence of its occurrence there is needed. It has not a high northern range, and its appearance in Norway and Sweden is casual. Though it breeds in many parts of Europe, in none can it be said to be common; but it ranges far to the eastward in Asia—even to Formosa, according to Swinhoe—and yearly visits India in winter. Those that breed in Norfolk arrive somewhat late in spring and make their nests in the vast reed-beds which border the Broads—a situation rarely or never chosen by the Teal. The labyrinth or bony enlargement of the trachea in the male Garganey differs in form from that described in any other Drake, being more oval and placed nearly in the median line of the windpipe, instead of on one side, as is usually the case.

GARHWÁL, a district of British India, in the Kumáon division, under the jurisdiction of the lieutenant-governor of the North-Western Provinces, situated between 29° 16′ 15″ and 31° 5′ 30″ N. lat., and 78° 18′ 45″ and 80° 8′ E. long, and bounded on the N. by Chinese Tibet, on the E. by Kumáon district, on the S. by Bijnor district, and on the W. by Independent Garhwál or Tehri. Garhwál district consists almost entirely of rugged mountain ranges running in all directions, and separated by narrow valleys, which may almost be described as gorges or ravines. The only level portion of the district consists of a narrow strip of waterless forest, between the southern slopes of the hills and the fertile plains of Rohilkhand. The highest mountains are in the north of the district, the principal peaks being Nandá Devi (25,661 feet), Kamet (25,413), Ircoul (23,382), Dunagiri (23,181), Badrinath (22,901), and Kedarnath (22,853). The Alaknandá, one of the main sources of the Ganges, receives with its affluents the whole drainage of the district. The river is regarded as of peculiar sanctity, and is annually resorted to by thousands of devout Hindus. At Deoprayág the Alaknandá joins the Bhágirathí, and thenceforward the united streams bear the name of the Ganges. Navigation is impracticable in all the rivers, owing to the velocity of their currents, and the existence of shoals and rapids. Cultivation is principally confined to the immediate vicinity of the rivers, which are employed for purposes of irrigation; but out of a total estimated area of 5500 square miles in 1872, only 209 were returned as under cultivation. Agriculture, however, is carried on with great skill and industry, by terracing out the hill sides. Wheat, rice, and *manduá* are the staple crops, the surplus produce being exported to Tibet. Tea planting is also carried on under European supervision.

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[1] The word was introduced by Willughby from Gesner (*Orn.*, lib. iii. p. 127), but, though generally adopted by authors, seems never to have become other than a book-name in English, the bird being invariably known in the parts of this island where it is indigenous as "Summer-Teal."

The census of 1872 disclosed a population in the Garhwál district of 310,288 (115,745 males and 154,537 females), distributed among 3944 villages and 57,293 houses. The Hindus numbered 308,398, or no less than 99·3 per cent. of the population, the Mahometans 1799, and Christians 85. The two great Hindu temples of Badrináth and Kedarnáth, which lie hidden among the recesses of the snowy range, attract large numbers of pilgrims, who considerably add to the prosperity of the district. No place in Garhwál contains as many as 5000 inhabitants. Srínagar is the largest town, but the administrative headquarters is at Pauni. Trade is principally carried on with Tibet, by way of the Mána and Níti passes, sheep and goats being used as beasts of burden. The chief exports are grain, *gur*, cloth, and tobacco; the imports salt, borax, wool, gold, and precious stones. Good hill roads, from 10 to 12 feet in width, intersect the district in every direction, the total length being about 1000 miles. The land revenue in 1875 amounted to £9555. Only a small force of regular police is stationed at headquarters, and there is little crime of any kind. Education has made greater progress among these mountain valleys than in the plain districts beneath them. In 1875, 73 schools afforded education to 3609 pupils.

Garhwál originally consisted of 52 petty chieftainships, each chief with his own independent fortress (*garh*). Between 400 and 500 years ago, one of these chiefs, Ajai Pál, ruler of Chanpur, reduced all the minor principalities under his own sway, and founded the Garhwál kingdom. He and his ancestors ruled over Garhwál and the adjacent state of Tehri, in an uninterrupted line till 1803, when the Gúrkhás invaded Kumáon and Garhwál, driving Pridhimán Sáh, the Garhwál chief, into the plains. For twelve years the Gúrkhás ruled the country with a rod of iron, until a series of encroachments by them on British territory, led to the war with Nepál in 1814. At the termination of the campaign, Garhwál and Kumáon were converted into British districts, while the Tehri principality was restored to Pridhimán Sáh, whose grandson still holds it. Since the annexation, Garhwál has rapidly advanced in material prosperity. Cultivation has rapidly increased, and the spread of tea-culture has opened the country to British capital and enterprise, which are converting this long harassed tract into an important and wealthy district.

GARLIC (Greek, *σκόροδον*; Latin, *Allium;* Italian, *Aglio;* French, *Ail;* German, *Knoblauch*), *Allium Sativum*, Linn., a bulbous perennial plant of the tribe *Hyacinthineæ* of the natural order *Liliaceæ*, indigenous apparently to the south of Europe and to the East, having entire, obscurely keeled leaves, a deciduous spathe, a bulbiferous globose umbel, and whitish flowers, with exsert pistil and stamens. The bulb, which is the only part eaten, has membranous scales, in the axils of which are 10 or 12 cloves, or smaller bulbs. From these new bulbs can be procured by planting out in February or March. The bulbs are best preserved hung in a dry place. If of fair size, twenty of them weigh about 1 ℔. To prevent the plant from running to leaf, Pliny (*Nat. Hist.*, xix. 34) advises to bend the stalk downward, and cover with earth; seeding, he observes, may be prevented by twisting the stalk. Garlic is cultivated in the same manner as the SHALLOT (*q. v.*). It is stated to have been grown in England before the year 1548. The percentage composition of the bulbs is given by Mr. E. Solly (*Trans. Hort. Soc. Lond.*, new ser., iii. p. 60) as water 84·09, organic matter 13·38, and inorganic matter 1·53,—that of the leaves being water 87·14, organic matter 11·27, and inorganic matter 1·59. The bulb has a strong and characteristic odor, and an acrid taste, and yields an offensively smelling oil, essence of garlic, identical with allylic sulphide $(C_3H_5)_2S$ (see Hofmann and Cahours, *Journ. Chem. Soc.*, x. p. 320). This, when garlic has been eaten, is evolved by the excretory organs, the activity of which it promotes. From the earliest times garlic has been used as an article of diet. It formed part of the food of the Israelites in Egypt (Numb. xi. 5), and of the laborers employed by Cheops in the construction of his pyramid, and is still grown in Egypt, where, however, the Syrian is the kind most esteemed (see Rawlinson's *Herodotus*, ii. 125). It was largely consumed by the ancient Greek and Roman soldiers, sailors, and rural classes (*cf.* Virg., *Ecl.*, ii. 11), and, as Pliny tells us (*N. H.*, xix. 32), by the African peasantry. Galen eulogizes it as the rustic's *theriac* (see F. Adams's *Paulus Æginetu*, p. 99), and Alexander Neckam, a writer of the 12th century (see Wright's edition of his works, p. 473, 1863), recommends it as a palliative of the heat of the sun in field labor. "The people in places where the simoon is frequent," says Elphinstone (*An Account of the Kingdom of Caubul*, p. 140, 1815), "eat garlic, and rub their lips and noses with it, when they go out in the heat of the summer, to prevent their suffering by the simoon." "O dura messorum ilia," exclaims Horace (*Epod.*, iii.), as he records his detestation of the popular esculent, to smell of which was accounted a sign of vulgarity (*cf.* Shakespeare, *Coriol.*, iv. 6, and *Meas. for Meas.*, iii. 2). In England garlic is seldom used except as a seasoning, but in the southern countries of Europe it is a common ingredient in dishes, and is largely consumed by the agricultural population. Garlic was placed by the ancient Greeks on the piles of stones at cross-roads, as a supper for Hecate (Theophrastus, *Characters*, *Δεισιδαιμονίας*); and according to Pliny garlic and onions were invocated as deities by the Egyptians at the taking of oaths. The inhabitants of Pelusium in Lower Egypt, who worshipped the onion, are said to have held both it and garlic in aversion as food. Garlic possesses stimulant and stomachic properties, and was of old, as still sometimes now, employed as a medicinal remedy. Pliny (*N. H.*, xx. 23) gives an exceedingly long list of complaints in which it was considered beneficial. Dr. Sydenham valued it as an application in confluent small-pox, and, says Cullen (*Mat. Med.*, ii. p. 174, 1789), found some dropsies cured by it alone. The volatile oil has proved efficacious in indigestion, and in some stages of bronchitis, especially in the acute form of the disease in infants, also in chronic colds, and as a rubefacient and nervine tonic; and poultices of the pounded pulp are recommended for the convulsions and suffocative catarrh of infants (Wood, *Treat. on Therapeutics*, p. 451, 1874). With lemon-juice garlic has also been resorted to for the cure of diphtheria (*Brit. and For. Med. Chir. Rev.*, 1860, i. p. 281). The wild "Crow Garlic" and "Field Garlic" of Britain are the Linnean species *Allium vineale* and *A. oleraceum* respectively.

See Phillips, *Hist. of Culinary Vegetables*, vol. ii.; Pereira, *Materia Medica*, vol. ii. pt. i.; M'Intosh, *The Book of the Garden*, vol. ii., 1855, p. 29.

GARNET (German, *Granat;* French, *Grenat*), a mineral the name of which is derived from the Latin *granatum*, the pomegranate, or, as Lydgate calls it, "garnet appille" (see Halliwell, *Dict.*, i. p. 392), on account of the resemblance of its granular varieties to the seeds of that fruit. Several sorts of garnets, with other stones, seem to have been included under the terms *ἄνθραξ* and *carbunculus*, employed by Theophrastus and Pliny. Garnet occurs in crystals, mostly dodecahedral or trapezohedral, very rarely octahedral,[1] of the isometric, regular, or cubical system, also in pebbles and grains (as in alluvial deposits), and massive, with a granular or coarse lamellar structure. It varies in diaphaneity from transparent to nearly opaque; is red, red-brown, or black in color, less frequently white, yellow, pink, or green, has a vitreous to resinous lustre, a white streak, dodecahedral cleavage, hardness of 6·5 to 7·5, specific gravity of 3·15 to 4·30,[2] and an uneven sub-conchoidal fracture; and is brittle and sometimes friable, or, in the compact cryptocrystalline varieties, tough. Before the blowpipe it gives a brown, green, or black (often magnetic) glass, which hydrochloric acid decomposes, with the separation of gelatinous silica. Previous to melting, the mineral is but little affected by the acid. The least fusible forms are the lime-iron garnets. It has been shown by Professor Church that, although unaffected by exposure to a full red heat for a quarter of an hour, iron garnet may by fusion have its specific gravity lowered from 4·059 to 3·204. By almost complete fusion a specimen of almandine garnet examined by him had its specific gravity increased from 4·103 to 4·208. Long-continued ignition effected only a slight increase in the density of various specimens of lime garnet (see *Journ. Chem. Soc.*, vol. xvii. p. 388). Garnets which through the isomorphism of their constituents are extremely variable in chemical composition, are silicates of the general formula $R''_3R^{iv}_2.Si_3O_{12}$, or $3R''O,R^{iv}_2O_3.3SiO_2$, in which R'' = calcium, magnesium, iron, and manganese, and R^{iv} = aluminium, iron, and chromium. Occasionally rarer metals are present; yttrium, for instance, has been found in garnets from Brevig, Norway. Three principal groups have been recognized, called, according to their chief sesquioxide basic components, alumina, iron, and chrome garnets, which have the general formula $R''_3Al_2.Si_3O_{12}$, $R''_3Fe_2.Si_3O_{12}$, and $R''_3Cr_2.Si_3O_{12}$, respectively. These are further classed, by the predominance of one or other of their contained protoxides, into numerous subordinate groups, as lime-alumina garnet, $Ca_3Al_2.Si_3O_{12}$, *e. g.*, grossularite, topazolite, and essonite; magnesia-alumina garnet, comprising pyrope, the typical specimens of which contain a small percentage of chromium; iron-alumina garnet, *e. g.*, almandite, common garnet in part, and allochroite; manganese-alumina garnet, as spessartite and romanzovite; lime-iron garnet, which includes andradite, melanite, or black garnet, which may be titaniferous, as at Frascati, and pyreneite, aplome, and common garnet in part; lime-magnesia-iron garnet $(CaMg)_3Fe_2.Si_2O_{12}$, or bredbergite; and lime-chrome garnet, or ouvarovite. Colophonite, a yellow-brown to honey-yellow or almost pitch-black mineral, with a resinous lustre, commonly considered to be a lime-iron garnet, according to Wichmann and Des-Cloiseaux must be regarded as for the most part granular vesuvian.

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[1] See Max Bauer, "Ueber die selteneren Krystallformen des Granats," *Zeitschr. der. deut. geolog. Ges.*, Bd. xxvi., 1874, pp. 119–37, pl. i.

[2] On the specific gravity of several varieties of garnet, see Prof. A. H. Church, *Geological Mag.*, new ser., vol. ii., 1875, p. 321.

Garnet is a wide-spread mineral, and is found in micaceous, talcose, chloritic, and hornblendic schists, and in syenitic gneiss, syenite, granite, dolomite, and crystalline limestone; sometimes as pyrope, in serpentine; also in felspar-porphyry, and in volcanic rocks. In Cornwall it is met with chiefly in greenstone, or in close proximity thereto. It is an essential ingredient of the rock eklogite. Grossularite, a greenish to gray-green garnet, is found at Rezbanya in Hungary, and the Wilui river, Siberia; topazolite and essonite at Mussa, Piedmont, the latter also in Ceylon, Piedmont, and Elba; pyrope in Bohemia, and at Zöblitz in Saxony; and almandite in Ceylon, Pegu, Brazil, and Greenland. Spessartite is obtained at Haddam, Ct., and elsewhere; melanite in Vesuvian and other lavas; aplome at Breitenbrunn and Schwarzenberg in Saxony; the fine green garnet ouvarovite chiefly at Saranovskaja, 14 versts from Bissersk in the Urals, and at New Idria in California; and white garnet in the Urals. Numerous other localities for garnet might be mentioned. Precious garnet, almandite or almandine (so termed, it is said, from being cut at Alabanda in Caria, whence the appellation *alabandicus* employed by Pliny), essonite or cinnamon-stone, grossularite, grossularia, or gooseberry stone, and pyrope or Bohemian garnet are the varieties of the mineral employed as gems. They are shaped by means of garnet powder or emery on a copper wheel, and polished on lead with tripoli. Carbuncles are almadine garnets cut *en cabochon;* when of large size, and free from black spots, they may be worth as much as £20 apiece. The deep red or precious garnet often has a density close to that of the ruby, for which stone it has been sold. The Syriam or Pegu garnets, possibly the *amethystizontas* of Pliny (*Nat. Hist.*, xxxvii. 25), commonly designated amethystine or oriental garnets, vary in color from a deep red to a violet-purple, and may occur 3 inches in diameter. They are usually cut with four large and four small facets, and may fetch very high prices, a single specimen, of a fiery-red hue, measuring 1 inch by $\frac{6}{10}$ inch, having been sold for £40, and another, of octagonal form, for £140. Pyrope is a dark hyacinth-red to blood-red gem, much esteemed in Austria, Transylvania, and Turkey. Viewed by transmitted light it appears of a yellowish-red tint, more especially at the edges. Essonite, yellow to hyacinth-red in color, is a softer and more fusible garnet than the other kinds used in jewelry. It is commonly called hyacinth, and has frequently been mistaken, as also sold, for true hyacinth or jacinth, which is a zirconium silicate, and may be distinguished by its density of 4·05–4·75, that of essonite being about 3·60–3·66. The garnet was much used as a jewel in ancient times. Antique intaglios on garnet are recognized by their usually fragmentary condition, due to their brittleness, and by a softness in color, imparted to them by time, which defies imitation by even the ablest artists (Castellani). The bust of Hadrian in the Odescalchi museum, the Venus Genetrix in the cabinet of Abbé Pullini at Turin, and the representation of Sirius on the celebrated Marlborough stone, are among the finer examples of engraving in garnet. Garnet, where abundant, has been used in the smelting of iron ores. For polishing purposes it is sometimes substituted for emery. The large dull-colored "carbunculus of India," according to Pliny (*l. c.*), used to be hollowed out into vessels that would hold as much as a pint. Garnet has been obtained as a furnace-product, and otherwise artificially. What is known as "white garnet" is the mineral leucite.

See Bischof, *Chemical Geology*, vol. ii. chap. xxxiii., and vol. iii. p. 348; C. E. Kluge, *Hdb. d. Edelsteinkunde*, Leipsic, 1860; Emanuel, *Diamonds and Precious Stones*, 3d ed., 1867; A. Schrauf, *Hdb. d. Edelsteinkunde*, Vienna, 1869; A. Castellani, *Gems*, 1871; J. D. Dana, *A System of Mineralogy*, 5th ed., pp. 265–72, New York, 1874; C. F. Naumann, *Elemente der Mineralogie*, 10th ed., by Dr. F. Zirkel, pp. 532–5, Leipsic, 1877. On so-called garnets from the river Bobrowska, Urals, see Church, *Mineralog. Mag.* ii., 1879, p. 191. (F. H. B.)

GARNIER, GERMAIN (1754–1821), an able writer on political economy, was born at Auxerre, on 8th November, 1754. He was educated for the law, and obtained when young the office of *procureur* at Chatelet. He acted for some time as secretary to Mme. Adelaide, aunt of Louis XVI., and by his fine presence and manners acquired considerable reputation and power at court. On the calling of the states-general he was named as deputy for Chatelet, and in 1790 he appears to have been a member of the monarchical club in Paris. After 1792 he withdrew to the Pays de Vaud, and did not return till 1795. In public life, however, he seems to have been singularly fortunate. In 1797 he was on the list of candidates for the Directory; in 1800 he was prefect of Seine-et-Oise; in 1804 he was made senator; and from 1809 to 1811 he acted as president of the senate. After the restoration he obtained a peerage, and on the return of Louis XVIII., after the Hundred Days, he became minister of state and member of privy council. He died at Paris, 4th October, 1821. Garnier was somewhat advanced in years before he began to take any interest in political economy; his previous efforts in literature had been of an altogether different kind. At court he was, when young, noted for his facile power of verse-writing, and he translated Mrs. Radcliffe and Mrs. Montague.

Garnier is best known by his admirable translation, with notes and introduction, of Smith's *Wealth of Nations* (1st ed. 1805, 2d ed. 1822), and by his *Histoire de la Monnaie* (2 vols., 1819), which contains much sound and well-arranged material. His *Abrégé des Principes de l' Écon. Polit.* (1796) is a very clear and instructive manual. Of high value also is the *Description géographique, physique, et politique du département de Seine-et-Oise* (1822), drawn up from his instructions. Other works are *De la Propriété* (1792), and *Histoire des Banques d' Escompte* (1806).

GARNIER, MARIE JOSEPH FRANÇOIS (1839–1873), usually called Francis Garnier, a French officer and explorer, was born at St. Étienne, July 25, 1839, and perished by assassination in Tong-king, December 7, 1873. He entered the navy, and after voyaging in Brazilian waters and the Pacific he obtained a post on the staff of Admiral Charner, who from 1860 to 1862 was campaigning in Cochin-China. After some time spent in France he returned to the East, and in 1852 he was appointed inspector of the natives in Cochin-China, and entrusted with the administration of the town of Cho-len or Sho-len. It was at Garnier's suggestion that the Marquis de Chasseloup-Laubat determined to send a mission through Laos to Tibet, but as he was not considered old enough to be put in command, the chief authority was entrusted to Captain Doudart de Lagrée. In the course of the expedition—to quote the words of Sir Roderick Murchison addressed to the youthful traveller when, in 1870, he was presented with the Victoria Medal of the Royal Geographical Society of London—from Cratieh in Cambodia to Shanghai 5392 miles were traversed, and of these 3625 miles, chiefly of country unknown to European geography, were surveyed with care, and the positions fixed by astronomical observations, nearly the whole of the observations being taken by Garnier himself. Volunteering to lead a detachment to Talifu the capital of Sultan Suleiman, the sovereign of the Mahometan rebels in Yunnan, he successfully carried out the more than adventurous enterprise. When shortly afterwards Lagrée died, Garnier naturally assumed the command of the expedition, and he conducted it in safety to the Yang-tze-Kiang, and thus to the Chinese coast. On his return to France he was received with enthusiasm. The preparation of his narrative was interrupted by the Franco-German war, and during the siege of Paris he served as principal staff officer to the admiral in command of the eighth "sector." His experiences during the siege were published anonymously in the feuilleton of *Le Temps*, and appeared separately as *Le Siége de Paris, journal d'un officier de marine*, 1871. Returning to Cochin-China he found the political circumstances of the country unfavorable to further exploration, and accordingly he went to China, and in 1873 followed the upper course of the Yang-tze-Kiang to the waterfalls. He was next commissioned by Admiral Dupré, governor of Cochin-China, to Tong-king to found a French protectorate or a new colony. On November 20, 1873, he took Hanoi, the capital of Tong-king, and on December 7th he was slain.

The narrative of the principal expedition appeared in 1873, as *Voyage d'exploration en Indo-Chine effectué pendant les années 1866, 1867, et 1868, publié sous la direction de M. Francis Garnier, avec le concours de M. Delaporte et de MM. Joubert et Thorel*, 2 vols. An account of the Yang-tze-Kiang from Garnier's pen is given in the *Bulletin de la Soc. de Géog.*, 1874. His *Chronique royale du Cambodje* was reprinted from the *Journal Asiatique* in 1872. See *Ocean Highways*, 1874, for a memoir by Colonel Yule.

GAROFALO, BENVENUTO. See TISIO.

GARONNE, the ancient *Garumna*, a river of southern France, which rises in the Spanish Pyrenees not far from the massif of Maladetta, flows through the fine gorge called the Val d'Aran, partly loses itself under the calcareous rocks that form the gulf of Clédes, enters France near the Pont du Roi, and proceeds in a general north-west direction till it falls into the Bay of Biscay. Rafts can be sent down the river from the Spanish frontier; boats can pass with the stream from the confluence of the Salat to Toulouse; from Toulouse downwards regular navigation with boats can be maintained; and seafaring vessels can sail up as far as Castets, 32 miles above Bordeaux. At Bec d'Ambes, near the confluence of the Dordogne, the river widens out to a breadth of from 2 to 4 miles, and takes the name of the Gironde. This estuary presents an almost uninterrupted succession of islands and banks, which divide it into two nearly equal branches, and render the navigation somewhat difficult. At the mouth stands the famous tower of Cordouan, which dates from 1584–1610, and ranks as one of the finest lighthouses on the coast of France. The current at Toulouse, when the water is at its lowest, amounts to 1271 cubic feet per second, but in the ordinary state of the river it is 5297 cubic feet. During ordinary flood it rises about 25 feet; but in exceptional cases, as in 1855 and 1856, this increases to 28 or even 30 feet, and as the banks of the river are low the inundations are very extensive. The principal affluents on the right are the Salat, the Ariége, the Tarn, the Lot, the Dropt, and the Dordogne; and on the left the Neste, the Bouge, the Save, the Gimoné, the Gers, the Baise, and the Ciron.

GARONNE, HAUTE-, or UPPER GARONNE, is one of the frontier departments in the south of France, being continuous with Spain along the line of the Pyrenees. To the N. lies the department of Tarn-et-Garonne, to the E. are those of Tarn, Aude, and Ariége, and to the W. those of Gers and Hautes-Pyrénées. The form of the department is very irregular. Its greatest length is 99 miles from N. E. to S. W., and its greatest breadth about 56 miles; but its area only amounts to 629,000 hectares or 2428 English square miles. The northern portion is a fertile but mountainous stretch of country, with continual interchange of hill and valley nowhere thrown into striking relief; while towards the south the land rises gradually to the Pyrenees, which there attain a height of upwards of 11,000 feet. All the streams by which the department is watered—the Neste, the Salat, the Lers, the Logue, the Touche, etc.—belong to the system of the river from which it takes its name. Except in the mountainous region the climate is mild, the mean annual temperature being rather higher than that of Paris. The rainfall, which averages 23 inches at Toulouse and 26 at St. Gaudens, is distributed over 125 days. The winds are often violent. Thick forests of oak, fir, and pine exist in the mountains, and furnish timber for shipbuilding. The arable land (360,241 hectares, or 890,207 acres) is well adapted for the cultivation of wheat, maize, and other grain crops; and the produce of cereals is generally much more than is required for the local consumption. Oats, buckwheat, barley, flax, colza, and potatoes are all grown; fruit is plentiful, and about 54,000 hectares, or 133,441 acres, are occupied by vineyards, though the wine is only of medium quality. As pasture land is abundant, a good deal of attention is given to the rearing of cattle and sheep; and owing to the mountainous character of the southern region asses and mules are favorite beasts of burden, and may be estimated at 24,000 in number. Iron, lead, copper, and coal are among the mineral productions, as well as marble, both white and variegated, granite, freestone, lime, and slate. The manufactures are various though not individually extensive, and include iron and copper utensils, earthenware, woollen, cotton, and linen goods, leather, paper, watches, mathematical instruments, etc. Railway communication is furnished by the line from Bordeaux to Cette which passes by Toulouse, and there sends off branch lines leading to Albi, Auch, Foix, St. Giron, and Bagnères de Luchon. The Canal du Midi traverses the department for 32 miles. There are four arrondissements—Toulouse, Villefranche, Muret, and St. Gaudens, subdivided into 39 cantons and 585 communes. The chief town, Toulouse, contained 120,208 inhabitants in 1875, but there is no other town of even 5000 in the department, the largest being St. Gaudens with 4087. The population of Haute-Garonne in 1801 was 405,574, including the arrondissement of Castelsarrasin with 60,545 inhabitants, which was detached in 1806; in 1851 it was 481,610, and in 1875, 477,730.

GARRICK, DAVID (1716-1779), the greatest actor of his age, and the most successful of English theatrical managers, was descended from a good French Protestant family of Bordeaux which had settled in England on the revocation of the edict of Nantes. His father, Captain Peter Garrick, was on a recruiting expedition when his celebrated son was born at Hereford on February 19, 1716–17. The captain usually resided at Lichfield on half pay, but, in order to benefit his large family, he accepted an offer to proceed on service to Gibraltar, in place of a brother officer who was desirous of returning to England. This kept him many years absent from home, and the letters written to him by "little Davy," acquainting him with the doings at Lichfield, are highly interesting memorials of the future Roscius. In his nineteenth year, after receiving a good education at the grammar school of Lichfield, David was sent to the establishment at Edial, opened in June or July, 1736, by Samuel Johnson, his senior by seven years. The Edial academy was shut in about six months, and on the 2d of March, 1736–7, master and pupil—Johnson and Garrick—left Lichfield for London, the one to commence the study of the law, and the other to try his tragedy of *Irene*—Johnson, as he afterwards said, "with twopence halfpenny in his pocket," and Garrick "with three halfpence in his." Seven days afterwards, however, Garrick was entered of Lincoln's Inn, but after remaining for a few months in London, he resided for some time with Mr. Colson, a distinguished teacher at Rochester (afterwards Lucasian professor at Cambridge). Captain Garrick, who had returned from Gibraltar, died about a month after his son's arrival in London. Soon afterwards a rich uncle, a wine merchant at Lisbon, in his will left David a sum of £1000, and he and his brother entered into partnership as wine merchants in London and Lichfield. The concern was not prosperous—though Foote's assertion that he had known Garrick with three quarts of vinegar in the cellar calling himself a wine merchant need not be taken literally—and before the end of 1741 he had spent nearly half of his £1000. His passion for the stage completely engrossed him; he tried his hand both at dramatic criticism and at dramatic authorship, and made his first appearance on the stage late in 1740–41, *incognito*, as harlequin at Goodman's Fields, where Woodward, being ill, allowed him to take his place during a few scenes. When the manager of the same theatre, Giffard, took a party of players to Ipswich, Garrick accompanied them, and there made his first essay as an actor under the name of Lyddal, in the part of the black Aboan (in Southerne's *Oroonoko*). His success on the provincial boards determined his future career. On the 19th of October, 1741, he made his appearance at Goodman's Fields in the character of Richard III., and gained the most enthusiastic applause. His staid and sedate brother, and his sisters at Lichfield, were scandalized at this derogation from the provincial dignity of the family; and Garrick, greatly distressed at the shock they had received by the intelligence (which, however, he expected), hastened to give up his interest in the wine company. Each night added to his popularity on the stage. He was received by the best company in town. While his Richard was still calling forth general admiration, he won new applause in Lear and Pierre, as well as in several comic characters (including that of Bayes). Glover ("Leonidas") attended every performance; Lyttelton, Pitt, and several other members of parliament had shown him the greatest civility. From December 2d he appeared in his own name. Pope went to see him thrice during his first performances, and pronounced that "that young man never had his equal as an actor, and he will never have a rival." Before next spring he had supped with "the great Mr. Murray, counsellor," and hoped to do so with Mr. Pope through Murray's introduction, while he was dining with Halifax, Sandwich, and Chesterfield. "There are a dozen dukes of a night at Goodman's Fields," writes Horace Walpole. *The Lying Valet* being at this time brought out with success, the honors of dramatic author were added to those of the stage. His fortune was now made, and while the managers of Covent Garden and Drury Lane resorted to the law to make Giffard close his little theatre, Garrick was engaged by Fleetwood for Drury Lane for the season of 1742. In the mean time, having very advantageous terms offered him for performing in Dublin during part of the summer, he went over to that city, where he found the same homage paid to his merit which he had received from his own countrymen. From September, 1742, to April, 1745, he continued at Drury Lane, after which he again went over to Ireland, and remained there the whole season, as joint-manager with Sheridan, in the direction and profits of the theatre-royal in Smock Alley. From Dublin he returned to England, and fulfilled a short engagement in 1746–7 with Rich at Covent Garden. This was his last series of performances as a hired actor; for in the close of that season Fleetwood's patent for the management of Drury Lane expired, and Garrick, in conjunction with Lacy, purchased the property of the theatre, together with the renovation of the patent, and in the winter of 1747 opened it with a strong company of actors, the prologue for the occasion being written by his old preceptor Johnson.

For a time, at least, "the drama's patrons" were content with the higher entertainment furnished them; in the end Garrick had to "please" them, like most other managers, by gratifying their love of show. Garrick was surrounded by many players of eminence; and he had the art, as he was told by Miss Clive, "of contradicting the proverb that one cannot make bricks without straw, by doing what is infinitely more difficult, making actors and actresses without genius." The naturalness of his own acting was its great charm. As Churchill says in the *Rosciad*, which remains the chief literary monument of Garrick's pre-eminence among his fellows, he who is "pleased with Nature, must be pleased with thee." Booth, Quin, and the old tragedians were remarkable for a style of stately declamation, sonorous, and often graceful and impressive, but wanting the versatility and rapid changes of passion that, when exhibited by Garrick, at once captivated the audience. "It seemed," said Richard Cumberland, "as if a whole century had been stepped over in the passage of a single scene; old things were done away, and a new order at once brought forward, bright and luminous, and clearly destined to dispel the barbarisms of a tasteless age, too long superstitiously devoted to the illusions of imposing declamation." Garrick's French descent and his education may have contributed to give him the vivacity of manner and versatility of conception which distinguished him as an actor; and nature had given him an eye, if not a stature, to command, and a mimic power of wonderful variety. The list of his characters in tragedy, comedy, and farce is large, and would be extraordinary for a modern actor of high rank; it includes not less than seventeen Shakespearean parts. As a manager, though he committed some grievous blunders, he did good service to the theatre and signally advanced the popularity of Shakespeare's plays, of which not less than twenty-four were produced at Drury Lane under his management. Many of these were not pure Shakespeare; but not every generation has the same notions of the way in which he is best honored. He purified the stage of much of its grossness, and introduced a relative correctness of costume and decoration unknown before.

After, about the year 1745, escaping from the chains of an unreturned passion for the beautiful but reckless actress "Peg" Woffington, Garrick had, in 1749, married Mademoiselle Violette (Eva Maria Veigal), a German lady who had attracted the admiration of the court of Vienna as a dancer, and was patronized in England by the countess of Burlington. This lady Garrick called "the best of women and wives," and he lived most happily with her in his villa at Hampton (acquired by him in 1754, and adorned by the famous Shakespeare temple), whither he was glad to escape from his house in Southampton Street. Their union was childless, and Mrs. Garrick survived her husband, living in great respect until 1822. Having sold the moiety of his theatre for £35,000, Garrick took leave of the stage by playing a round of his favorite characters—Hamlet, Lear, Richard, Lusignan, and Kitely, as the graver; Archer, Abel Drugger, Sir John Brute, Benedick, Leon, and Don Felix, as those of a lighter cast. He ended the series with Don Felix (in *The Wonder*) on June 10, 1776. But he was not long to enjoy his opulent and well-earned repose, for he died in London on the 20th of January 1779. He was buried in Westminster Abbey with imposing solemnities, and amidst an unexampled concourse of people of all ranks. Johnson, whose various and not always consistent criticisms on Garrick are scattered through the pages of Boswell, spoke warmly of the elegance and sprightliness of his friend's conversation, as well as of his liberality and kindness of heart; and his death, which came upon him unexpectedly, "eclipsed," Johnson said, "the gayety of nations, and impoverished the public stock of harmless pleasure." But the most accurate and discriminating character of Garrick, slightly tinged with satire, is that drawn by Goldsmith in his poem of *Retaliation*. As a literary man Garrick was very happy in his epigrams and slight occasional poems. He had the good taste to recognize, and the spirit to make public his recognition of, the excellence of Gray's *Odes* at a time when they were either ridiculed or neglected. His dramatic pieces (*The Lying Valet*, *Lethe*, *The Guardian*, *Miss in her Teens*, *Irish Widow*, *etc.*), and his alterations and adaptation of old plays, which together fill four volumes, evinced his knowledge of stage effect and his appreciation of lively dialogue and action; but he cannot be said to have added one new or original character to the drama. He was joint author with Colman of *The Clandestine Marriage*, in which he is said to have written his famous part of Lord Ogleby. The excellent farce, *High Life below Stairs*, appears to have been wrongly attributed to Garrick, and to be by Townly, a clergyman. As a matter of course he wrote many prologues and epilogues.

Garrick's correspondence (published, with a short memoir by Boaden, in 2 vols. 4to), and the notices of him in the memoirs of Hannah More and Madame D'Arblay, and above all in Boswell's *Life of Johnson*, bear testimony to his general worth, and to his many fascinating qualities as a friend and companion. The earlier biographies of Garrick are by Arthur Murphy (2 vols. 1801) and by the bookseller Tom Davies (2 vols., 4th ed., 1805), the latter a work of some merit, but occasionally inaccurate and confused as to dates. Mr. Percy Fitzgerald's *Life* (2 vols. 1868) is full and spirited. A charming essay on Garrick appeared in the *Quarterly Review*, July, 1868.

(R. CA.—A. W. W.)

GARRISON:* An Outline of his Life (*copyright, 1879, by Charles Scribner's Sons*).—William Lloyd Garrison, the founder and leader of the movement for the abolition of slavery in the United States of America, was born in Newburyport, Massachusetts, December 10, 1805. His parents were from the British province of New Brunswick. The father, a sea-captain, went away from home when William was a child, and it is not known whether he died at sea or on the land. The mother is said to have been a woman of high character, charming in person, and eminent for piety. For her William had the deepest reverence, and he is supposed to have inherited from her the moral qualities that specially fitted him for his career. She was entirely dependent for the support of herself and children upon her labors as a nurse. She was able to give William but a meagre chance for an education, but he had a taste for books, and made the most of his limited opportunities. She first set him to learn the trade of a shoemaker, and, when she found this did not suit him, let him try his hand at cabinet-making. But the latter pleased him no better than the former. In October, 1818, however, when he was in his fourteenth year, he was made more than content by being indentured to Ephraim W. Allen, proprietor of the *Newburyport Herald*, to learn the trade of a printer. He found in this occupation a happy stimulus to his literary taste and ambition, as well as some available opportunities for mental culture. He soon became an expert compositor, and after a time began to write anonymously for the *Herald*. His communications won the commendation of the editor, who had not at first the slightest suspicion that he was the author. He also wrote for other papers with equal success. A series of political essays, written by him for the *Salem Gazette*, was copied by a prominent Philadelphia journal, the editor of which attributed them to the Hon. Timothy Pickering, a distinguished statesman of Massachusetts. His skill as a printer won for him the position of foreman while his ability as a writer was so marked that the editor of the *Herald*, when temporarily called away from his post, left the paper in his charge.

The printing-office was for him, what it has been for many another poor boy, no mean substitute for the academy and the college. He was full of enthusiasm for liberty; the struggle of the Greeks to throw off the Turkish yoke enlisted his warmest sympathy, and at one time he seriously thought of entering the West Point Academy and fitting himself for a soldier's career. His apprenticeship ended with his minority in 1826, when he began the publication of a new paper, the *Free Press*, in his native place. This paper was full of spirit and intellectual force, but Newburyport was a sleepy place and did not appreciate a periodical so fresh and free; and so the enterprise failed. Mr. Garrison then went to Boston, where, after working for a time as a journeyman printer, he became the editor of the *National Philanthropist*, the first journal established in America to promote the cause of total abstinence from intoxicating liquors. His work in this paper was highly appreciated by the friends of temperance, but a change in the proprietorship led to his withdrawal before the end of a year. In 1828 he was induced to establish the *Journal of the Times* at Bennington, Vermont, to support the re-election to the presidency of the United States of John Quincy Adams. The new paper, though attractive in many ways, and full of force and fire, was too far ahead of public sentiment on moral questions to win a large support. Whether or not it would have lived if he had continued to be its editor, it is impossible to say; but the time had come at last when he was to enter upon the work with which his name will be for ever associated. In Boston he had met Benjamin Lundy, a Quaker philanthropist, who had been for years engaged in an effort to convince the people of the United States that they ought to do something to promote the abolition of slavery. Mr. Garrison had been deeply moved by Mr. Lundy's appeals, and after going to Vermont he showed the deepest interest in the slavery question. Mr. Lundy was then publishing in Baltimore a small monthly paper, entitled *Genius of Universal Emancipation*, and he resolved to go to Bennington and invite Mr. Garrison to join him in the editorship. With this object in view he walked from Boston to Bennington, through the frost and snow of a New England winter, a distance of 125 miles. His mission was successful. Mr. Garrison was deeply impressed by the good Quaker's zeal and devotion, and he resolved to join him and devote himself thereafter to the work of abolishing slavery.

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In pursuance of this plan he went to Baltimore in the autumn of 1829, and thenceforth the *Genius* was published weekly, under the joint editorship of the two men. It was understood, however, that Mr. Garrison would do most of the editorial work, while Mr. Lundy would spend most of his time in lecturing and procuring subscribers. On one point the two editors differed radically, Lundy being the advocate of gradual, and Garrison the champion of immediate emancipation. The former was possessed with the idea that the negroes, on being emancipated, must be colonized somewhere beyond the limits of the United States; the latter held that they should be emancipated on the soil of the country, with all the rights of freemen. In view of this difference it was agreed that each should speak on his own individual responsibility in the paper, appending his initial to each of his articles for the information of the reader. It deserves mention here that Mr. Garrison was then in utter ignorance of the change previously wrought in the opinions of English abolitionists by Elizabeth Heyrick's pamphlet in favor of immediate, in distinction from gradual emancipation. The sinfulness of slavery being admitted, the duty of immediate emancipation to his clear ethical instinct was perfectly manifest. He saw that it would be idle to expose and denounce the evils of slavery, while the responsibility for the system was placed upon former generations, and the duty of abolishing it transferred to an indefinite future. His demand for immediate emancipation fell like a tocsin upon the ears of slaveholders. For general talk about the evils of slavery they cared little, but this assertion that every slave was entitled to instant freedom filled them with alarm and roused them to anger, for they saw that, if the conscience of the nation were to respond to the proposition, the system must inevitably fail. The *Genius*, now that it had become a vehicle for this dangerous doctrine, was a paper to be feared and intensely hated. Baltimore was then one of the centres of the domestic slave trade, and upon this traffic Mr. Garrison heaped the strongest denunciations. A vessel owned in Newburyport having taken a cargo of slaves from Baltimore to New Orleans, he characterized the transaction as an act of "domestic piracy," and avowed his purpose to "cover with thick infamy" those engaged therein. He was thereupon prosecuted for libel by the owner of the vessel, fined in the sum of fifty dollars, mulcted in costs of court, and, in default of payment, committed to jail. His imprisonment created much excitement, and in some quarters, in spite of the pro-slavery spirit of the time, was a subject of indignant comment in public as well as private. The excitement was fed by the publication of two or three striking sonnets, instinct with the spirit of liberty, which Mr. Garrison inscribed on the walls of his cell. One of these, *Freedom of Mind*, is remarkable for freshness of thought and terseness of expression, and will probably hold a permanent place in American literature.

John G. Whittier, the Quaker poet, interceded with Henry Clay to pay Mr. Garrison's fine and thus release him from prison. To the credit of the slaveholding statesman it must be said that he responded favorably, but before he had time for the requisite preliminaries, Mr. Arthur Tappan, a philanthropic merchant of New York, contributed the necessary sum and set the prisoner free after an incarceration of seven weeks. The partnership between Mr. Garrison and Mr. Lundy was then dissolved by mutual consent, and the former resolved to establish a paper of his own, in which, upon his sole responsibility, he could advocate the doctrine of immediate emancipation and oppose the scheme of African colonization. He was sure, after his experiences at Baltimore, that a movement against slavery resting upon any less radical foundation than this would be inefficacious. He first proposed to establish his paper at Washington, in the midst of slavery, but on returning to New England and observing the state of public opinion there, he came to the conclusion that little could be done at the South while the non-slaveholding North was lending her influence, through political, commercial, religious, and social channels, for the sustenance of slavery. He determined, therefore, to publish his paper in Boston, and, having issued his prospectus, set himself to the task of awakening an interest in the subject by means of lectures in some of the principal cities and towns of the North. It was an up-hill work. Contempt for the negro and indifference to his wrongs were almost universal. In Boston, then a great cotton mart, he tried in vain to procure a church or vestry for the delivery of his lectures, and thereupon announced in one of the daily journals that if some suitable place was not promptly offered he would speak on the common. A body of infidels proffered him the use of their small hall; and, no other place being accessible, he accepted it gratefully, and delivered therein three lectures, in which he unfolded his principles and plans. He visited privately many of the leading citizens of the city, statesmen, divines, and merchants, and besought them to take the lead in a national movement against slavery; but they all with one consent made excuse, some of them listening to his plea with manifest impatience. He was disappointed, but not disheartened. His conviction of the righteousness of his cause, of the evils and dangers of slavery, and of the absolute necessity of the contemplated movement, was intensified by opposition, and he resolved to go forward, trusting in God for success.

On the 1st of January, 1831, without a dollar of capital save in hand and brain, and without a single subscriber, he and his partner issued the first number of the *Liberator*, avowing their "determination to print it as long they could subsist on bread and water, or their hands obtain employment." Its motto was, "Our country is the world—our countrymen are mankind;" and the editor, in his address to the public, uttered the words which have become memorable as embodying the whole purpose and spirit of his life:—"I am in earnest—I will not equivocate—I will not excuse—I will not retreat a single inch—and I will be heard." Help came but slowly. For many months Mr. Garrison and his brave partner, Mr. Isaac Knapp, who died long before the end of the conflict, made their bed on the floor of the room, "dark, unfurnitured, and mean," in which they printed their paper, and where the mayor of Boston, in compliance with the request of a distinguished magistrate of the South, "ferreted them out," in "an obscure hole," "their only visible auxiliary a negro boy." But the paper founded on such inauspicious circumstances exerted a mighty influence, and lived to record not only President Lincoln's proclamation of emancipation, but the adoption of an amendment to the constitution of the United States for ever prohibiting slavery. It was the beginning and the nucleus of an agitation that eventually pervaded and filled every part of the country, and that baffled alike the wiles of politicians and parties and the devices of those pulpits and ecclesiastical bodies which forgot that Jesus came to preach deliverance to the captives and the opening of the prison to them that are bound. Other newspapers were afterwards established upon the same principles; anti-slavery societies, founded upon the doctrine of immediate emancipation, sprang up on every hand; the agitation was carried into political parties, into the press, and into legislative and ecclesiastical assemblies; until in 1860 the Southern States, taking alarm from the election of a president known to be at heart opposed to slavery though pledged to enforce all the constitutional safeguards of the system, seceded from the Union and set up a separate government. In the struggle that ensued slavery was abolished by an exercise of the powers of war, as a necessary means of restoring the Union.

Mr. Garrison sought the abolition of slavery by moral means alone. He knew that the national Government had no power over the system in any State, though it could abolish it at the national capital, and prohibit it in the inchoate States called Territories. He thought it should, by the exercise of such limited powers as it possessed, bring its moral influence to bear in favor of abolition; but neither he nor his associates ever asked Congress to exercise any unconstitutional power. His idea was to combine the moral influence of the North, and pour it through every open channel upon the South. To this end he made his appeal to the Northern churches and pulpits, beseeching them to bring the power of Christianity to bear against the slave system, and to advocate the right of the slaves to immediate and unconditional freedom. He thought that, under the moral pressure thus created, and which would be re-enforced by the civilization and Christianity of the foremost nations of the world, the South would speedily give way and proclaim freedom to her bondmen. He was a man of peace, hating war not less than he did slavery; but he warned his countrymen that if they refused to abolish slavery by moral power a retributive war must sooner or later ensue. The conflict was irrepressible. Slavery must be overthrown, if not by peaceful means, then in blood. The first society organized under Mr. Garrison's auspices, and in accordance with his principles, was the "New England Anti-Slavery Society," which adopted its constitution in January, 1832. In the spring of this year Mr. Garrison issued his work entitled *Thoughts on African Colonization*, in which he showed by ample citations from official documents that the American Colonization Society was organized in the interest of slavery, and that in offering itself to the people of the North as a practical remedy for that system it was guilty of deception. His book smote the society with a paralysis from which it has never recovered. Agents of the American Colonization Society in England having succeeded in deceiving leading abolitionists there as to the character and tendency of that Society, Mr. Garrison was deputed by the New England Anti-Slavery Society to visit that country for the purpose of counteracting their influence. He went in the spring of 1833, when he was but twenty-seven years of age, and was received with great cordiality by British abolitionists, some of whom had heard of his bold assaults upon American slavery, and seen a few numbers of the *Liberator*. The struggle for emancipation in the West Indies was then at the point of culmination; the leaders of the cause, from all parts of the kingdom, were assembled in London, and Mr. Garrison was at once admitted to their councils and treated with distinguished consideration. He formed the acquaintance of Wilberforce, Clarkson, Buxton, O'Connell, George Thompson, and many others, and was greatly cheered by what he saw and heard. He was thoroughly successful in his efforts to undeceive the people of England in respect to the character and designs of the American Colonization Society, and took home with him a "Protest" against it, signed by Wilberforce, Zachary Macaulay, Samuel Gurney, William Evans, S. Lushington, T. Fowell Buxton, James Cropper, Daniel O'Connell, and others, in which they declared their deliberate judgment that "its precepts were delusive," and "its real effects of the most dangerous nature." He also received assurances of the cordial sympathy of British abolitionists with him in his efforts to abolish American slavery. He gained a hearing before a large popular assembly in London, and won the confidence of those whom he addressed by his evident earnestness, sincerity, and ability.

Sir Thomas Fowell Buxton, before he had an opportunity of meeting him, invited him to breakfast at his house. Mr. Garrison presented himself at the appointed time; but Mr. Buxton, instead of coming forward promptly to take his hand, scrutinized him from head to foot, and then inquired, somewhat dubiously, "Have I the pleasure of addressing Mr. Garrison of Boston, in the United States?" Being answered in the affirmative, he lifted up his hands and exclaimed, "Why, my dear sir, I thought you were a black man, and I have consequently invited this company of ladies and gentlemen to be present to welcome Mr. Garrison, the black advocate of emancipation, from the United States of America." Mr. Garrison often said that, of all the compliments he ever received, this was the only one that he cared to remember or repeat; for Mr. Buxton had somehow or other supposed that no white American could plead for those in bondage as he had done, and that therefore he must be black. Mr. Garrison's visit to England enraged the pro-slavery people and press of the United States at the outset, and when he returned home in September with the "Protest" against the Colonization Society, and announced that he had engaged the services of George Thompson as a lecturer against American slavery, there were fresh outbursts of rage on every hand. The American Anti-Slavery Society was organized in December of that year, putting forth a masterly declaration of its principles and purposes from the pen of Mr. Garrison. This added fresh fuel to the public excitement, and when Mr. Thompson came over in the next spring, the hostility to the cause began to manifest itself in mobs organized to suppress the discussion of the slavery question. Now began what Harriet Martineau called "the martyr age in America." Mr. Thompson gained a favorable hearing in a few places, but his appearance in any town or city became at length the signal of a mob, and in the fall of 1835 he was compelled, in order to save his life, to embark secretly for England. Just before his departure, the announcement that he would address the Women's Anti-Slavery Society of Boston created "a mob of gentlemen of property and standing," from which, if he had been present, he could hardly have escaped with his life. The whole city was in an uproar. Mr. Garrison, almost denuded of his clothing, was dragged through the streets by infuriated men with a rope around his body, by which they doubtless intended to hang him. He was rescued with great difficulty, and consigned to the jail for safety, until he could be secretly removed from the city. For two or three years these attempts to suppress the anti-slavery movement by violence were persisted in, but it was like attempting to extinguish a fire by pouring oil upon the flames, or like an effort to stop the roar of Niagara by increasing the volume of its waters.

Anti-slavery societies were greatly multiplied throughout the North, and many men of influence, both in the church and in the state, were won to the cause. Mr. Garrison, true to his original purpose, never faltered or turned back. Other friends of the cause were sometimes discouraged—he, never. The abolitionists of the United States were a united body until 1839–40, when divisions sprang up among them. Mr. Garrison countenanced the activity of women in the cause, even to the extent of allowing them to vote and speak in the anti-slavery societies, and appointing them as lecturing agents. To this a strong party was opposed upon social and religious grounds. Then there were some who thought Mr. Garrison dealt too severely with the churches and pulpits for their complicity with slavery, and who accused him of a want of religious orthodoxy. He was, moreover, a non-resistant, and this to many was distasteful. The dissentients from his opinions determined to form an anti-slavery political party, while he believed in working by moral rather than political party instrumentalities. These differences led to the organization of a new National Anti-Slavery Society in 1840, and to the formation of the "Liberty Party" in politics. The two societies sent their delegates to the World's Anti-Slavery Convention in London in 1840, and Mr. Garrison refused to take his seat in that body, because the women delegates from the United States were excluded. The discussions of the next few years served to make clearer than before the practical workings of the constitution of the United States as a shield and support of slavery; and Mr. Garrison, after long and painful reflection, came to the conclusion that its pro-slavery clauses were immoral, and that it was therefore wrong to take an oath for its support. The Southern States had a greatly enlarged representation in Congress on account of their slaves, and the national Government was constitutionally bound to assist in the capture of fugitive slaves, and to suppress every attempt on their part to gain their freedom by force. In view of these provisions, Mr. Garrison, adopting a bold scriptural figure of speech, denounced the Union as "a covenant with death and an agreement with hell," and adopted as his motto the legend, "No union with slaveholders." His argument on this question, in the light of ethical principles generally admitted to be sound, could not easily be answered, and many men, who shrank from the conclusion that followed therefrom, were held by it as in a vice. His exposures of the character and practical working of the pro-slavery clauses of the constitution, in spite of the impatience with which they were regarded in some quarters, made a deep impression upon the national conscience, and served to abate that undiscriminating and idolatrous reverence for the Union, upon which the slaveholders had so long relied for the protection of their system.

One class of abolitionists sought to evade the difficulty by strained interpretations of the clauses referred to, while others, admitting that they were immoral, felt themselves obliged, notwithstanding, to support the constitution in order to avoid what they thought would be still greater evils. The American Anti-Slavery Society, of which Mr. Garrison was the president from 1843 to the day of emancipation, was during all this period the nucleus of an intense and powerful moral agitation, which was greatly valued by the soundest and most faithful workers in the field of politics, who greatly respected him for his fidelity to his convictions. On the other hand, Mr. Garrison always had the highest respect for every earnest and faithful opponent of slavery, however far he might be from adopting his special views. He was intolerant of nothing but conscious treachery to the cause. When in 1861 the Southern States seceded from the Union and took up arms against it, he saw clearly that slavery would perish in the struggle, that the constitution would be purged of its pro-slavery clauses, and that the Union thenceforth, instead of being "a covenant with death and an agreement with hell," would rest upon the sure foundations of liberty, justice, and equality to all men. He therefore ceased from that hour to advocate disunion, and devoted himself to the task of preparing the way for and hastening on the inevitable event. His services at this period were recognized and honored by President Lincoln and others in authority, and the whole country knew that the agitation which made the abolition of slavery feasible and necessary was due to his uncompromising spirit and indomitable courage. He lived to witness the redemption of his country from the curse of human bondage, not indeed by the means which he preferred, and which he hoped would prove sufficiently potent, but by the bloody arbitrament of war. None the less, however, did he see in the great event the hand of that Divine Providence on which he had always relied for support in the great struggle to which his life was devoted. In 1865, at the close of the war, he declared that, slavery being abolished, his career as an abolitionist was ended. He counselled a dissolution of the American Anti-

Slavery Society, insisting that it had become *functus officiis*, and that whatever needed to be done for the protection of the freedmen could best be accomplished by new associations formed for that purpose. The *Liberator* was discontinued at the end of the same year, after an existence of thirty-five years. He visited England for the second time in 1846, and again in 1867, when he was received with distinguished honors, public as well as private. In 1877, when he was there for the last time, he declined every form of public recognition. He died in New York, May 24, 1879, in the seventy-fourth year of his age, and was buried in Boston, after a most impressive funeral service, May 28. In 1843 a small volume of his *Sonnets and other Poems* was published, and in 1852 appeared a volume of *Selections from his Writings and Speeches*. His wife, Helen Eliza Benson, died in 1876. Four sons and one daughter survive them.

GARTER, Order of the. See Knighthood.

GARTH, Sir Samuel (1670?–1719), a physician and poet of the age of Anne, was born of a good Yorkshire family, in 1670, it is said, but more probably at an earlier date. He was a student of Peterhouse, Cambridge, where he resided until he was received into the College of Physicians in 1691. In 1696 he became a prominent supporter of the new scheme of providing dispensaries for the relief of the sick poor, as a protection against the greed of the apothecaries. This labor having exposed him to the animosity of many of his own profession, and especially of the last-named body, he published in 1699 a mock-heroic poem, *The Dispensary*, in six cantos, which had an instant success, passing through three editions within the year. Garth became the leading physician of the Whigs, as Radcliffe was of the Tories. In 1714 he was knighted by George I., and he died on the 18th of January, 1718–19. Garth was a wealthy man, leaving estates in Warwickshire, Oxfordshire, and Buckinghamshire. He wrote little besides his best-known work *The Dispensary*, and *Claremont*, a moral epistle in verse. In 1717 he edited a translation of Ovid's *Metamorphoses*, himself supplying the fourteenth and part of the fifteenth book. The subject of his mock-heroic epic is treated in a cumbrous style; and even in his own day Garth was accused of flatness and poverty of thought.

GAS and GAS-LIGHTING. All artificial light is obtained as a result either of combustion or of incandescence; or it might be more accurate to classify illuminating agents as those which emit light as a result of chemical action, and those which glow, from the presence of a large amount of heat, without thereby giving rise to any chemical change. The materials whence artificial light of the nature of flame has been derived are principally bodies rich in carbon and hydrogen. Wax, fats, and oils, on exposure to a certain amount of heat, undergo destructive distillation, evolving inflammable gases; and it is really such gases that are consumed in the burning of lamps and candles, the wicks bringing small proportions of the substances into a sufficient heat. Wood and coal also, when distilled, give off combustible gases; and ordinary gas-lighting only differs from illumination by candles and lamps in the gas being stored up and consumed at a distance from the point where it is generated.

Inflammable gas is formed in great abundance within the earth in connection with carbonaceous deposits, such as coal and petroleum; and similar accumulations not unfrequently occur in connection with deposits of rock-salt; the gases from any of these sources, escaping by means of fissures or seams to the open air, may be collected and burned in suitable arrangements. Thus the "eternal fires" of Baku, on the shores of the Caspian Sea, which have been known as burning from remote ages, are due to gaseous hydrocarbons issuing from and through petroleum deposits. In the province of Szechuen in China, gas is obtained from beds of rock-salt at a depth of 1500 or 1600 feet: being brought to the surface, it is conveyed in bamboo tubes and used for lighting as well as for evaporating brine; and it is asserted that the Chinese used this naturally evolved gas as an illuminant long before gas-lighting was introduced among European nations. At a salt mine in the comitat of Marmaro in Hungary, gas is obtained at a depth of about 120 feet, and is used for illuminating the works of the mine. Again at Fredonia (New York State) a natural emission of gas was discovered in a bituminous limestone, over the orifice of which a gasholder has been erected, and thus about 6000 cubic feet per day of a gas composed of marsh gas and hydride of ethyl have been made available for illumination. In the city of Erie (Pa.) there are 13 gas-wells, each yielding from 10,000 to 30,000 feet per day, the gas escaping from one of them at a pressure of 200 lb per square inch. At Bloomfield, Ontario co., New York, there is a spring which yields daily no less than 800,000 feet of gas of an illuminating power equal to 14½ candles. The city of East Liverpool (Ohio) is entirely illuminated, and to a large extent heated, by gas-wells which exist in and around the town. The light is of extraordinary brilliancy, and is so abundant and free that the street lamps are never extinguished, and much of the manufacturing steam-power of the town, which embraces 22 potteries, giving employment to 2000 hands, is derived from the gas. The first "well," 450 feet deep, was opened in 1859, and up to the present year (1879) neither it nor any of those tapped at later dates show any sign of failing. In many other parts of America similar gas-wells exist; and several such natural jets of gas have been observed in England.

By general consent the merit of the discovery and application of artificial gas belongs to Great Britain, and the name most honorably connected with the beginning and early stages of gas-lighting is that of a Scotchman—Robert Murdoch. But previous to Murdoch's time there occur numerous suggestive observations and experiments as to inflammable air and its sources. In the *Philosophical Transactions* of the Royal Society for 1667 the existence of a "burning spring" in the coal district of Wigan is noticed by Thomas Shirley, who traced its origin to the underlying coal. In the same *Transactions* for 1739 is printed a letter addressed to the Hon. Robert Boyle, who died in 1691, in which the Rev. John Clayton details a series of experiments he made in distilling coal in a retort, showing, not only that he had observed the inflammable gases evolved, but that he collected and stored them for some time in bladders. In Dr. Stephen Hales's work on *Vegetable Staticks*, published in 1726, more precise statements are made as to the distillation of coal, he having obtained from 158 grains of Newcastle coal 180 inches of inflammable air. In 1787 Lord Dundonald, in working a patented process for obtaining coal-tar, experimented with the gas evolved in the process, and occasionally used it for lighting up the hall of Culross Abbey. None of these observations, however, led to distinct practical results; and it was not till the year 1792 that Robert Murdoch, then residing at Redruth in Cornwall, began the investigations into the properties of gases given off by various substances which eventuated in the establishment of coal-gas as an illuminating agent. In 1797 he publicly showed the system he had matured, and in 1798, being then employed in the famous Soho (Birmingham) workshop of Boulton & Watt, he fitted up an apparatus for the manufacture of gas in that establishment, with which it was partly lighted. Thereafter the apparatus was extended, and the gas manufactured by it was introduced to other neighboring workshops and factories. Among others who helped most materially to develop the infant art in England were Dr. Henry of Manchester, and Mr. Clegg, who, succeeding Mr. Murdoch at Boulton & Watt's, introduced many improvements in gas manufacture, and ultimately became the most skilful and famous gas engineer in the United Kingdom.

In 1801 M. Lebon introduced gas distilled from wood into his own house in Paris, and the success of his experiment attracted so much notice and comment as to give rise to an impression that he is entitled to the credit of the invention. Lebon's experiment came under the notice of Mr. F. A. Winsor, who took up the subject with a zeal and unwearying patience which led to a recognition of the advantages of the system, and the breaking down of the powerful prejudice which existed in England against the innovation. In 1803, through Winsor's efforts, the Lyceum Theatre was lighted with gas; but it was not till 1810 that he succeeded in forming a public company for manufacturing gas, and in obtaining an Act of Parliament for the Gas-Light and Coke Company. In 1813 Westminster Bridge was first lighted with gas, and in the following year the streets of Westminster were thus illuminated, and in 1816 gas became common in London. So rapid was the progress of this new mode of illumination that in the course of a few years after its introduction it was adopted by all the principal towns in the kingdom, for lighting streets as well as shops and public edifices. In private houses it found its way more slowly, partly from an apprehension of danger attending its use, and partly from the annoyance which was experienced in many cases through the careless and imperfect manner in which the service-pipes were at first fitted up.

SOURCES OF GAS.

Artificial gas is now distilled from a variety of substances, among which are coal, shale, lignite, petroleum, turf, wood, resins, oils, and fats; and it is also prepared by carburetting or impregnating with volatile hydrocarbons other non-luminiferous gases. Of the very numerous systems of gas-making which have been proposed since the early part of the century, none can compete for general purposes with the ordinary coal-gas process, when a supply of the raw material can be obtained at a moderate expense.

Coal-Gas.—Coals, varying greatly as they do in chemical constitution, differ also, as might be expected, as widely in their value and applicability for the manufacture of gas. Taking the leading varieties of coal to be included under anthracite, bituminous coal, and lignite or brown coal, we find that it is the class bituminous coal alone that yields varieties really serviceable for gas-making. Anthracite may be regarded as a natural coke from which the volatile constituents have been already driven off, and the more anthracitic any coal is, the less is it capable of yielding gas. Lignite also is rarely used for distillation, owing to the large proportion of oxygen and the amount of water in its composition. Of the bituminous coals again, it is only the caking or pitch coals, and the cannel or parrot coals, that are in practice used in gas-works. These also vary within very wide limits in their gas-making value, not only from the great difference among them in yield of gas, but also in the illuminating value of the gas they evolve. As a rule the coals which yield the largest percentage produce also the most highly illuminating qualities of gas. The cannel coals, which are specially recognized as "gas-coal," are most abundantly developed in Scotland and in Lancashire, and the fact of the unequalled qualities of Scotch cannel and of the allied substance, bituminous shale, for gas-making, has had the effect of rendering illumination by gas much more general and satisfactory in Scotland than in any other country. It is only a very imperfect valuation of any gas-coal that can be made from chemical analysis, the really satisfactory test being actual experiment. According to H. Fleck, the coal most available for gas-making should contain to every 100 parts of carbon 6 parts of hydrogen, of which 4 parts are available for forming hydrocarbon compounds. It is desirable that coal used for distillation in gas retorts should be as far as possible free from sulphur, that in the case of coking coal the amount of ash should be small, and the proportion of oxygen should also be low, since that element abstracts hydrogen to form injurious watery vapor. The amount of ash present, however, in the best forms of Scotch cannel is large; and consequently the resulting coke, if the residue can be so called, is of comparatively little value. Unless coal can be stored in sheds which protect it from the weather, it ought to be used as soon as possible after being raised, rain and sunshine being detrimental to its gas-making qualities. The following table exhibits the chemical analysis and gas-yielding properties of a few of the principal and typical examples of coal for gas-making :—

Composition of Coals used in Gas-Making.

Variety of Coal.		Disposable Hydrogen.	Carbon.	Hydrogen.	Nitrogen.	Sulphur.	Oxygen.	Ash.
Newcastle Peareth Gas-Coal		...	82·42	4·82	...	0·86	11·11	0·79
Blaydon Main, Tyneside		6·88	78·06	5·80	1·85	2·22	3·12	8·94
Dukinfield, Ashton-under-Lyne		6·19	83·25	5·75	...	0·86	5·06	3·48
Wigan Cannel		5·65	84·07	5·71	...	...	7·82	2·40
Mold-Leeswood Green Cannel		...	77·81	8·47	...	0·71	6·32	...
Boghead Cannel	Scotland.	12·68	63·10	8·91	...	0·96	7·25	19·78
Methil Brown Shale		9·33	66·44	7·54	1·36	0·84	10·84	12·98
Kelty Gin Seam		...	76·50	5·03	...	0·94	11·68	2·25

Products of the Distillation of 1 ton of Coal.

	Cubic feet of Gas.	Lbs. of Coke.	Lbs. of Tar.	Lbs. of Ammonia Liquor.	Illuminating power of Gas in Candles.
Newcastle Cannel	9,883	1,426	98·3	60·0	25·2
Wigan Cannel	10,850	1,332	218·3	161·6	19·4
Boghead Cannel	13,334	715	733·3	nil.	46·2

When the bowl of an ordinary clay pipe is filled with small fragments of bituminous coal, luted over with clay and placed in a bright fire, immediately smoke is seen to issue from the stalk which projects beyond the fire. The smoke soon ceases, and if a light is then applied to the orifice of the stalk, the issuing gas burns with a bright, steady flame, while a proportion of a black, thin, tarry liquid oozes out from the stalk. After the combustion ceases there is left in the bowl of the pipe a quantity of char or coke. This simple operation is, on a small scale, an exact counterpart of the process by which the destructive distillation of coal is accomplished in the manufacture of gas. The products of the distillatory process classed in the gas-works as gas, tar, and ammoniacal liquor, with a solid residue of coke, are in themselves mixtures of various definite chemical compounds; and as may be evident from the following list, these substances are very numerous and complex :—

Products of the Distillation of Coal at High-red Heat.

I. *Illuminating Gases.*

Acetylene, C_2H_2	Gases.
Ethylene, C_2H_4	
Propylene, C_3H_6	
Butylene, C_4H_8	
Benzol, C_6H_6	Vapors.
Naphthalin, $C_{10}H_8$	
Hydrogen, H	Diluents.
Light carburetted hydrogen, CH_4	
Carbonic oxide, CO	
Carbonic acid, CO_2	Impurities.
Ammonia, NH_3	
Cyanogen, C_2N_2	
Bisulphide of carbon, CS_2	
Sulphuretted hydrogen, H_2S	
Oxygen, O	
Nitrogen, N	
Aqueous vapor, H_2O	

II. *Components of Tar.*

Benzol, C_6H_6	Liquid hydrocarbons.
Toluol, C_7H_8	
Cumol, C_9H_{12}	
Cymol, $C_{10}H_{14}$	
Naphthalin, $C_{10}H_8$	Solid hydrocarbons.
Anthracene, $C_{14}H_{10}$	
Pyrene, $C_{16}H_{10}$	
Crysene, $C_{18}H_{12}$	
Carbolic acid, C_6H_6O.	
Cresylic acid, C_7H_8O.	
Rosolic acid, $C_{20}H_{16}O_3$.	
Pyridine, C_5H_5N.	
Aniline, C_6H_7N.	
Picoline, C_6H_7N.	
Lutidine, C_7H_9N.	
Collidine, $C_8H_{11}N$.	
Leucoline, C_9H_7N.	

III. *Ammoniacal Liquor.*

Ammonium carbonate, $2NH_4.CO_3$.
" sulphydrate, $NH_4.HS$.
" sulphocyanate, $NH_4.NCS$.
" cyanide, $NH_4.NC$.
" chloride, $NH_4.Cl$.

IV. *Coke and Ash in Retort.*

The proportions in which coal yields these products may be indicated by the case of a cannel giving off 11,000 feet per ton of gas of a density of 0·600. From 100 parts of such a coal there would be yielded—

Gas	22·25
Tar	8·50
Ammonia water	9·50
Coke	59·75

The proportions, however, and even the nature of these products of distillation are greatly modified by the temperature at which the distillation is effected, a low red heat yielding a small proportion of non-condensable gas, but a large amount of heavy hydrocarbon oils, whence the distillation of shales and coal in the paraffin manufacture is conducted at a low red heat. By excessive heat, on the other hand, the compounds evolved become simpler in their chemical constitution, carbon is deposited, pure hydrogen is given off, and the gain in amount of gas produced is more than counterbalanced by its poverty in illuminating properties.

Of the gases and vapors which pass out of the retorts in a highly heated condition, some portion, consisting of tarry matter and ammoniacal liquor, precipitates almost immediately by simple cooling, and other injurious constituents must be removed by a system of purification to which the gaseous products are submitted. What thereafter passes on as ordinary gas for consumption still contains some percentage of incombustible matters—aqueous vapor, oxygen, nitrogen, and carbonic acid. The combustible portion also is separable into two classes, viz., non-luminous supporters of combustion, and the luminiferous constituents,—the former embracing hydrogen, marsh gas (light carburetted hydrogen), and carbonic oxide, while the latter includes the hydrocarbon gases acetylene, ethylene (olefiant gas or heavy carburetted hydrogen), propylene, butylene, and vapors of the benzol and naphthalin series.

Formerly it was the habit to regard the proportion of heavy carburetted hydrogen (ethylene and its homologues) as the measure of the illuminating power of a gas. It has, however, been pointed out by Berthelot that the proportion of such compounds in some gas of good luminous qualities is exceedingly small; and in particular he cites the case of Paris gas, which, according to his analysis, contains only a mere trace of acetylene, ethylene, and other hydrocarbons, with 3 to 3·5 per cent. of benzol vapors. Subsequent experiments of Dittmar have proved that a mixture of pure ethylene and hydrogen burnt in the proportion of 3 volumes of hydrogen to 1 of ethylene yields little more light than ordinary marsh gas, while benzol vapor to the extent of only 3 per cent. in hydrogen, gives a brilliantly luminous flame. Frankland and Thorne have more recently determined the illuminating power of a cubic foot of benzol vapor burnt for 1 hour in various combinations, with the following results:—

With hydrogen it gave the light of..................	69·71 candles.
" carbonic oxide "	73·38 "
" marsh gas "	92·45 "
" " (second series) "	93·94 "

Thus it is highly probable that the illuminating value of coal-gas depends much more on the presence of benzol vapor than on the proportion of the heavy gaseous hydrocarbons, and the estimation of benzol in the gas is a point which has hitherto been comparatively neglected. In view of the inference that the presence of benzol vapor is so intimately related to illuminating power, the fact observed by Dittmar that water readily and largely dissolves it out of any gas mixture is of great consequence. When benzolated hydrogen containing 6 per cent. of benzol vapor was shaken up with water, the percentage of the vapor was found on analysis to be reduced to less than 2.

The average composition of the gas supplied to London, is, on the authority of the late Dr. Letheby, thus stated:—

	Ordinary Gas, 12 Candles.	Cannel Gas, 20 Candles.
Hydrogen..............................	46·0	27·7
Light carburetted hydrogen........	39·5	50·0
Condensible hydrocarbons..........	3·8	13·0
Carbonic oxide........................	7·5	6·8
Carbonic acid..........................	0·6	0·1
Aqueous vapor.........................	2·0	2·0
Oxygen.................................	0·1	0·0
Nitrogen...............................	0·5	0·4

Cannel gas is now, however, supplied only to the Houses of Parliament and to certain of the Government offices.

Manufacture of Coal-Gas.

The series of operations connected with the preparation and distribution of coal-gas embrace the processes of distillation, condensation, exhaustion, scrubbing or washing, purification, measuring, storing, and distribution by the governor to the mains, whence the consumers' supply is drawn. In connection with consumption, pressure of the gas, measurement of the amount consumed, and the burners and other arrangements for lighting are the most important considerations.

Site and Arrangement of Works.—The choice of a site for a gas establishment is necessarily conditioned by local circumstances; but the facts that a considerable area is required, and that, at best, the works do not improve the amenity of any neighborhood, are important considerations. A central position with respect to the area to be supplied is certainly desirable, but in the circumstances it is seldom to be obtained. Of even greater consequence for a large work is ready access to a railway or other means of transport; and most of the great establishments are now connected by sidings with lines of railway, whereby coals, etc., are delivered direct from the wagons to the store or retort-house, and in the same way the coke and residual products are removed. Where the arrangement is practicable, it is also desirable that the works should be erected at the lowest level of the area to be supplied, since coal-gas, being specifically lighter than atmospheric air, acquires a certain amount of pressure as it rises in pipes, which pressure facilitates its distribution, and it is much easier to control than to beget pressure. In the planning of works, regard must be given to economy of space and to labor-saving arrangements, so that the cost of manual labor may be minimized, and operations proceed in an orderly, methodical, and easily-controlled manner. The accompanying ground plan of gas-works (fig. 1) has been kindly furnished by Mr. James Hislop of Glasgow, a gas engineer of known skill and experience; and while it shows arrangements of the most approved character, it will also enable the reader to recognize the position of the various erections and apparatus as they follow each other, and as they will now be described.

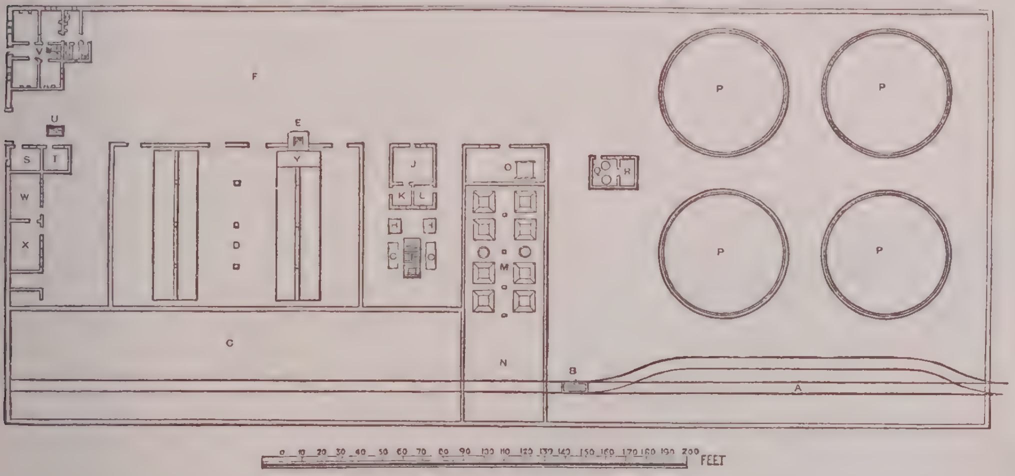


Fig. 1.—Ground-Plan of Gas-Works.

A, a line of rails leading into the works; B, wagon weighing machine; C, the coal store; D, retort house; E, chimney; F, coke yard; G, condensers; H, scrubbers; I, tar tank; J, exhauster house; K, pump room; L, store room (water tank is placed above K, L); M, purifier house; N, lime store; O, meter house; P, gas-holders; Q, governor house; R, photometer room: S, board room: T, office; U, weighing machine: V, superintendent's house; W, joiner's shop; X, smith's shop; Y, engine boiler.

Retorts.—Retorts for destructive distillation of coal are formed of cast iron, clay, brick, or wrought iron. Various shapes have been adopted in the construction of these vessels; nor have their forms been more varied than the modes in which they have been disposed in the furnaces. In many instances they have been constructed of a cylindrical shape varying in length and diameter. Those first employed were of iron, with the axis vertical, but experience soon showed that this position was extremely inconvenient, on account of the difficulty which it occasioned in removing the coke.

The retorts were therefore next placed in a horizontal position, as being not only more favorable to the most economical distribution of the heat, but better adapted to the introduction of the coal and the subsequent removal of the coke. At first the heat was applied directly to the lower part of the retort; but it was soon observed that the high temperature to which it was necessary to expose it, for the perfect decomposition of the coal, proved destructive to the lower side, and rendered it useless long before the upper part had sustained much injury. The next improvement was, accordingly, to interpose an arch of brickwork between it and the furnace, and to compensate for the diminished intensity of the heat by a more equally diffused distribution of it over the surface of the retort. This was effected by causing the flue of the furnace to return towards the mouth of the retort, and again conducting it in an opposite direction, till the heated air finally escaped into the chimney. This arrangement was continued so long as iron retorts were in use, but on the general adoption of clay retorts the furnaces were constructed to allow the fire to play freely around them.

The cylindrical form of retort *a* (fig. 2) was long in favor on account of its great durability, but it is not so well fitted for rapid decomposition of the coal as the elliptical *b*, or the flat-bottomed or D-shaped retorts *d*, which are now principally in use. Retorts are also made of a rectangular section with the corners rounded and the roof arched. Elliptical retorts are varied into what are called ear-shaped or kidney-shaped *c*, and it is not unusual to set retorts of different forms in the same bench, for the convenience of filling up the haunches of the arch which encloses them.

The length of single retorts varies from 6 to 9 feet, but they are now in some cases made 19½ feet in length, and 12½ inches in internal diameter, these being charged from both ends.

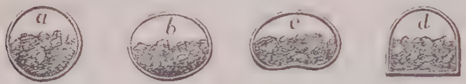


Fig. 2.

Every retort is furnished with a separate mouthpiece, usually of cast iron, with a socket *b* (fig. 3) for receiving the stand-pipe or ascension-pipe, and there is a movable lid attached to the mouth, together with an ear-box cast on each side of the retort for receiving the ears which support the lid. Fig. 3 shows a form of mouthpiece attached to the retort *a*, and also the method of screwing the lid to the mouthpiece. That part of the lid which comes in contact with the edge of the mouthpiece has applied to it a lute of lime mortar and fire clay, and when the lid is screwed up, a portion of this lute oozes out round the edges and forms a gas-tight joint.

Except for small works, where the manufacture is intermittent, and where, consequently, the retort heat has to be got up frequently, iron retorts are now little used. Clay retorts, which at present are in most general use, wear out quickly; they very frequently crack so seriously on the first application of heat that they must be removed from the bench before being used at all, and in scarcely any case are they in action perfectly free from cracks. Numerous attempts have been made to introduce retorts built of brick; but the difficulty of making and keeping the joints air-tight has proved a serious obstacle to their use. In the brick retort made of Glenboig Star fire-clay, according to the plan of Mr. James Hislop, it is claimed that the difficulty is surmounted, and that both the retort and its setting present great advantage and economy. These brick retorts (fig. 4) are ⌓-shaped, 9 feet long and with diameters of 22 and 13½ inches, set four in an oven to one unarched furnace, as in fig. 7. Each retort will, it is affirmed, carbonize 500 tons cannel coal, or 2000 tons per oven of four, without any repairs whatever. Decayed bricks may be removed from these retorts and new ones inserted, and when thoroughly repaired they are again equal to new.

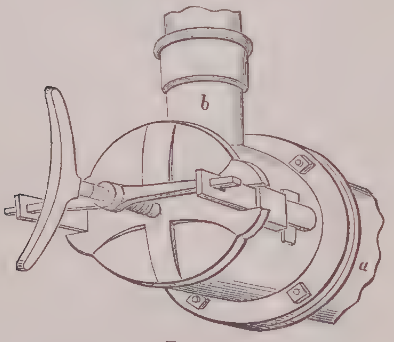


Fig. 3.

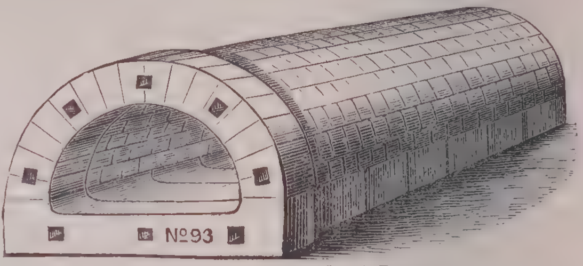


Fig. 4.—Hislop's Brick Retort.

Thus the durability of each retort is so great that they are calculated to cost about ⅛th of a penny per 1000 cubic feet of gas generated, as against 1d. in the case of moulded retorts, and 7d. with iron retorts, for the same production of gas. In the Hislop retort the arched bricks are made plain, without groove or rebate joints—being thus stronger, more readily put together, and also cheaper. Carbon does not collect so rapidly on brick retorts as on those of clay, the bricks being harder pressed and better burned. On first lighting brick retorts, a charge of coke, breeze, and tar mixed makes them perfectly gas-tight.

Retort Setting.—A furnace or bed of retorts is composed of a group or setting, heated by a separate fire. The furnace is lined with the most refractory fire-bricks, and while the whole brickwork is made of such strength and solidity as ensures the safety of the retorts, the internal construction is so planned that the heat has the utmost possible amount of direct play on the retorts. The number of retorts to one furnace varies from 1 to 15, from 4 to 7 being the number most commonly adopted; and these are variously arranged to bring them all as close to the furnace heat as practicable. In some retort-houses the furnaces are built in two stages or stories, from the upper of which the retorts are charged and drawn, while at the lower level the glowing coke is removed and quenched. The whole range of furnaces constitutes the retort bench, having a common flue which leads to the chimney shaft by which the products of combustion are carried away. The gas-coal for charging the retorts is broken into fragments about 1 ℔ in weight or thereby. Figs. 5 (elevation) and 6 (section) illustrate the retort setting and arrangement of furnace and flues adopted by Mr. Hislop for his brick retorts, in which by the use of centre blocks, as seen in the open front illustration (fig. 7), the necessity for internal arching is avoided.

Retort furnaces are commonly fired or heated with a portion of the coke which forms one of the bye-products of the gas manufacture; but in works where shale and rich cannel coals are distilled, common coal must be used in the furnaces. At the Ivry Gas Works of the *Compagnie Parisienne d'Éclairage et de Chauffage par le Gaz*, the retorts are heated by gas on a method modified from the Siemens regenerative gas furnace. Sectional illustrations of a retort setting on this plan, and a description of the various arrangements connected with the regenerators and the controlling of the air and gas currents, will be found in the article Furnace, vol. ix. p. 744.

Ordinarily the work of charging and drawing the retorts is accomplished by manual labor, by means simply of shovels for charging, and long iron rakes for drawing the spent charge. In the larger works it is usual to charge the retorts with a scoop semi-cylindrical in form, made a little shorter than the retort, and of such a diameter that it can with ease be pushed in and overturned within the retort. The scoop deposits the coal neatly over the sole of the retort, and of course the lid is much more quickly replaced than can be done with shovel charging. Numerous attempts have been made to introduce purely mechanical means of feeding retorts, hitherto with indifferent success,—such devices as a travelling endless sole and a rotating sole having been tried without good effect. A charging machine and a drawing machine, worked by hydraulic power, have been introduced by Mr. Foulis, the engineer of the Glasgow Corporation Gas Works, but after prolonged trial both in Glasgow and in Manchester, these have not yet proved satisfactory in action. In West's patent the charging is effected by the introduction of a small wagon within the retort, which distributes the charge evenly and uniformly. Neither has it, however, met general acceptance.

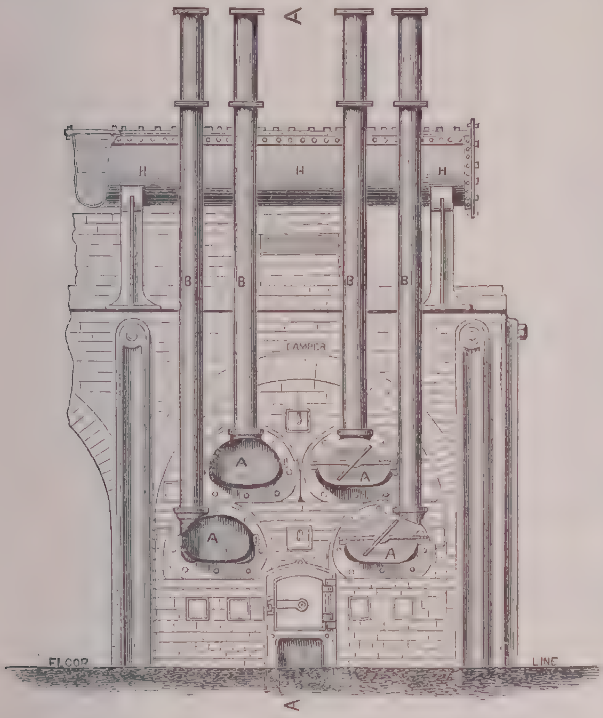


Fig. 5.—Elevation of Hislop's Gas Retort Furnace.

The retorts are kept at a bright red heat, and for coal with a high percentage of volatile matter a higher temperature is requisite than is needed for coal less rich in gas. As the retorts in one setting are necessarily subject to somewhat different amounts of heat, the charges in those nearest the furnace fire, and consequently most highly heated, must be drawn more frequently than the others, as otherwise the quality of the gas would be deteriorated, and a large proportion of sulphur compounds would be given off from the overburnt coke.

In drawing a charge the lid is first slightly opened and the escaping gas lighted, to prevent an explosion or "rap" that would otherwise ensue. The gas is prevented from escaping outward by the ascension-pipe dipping into the hydraulic main as afterwards explained; but in some cases special valves are fitted on the ascension pipe to prevent a back rushing of the gas. A carbonaceous deposit forms on the sides of the retorts, which requires to be periodically removed by "scurfing" with chisels, or burning it off with free admission of air or steam.

The Hydraulic Main.—From the retorts the gas, after its production, ascends by means of pipes called ascension-pipes B (figs. 5 and 6) into what is termed the condensing or hydraulic main HH, which is a large pipe or long reservoir placed in a horizontal position, and supported by columns in front of the brick-work which contains the retorts A. This part of a gas apparatus is intended to serve a twofold purpose:—first, to condense the tar and some ammoniacal liquor, and secondly, to allow each of the retorts to be charged singly without permitting the gas produced from the others, at the time that operation is going on, to make its escape. To accomplish these objects one end of the hydraulic main is closed by a flange; and the other, where it is connected with the pipes for conducting the gas towards the tar vessel and purifying apparatus, has, crossing it in the inside, a partition occupying the lower half of the area of the section, by which the condensing vessel is always kept half full of liquid matter. The stand-pipes are connected by a flange with a dip-pipe C, arising from the upper side of the condensing main HH, and as the lower end of it dips about 2 inches below the level of the liquid matter, it is evident that no gas can return and escape when the mouthpiece on the retort is removed, until it has forced the liquid matter over the bend, a result which is easily prevented by making it of a suitable length. The tar which is deposited in the hydraulic main overflows at the partition, and is carried by a pipe to the tar well.

Condensation.—The gas as it passes on from the hydraulic main is still of a temperature from 130° to 140° Fahr., and consequently carries with it heavy hydrocarbons, which, as its temperature falls, would be deposited. It is therefore a first consideration in ordinary working to have these condensable vapours at once separated, and the object of the condenser is to cool the gas down to a temperature nearly that of the surrounding atmosphere. The first contrivances employed for the purpose of condensation were all constructed on the supposition that the object would be best attained by causing the gas to travel through a great extent of pipes surrounded by cold water, and winding through it like the worm of a still, or ascending upwards and downwards in a circuitous manner. An improvement on this form of condenser, and one now in general use, is represented in fig. 8. It consists of a series of upright pipes connected in pairs at the top by semicircular pipes *e*, *e*, and terminating at the bottom in a trough X Y containing water, and divided by means of partitions in such a way that, as the the gas enters the trough from one pipe, it passes up the next pipe and down into the next partition, and so on to the end of the condenser. The cooling power of this air condenser, as it is called, is sometimes assisted by allowing cold water to trickle over the outer surface of the pipes. Annular tubes for condensing are also used, in which the gas is exposed to a much greater cooling surface, and in some large works the condensers are cooled by a current of water. In passing through the pipes the gas is considerably reduced in temperature, and the tar and ammoniacal liquor condense, the tar subsiding to the bottom of the troughs, and the ammoniacal liquor floating on the surface. In course of time the water in the trough is entirely displaced

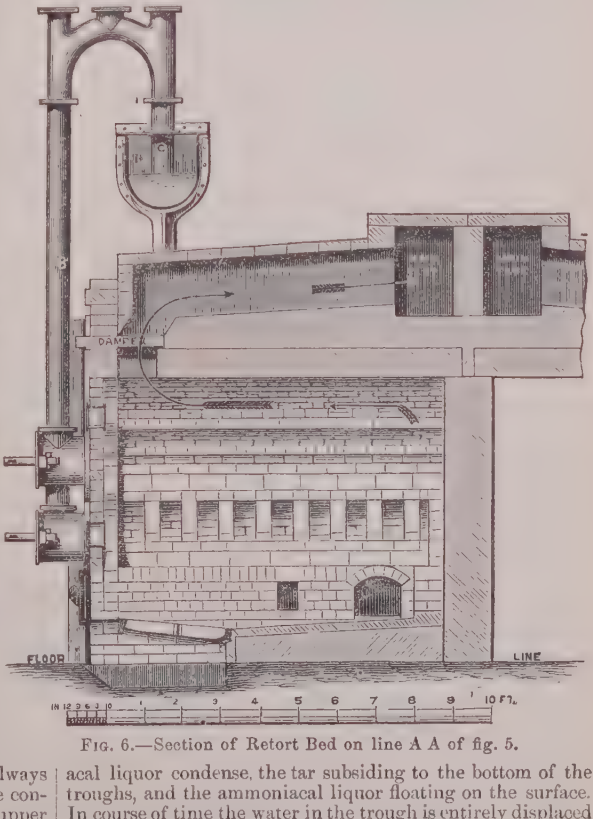


Fig. 6.—Section of Retort Bed on line A A of fig. 5.

by these two gaseous products, and as they accumulate they pass off into the tar-tank, from which either liquor can be removed by means of a pump adapted to the purpose. The New York Gas Lighting Company employ a multitubular condenser, consisting of two sets of eight boxes, each containing 100 tubes 3 inches diameter by 15 feet long. Through each set of tubes, up one and down another, the gas travels, cooled by an external stream of water, while it traverses the 240 feet of piping in the condenser.

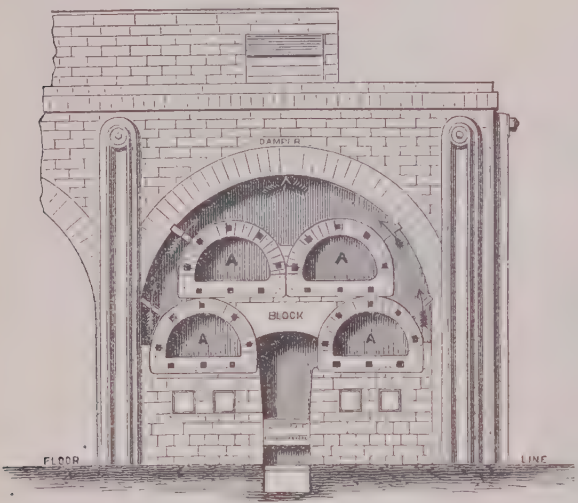


Fig. 7.—Retort Setting in Hislop's Furnace.

The practice of condensation and separation of tarry matter by rapid cooling is condemned by Mr. Bowditch and many eminent authorities, on the ground that thereby a proportion of light hydrocarbons are thrown down with the heavier deposit, which on another method of treatment would form part of the permanent gas and materially enrich its quality. A system of treating gas has accordingly been introduced by Messrs. Aitken & Young, in which the gas, kept at a high temperature, is carried from the retorts into an apparatus termed an analyzer, which consists of an enclosed series of trays and chambers, arranged in vertical series, in principle like a Coffey still, the lower portion of which is artificially heated. In action the analyzer separates the heavier carbonaceous part of the tarry matter in the lower part or chambers, and as the gas gradually ascends from one tray or tier to another, it is at once cooling and depositing increasingly lighter fluids, while it is meeting and being subjected to the purifying action of the light hydrocarbons already deposited. Thus on entering the analyzer it meets, at a high temperature, heavy tar deposits, and it passes out of the apparatus cooled down to nearly atmospheric temperature after being in contact with the lightest fluid hydrocarbons.

Exhaustion.—To the subsequent progress of the gas considerable obstructions are interposed in connection with its further purification and storing in the gasholders, and the result of which would be that, were it not artificially propelled, there would be a pressure in the retort equal to the amount of the resistance the gas meets with in its onward progress. The relief of this back pressure not only improves the quality of the gas, but also increases its amount by about 10 per cent. Among the numerous methods of exhaustion which have been proposed since the operation was first introduced in 1839, there are several rotary exhausters, having more or less of a fan action, and recently an apparatus on the principle of a Giffard's injector has been introduced, chiefly in Continental works. A most efficient form is found in the piston exhauster, a kind of pumping engine with slide valves, which exhausts the gas in both the upward and the downward strokes of its piston. The action of the exhauster is controlled by a governor, which passes back a proportion of the gas when the apparatus is working too fast for the rate of production in the retorts; and "pass by" valves are arranged to carry the gas onward without passing through the exhauster should it cease to work from accident or any other cause.

Purification.—The operations embraced under this head have for their object the removal from the gas of ammonia, sulphuretted hydrogen, and carbonic acid as the main impurities, with smaller proportions of other sulphuric and of cyanogen compounds. The agencies adopted are partly mechanical and partly chemical, the separation of the ammonia being first effected in the "scrubber," from which the gas passes on to complete its purification in the "purifiers." In early times the purifying was performed in a single operation by the use of milk of lime in the wet purifier, a form of apparatus still in use where wet purifying is permissible.

The Wet Purifier.—This apparatus was supplied with a cream of lime and water, but, although it was a most efficient purifying agent, the ammonia now of so much value was lost by its use, and the "blue billy," as the saturated liquid holding the impurities was termed, created an intolerable nuisance, and could be in no harmless way got rid of. Except in small works, wet purifying is not now practised.

The Scrubber.—The object sought in an ordinary scrubber is to cause a large amount of gas to come in contact with the smallest possible quantity of water, so as at once to dissolve out ammoniacal gases, which are exceedingly soluble in water, to obtain a strong ammoniacal liquor from the scrubber, and at the same time, as far as possible, to prevent the heavy hydrocarbons from being acted on,—they being also soluble in water. The ordinary form of scrubber consists of a tower or hollow column, vertically divided into two, and filled with coke, etc. The gas passes up one side and down the other, and from the top a constant small stream of weak ammoniacal liquor trickles down. Such a scrubber, it is stated, is subject to clogging by deposits of tar, and equally efficient work is done without that draw-

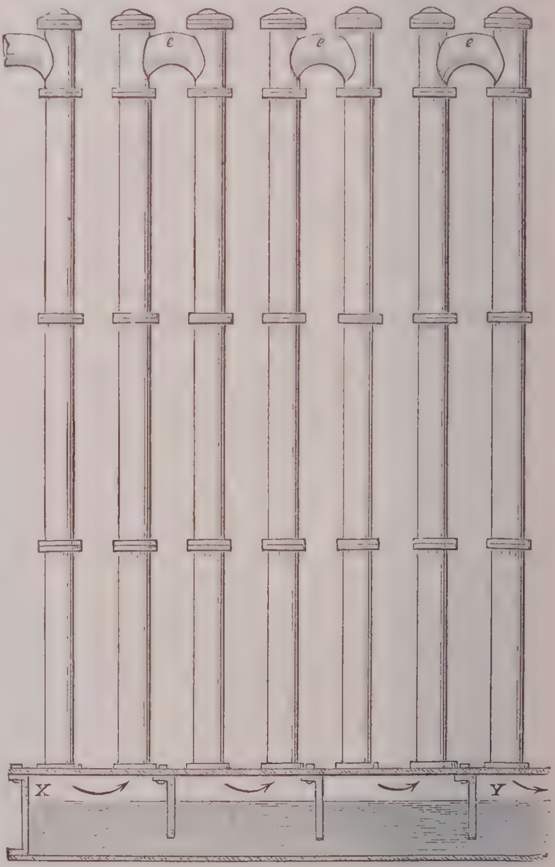


Fig. 8.

back by an apparatus in which perforated iron plates occupy the place of the coke, and in the Livesey scrubber layers of thin deal boards are employed. These boards are set in tiers perpendicularly, slightly crossing each other, with about ⅓ of an inch between each tier. Anderson's washer is a form of scrubber recently introduced, in which the interior is occupied with a series of rotating whalebone brushes, which dip into troughs of ammoniacal liquor, and in their revolution meet and agitate the gas in its passage upwards through the tower or column. The scrubber shown in section and plan in figs. 9 and 10 is a form introduced by Mr. James Hislop. It contains 10 tiers of trays of cast iron, perforated with ⅞ inch holes at a distance of 2 inches from centre to centre. The gas passes upwards through these, meeting in its course a shower of ammoniacal liquor pumped up and distributed by the rose arrangement shown in fig. 9. The bottom part of the scrubber, to the height of the first course of plates, is filled with liquor, which is repumped till it reaches the strength desired for the manufacturer of ammonia sulphate.

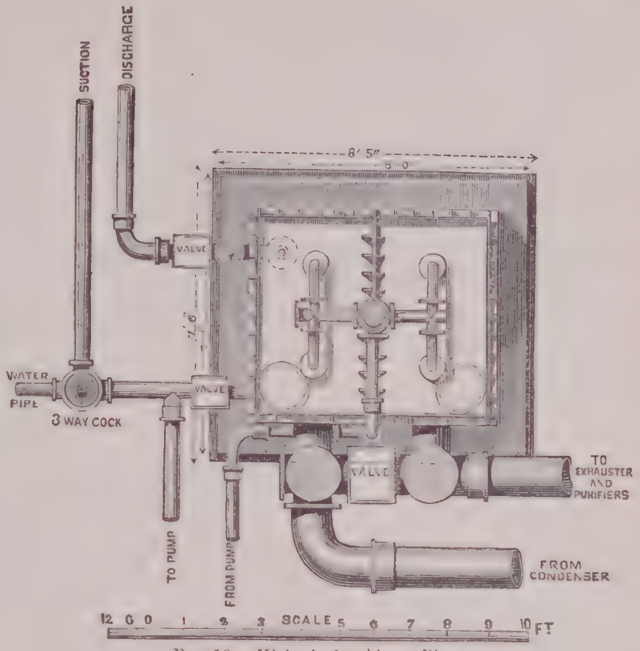


Fig. 10.—Hislop's Scrubber—Plan.

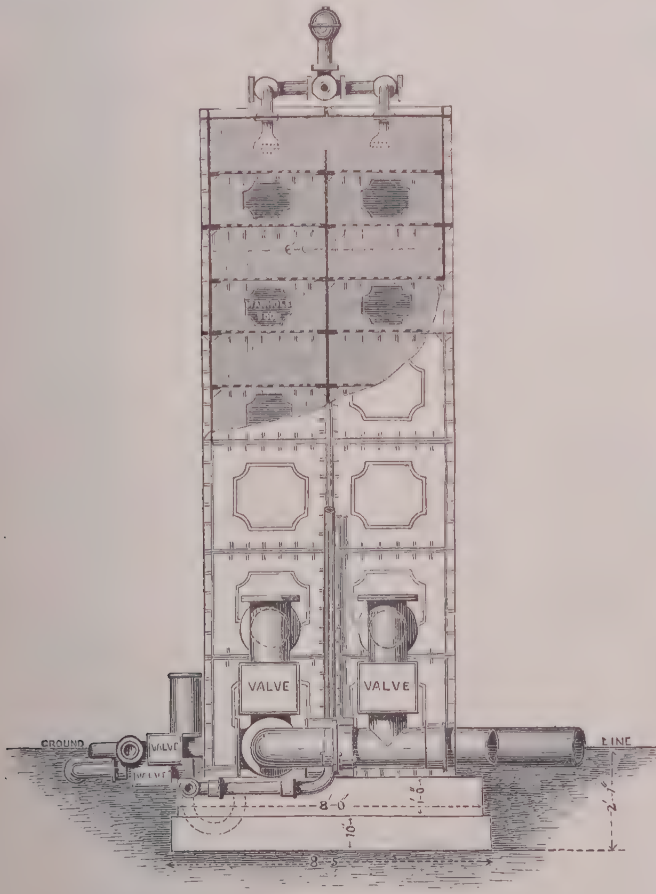


Fig. 9.—Hislop's Scrubber—Sectional Elevation.

The Purifiers.—The ordinary lime purifier, by which sulphuretted hydrogen and carbonic acid are abstracted from the gas, consists of a large rectangular vessel seen in section in fig. 11. Internally it is occupied with ranges of wooden trays or sieves A, made in the form of grids of ½-inch wood, with about half an inch between the bars. These are covered with slightly moistened slaked lime B to the depth of about 6 inches, and from three to six tiers of such sieves are ranged in each purifier. The gas enters at the bottom by a tube C, the mouth or inlet being protected from lime falling into it by a cover D, and it forces its way upward through all the trays till, reaching the lid or cover E, it descends by an internal pocket F to the exit tube G, which leads to the next purifier. The edges of the lid dip into an external water seal or lute H whereby the gas is prevented from escaping. The purifiers are generally arranged in sets of four, three being in use, through which the gas passes in succession while the fourth is being renewed; and to control the course of the gas current among the purifiers, the following ingenious arrangement of centre valves and pipes was devised by Mr. Malam (fig. 12).

It has a cover fitting within it in such a way as to communicate with the pipe *a* and either of the four inlet pipes, and also to communicate between one of the outlet pipes and the pipe *h*, which carries off the purified gas. The inlet pipes, *b*, *d*, *f*, admit the gas from the central case to the bottom of the purifiers; and the outlet pipes, *c*, *e*, *g*, return the gas from the purifiers back to the case, after it has passed up through the layers of lime, and descended at the back of a partition plate in each purifier to the outlet pipes at the bottom. *a* is the main inlet pipe for conveying the gas from the scrubber or the condenser, and *h* is the main outlet pipe for conveying the gas to the gasholder. The central cylinder contains water to the depth of 10 inches, and the ten pipes rise up through the bottom to the height of 12 inches, so that the mouth of each is 2 inches above the surface of the water. The cover which fits into the cylinder is 4 feet 3 inches in diameter, and is divided into five parts, the first of which, 1, fits over the inlet pipe *a*, and over either of the inlet pipes leading to the purifiers. The partitions 2, 3, and 5 fit each over an inlet and an outlet pipe, while one partition, 4, fits over one outlet pipe from one purifier, and over the pipe *h*, which leads to the gas-holder. In fig. 12 the arrangement is such as to open a communication between the inlet pipe *a* and the purifier A. Now supposing the gas to have passed from the scrubber into the centre of the cylinder, its only means of escape is to pass down the pipe *b* into the purifier A, where it ascends through the layers of lime, and passing over the top of a dividing plate, descends and escapes from the bottom of the purifier by the pipe *c* back to the cylinder. Here its only means of escape is by the pipe *d*, which conducts it to the purifier B, in which it ascends and descends as before, returning by the pipe *e* to the cylinder, whence it proceeds by the pipe *f* into the purifier C, then along the pipe *g*, which is shut off from communication with any pipe except *h*, by which it is conveyed away to the gas-holder. By this arrangement the three purifiers A B C are being worked, while a fourth purifier D is being emptied and recharged with lime. When it is found, on testing the gas, that the lime is unfit for its office, the purifier A is thrown out of work, and D is brought in. The frame is then shifted so as to bring the triangular division 1 over *d*, by which means B C D will be the working purifiers, and A will be thrown out of use. In this way, by shifting the frame round its centre over each of the four outlet pipes, any three of the purifiers can be brought into action.

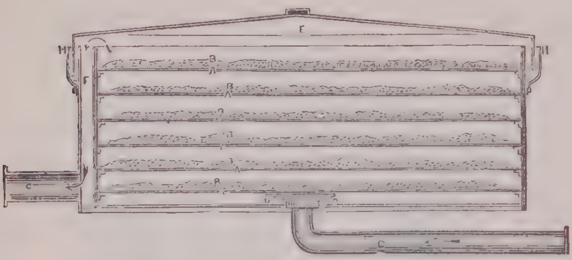


Fig. 11.—Section of Lime Purifier.

The "oxide" method of purifying the gas, originally introduced by M. Laming, and shortly afterwards patented by Mr. Hills, is now largely used in ordinary gas-works. It is based upon the property of the hydrated oxide of iron to decompose sulphuretted hydrogen, a portion of the sulphur forming a sulphide with the iron. Quicklime is also used to separate carbonic acid, and the oxide of iron is mixed with sawdust or cinders (breeze) for the purpose of increasing the surfaces of contact, and this mixture is placed in the purifiers. When a sufficient quantity of gas has passed through it, the purifiers are opened, and the mixture is exposed to the air, under which new condition it combines with oxygen, and again becomes fitted for use in the purifiers. The chemical changes which occur in these operations are thus stated. The mixture of hydrated oxide of iron, etc., absorbs sulphuretted hydrogen, forming ferrous sulphide and water, and liberating sulphur, thus:—$Fe_2O_3 + 3H_2S = 2FeS + S + 3H_2O$. The ferrous sulphide, by exposure to the air, absorbs oxygen, and its sulphur is separated in an uncombined form, $2FeS + 3O = Fe_2O_3 + 2S$. The mixed material can be again employed in the purification of the gas, and the process may be repeated until the accumulation of sulphur mechanically impairs the absorbent powers of the mixture. The sulphocyanogen which accompanies the gas is retained by the oxide of iron, and gradually accumulates in the mixture. For the separation of the carbonic acid, which is unaffected by this treatment, the gas next passes on to a dry lime purifier.

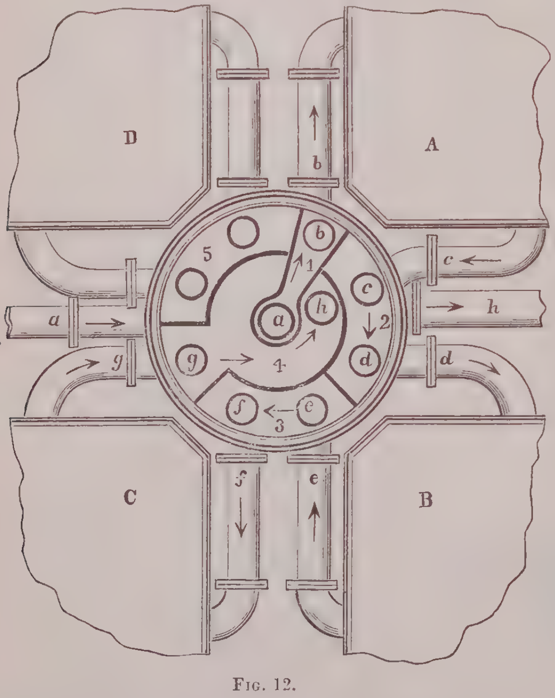


Fig. 12.

The gas is now ready for use, and it is passed on through the station meter to register the amount made and stored in the gas-holders. At this stage it may be interesting to compare the composition of the gas as it exists at different stages of the manufacture, as these show the result of the successive purifying processes. Taking 1000 cubic feet, the figures are—

	From Condenser.	From Scrubber.	From Purifiers.	
			Iron.	Lime.
Hydrogen	380	380	380	380
Marsh gas	390	388	403	394
Carbonic oxide	72	71	39	30
Heavy hydrocarbons	42	46	46	43
Nitrogen	48	50	79	100
Oxygen	3	5	5	6
Carbonic acid	40	39	33	4
Sulphuretted hydrogen	15	15	3	
Ammonia	10	5		
	1000	999	988	957

Storing and Distribution.

The Gas-holder.—This, which is frequently designated the gasometer, though incorrectly, since it does not in any way measure gas, but simply stores it for consumption, consists of two portions—the "tank" T (fig. 13) and the "holder" G. The tank is a cylindrical pit, surrounding a central core, which is usually covered with concrete *c* at top, and has its sides built of masonry or brick-work, *p*, *b*. The tank is water-tight, and is filled to a high level with water, above which project two tubes *m m*, one being the inlet and the other the supply pipe which leads to the main governor.

Formerly gas-holders were made of heavy plate iron, strengthened by angle-iron and stays, and of so great a weight as to require a complex system of equilibrium chains and counterbalancing weights to relieve the gas from the great pressure to which it would otherwise be subjected. They are now made so light that they require to be loaded in order to supply the required pressure, and their rise and fall are regulated by means of guide-rods *i i* round the tank. For economy of space holders in which different segments "telescope" over each other are now much employed. This form of holder consists of two or even three separate parts—the upper having the form of the common gas-holder, and the other being open at the top as well as the bottom. They are connected by the recurved upper edge of the lower fitting into a channel which runs round the bottom of the upper, whereby the entire structure is rendered air-tight at the line of junction. Holders of great capacity are now erected in connection with large works. The Imperial Company in London possesses two, at Bromley and Hackney, telescopic in form—the outer segment measuring 200 feet in diameter by 35 feet deep, and the inner 197 feet by 35. These holders are each capable of storing 2 million cubic feet of gas, which at sp. gr. 480 would weigh 73 tons. A still larger holder is at the Fulham station of the Gas Light Company, it being 223 feet in diameter and rising 66 feet, with a capacity equal to 3 million cubic feet.

The Governor.—An efficient control of the pressure of the gas, along its whole course from the gas-holder to the point of consumption, is an object of great importance for the avoiding of leakage, for equal distribution, and for supplying the burners at that pressure which yields the largest illuminating effect. Uncontrolled pressure may supply certain levels in a proper manner, but will leave low-lying districts insufficiently supplied, while the pressure in high districts will be excessive. The variations from simple difference of level may be very great. Thus, with a pressure of 1·7 inch at the Leith works, the gas would be delivered in some parts of Edinburgh at a pressure of 4·5 inches. The varying consumption from dusk onwards also greatly affects unregulated pressure. To control and correct these and other irregularities and disturbances governors are now used—at the works or station for delivering the gas to the mains, in districts to correct variations owing to level, and beyond the consumers' meters for controlling house supply; while in certain forms of burners a regulating apparatus is also inserted. The principle on which all governors are based consists in causing the gas by its own pressure to act on some form of sensitive surface which opens or closes a valve or aperture in proportion to the variations of pressure exerted on it. Fig. 14 is a diagrammatic section of the common form of station governor.

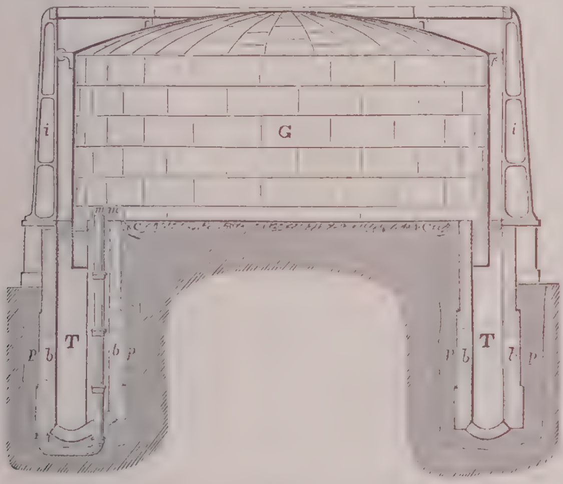


Fig. 13.—Section of Gas-holder.

The course of the gas is indicated by arrows, *d* being the inlet and *e* the outlet pipe; *c* is a valve of conical form fitted to the seat *i* and raised or depressed by the weight *f* working by a cord over a pulley; *bb* is the bell or holder,—a cylindrical vessel of sheet iron which rises and falls in the exterior vessel *aa*, in which water is contained to the level represented. The gas, entering at *d*, passes through the valve, fills the upper part of the inverted vessel *bb*, which it thus partially raises, and escapes by *e*. If the pressure from the holder be unduly increased or diminished, the buoyancy of *bb* will be increased or diminished in like proportion, and the valve being by this means more or less closed, the quantity of gas escaping at *e* will be unaltered. And not only will the governor accommodate itself to the varying pressure of the holder, but also to the varying quantities of gas required to escape at *e* for the supply of the burners. Thus, if it were necessary that less gas should pass through *e*, in consequence of the extinction of a portion of the lights, the increased pressure thus produced at the holder would raise the governor, and partially shut the valve, leaving just sufficient aperture for the requisite supply of gas.

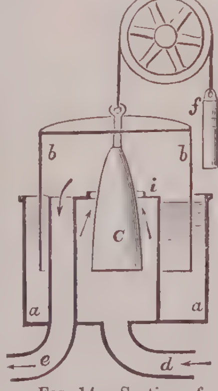


Fig. 14.—Section of Governor.

Numerous improvements have been made on the ordinary station governor. In the form invented and manufactured by D. Bruce Peebles, the bell or holder is enclosed in a gas-tight case or chamber, and a small portion of the inlet gas flows in and out of this chamber above the holder. The pressure of this small quantity of gas is regulated by passing it through a small separate governor; and, acting on the outer surface of the holder, this, in a very delicate and sensitive manner, performs the duty of weights in the older forms of governor. An arrangement similar in principle is applied to the district governor by Bruce Peebles, the minimum day pressure being secured by means of a stop-cock or screw-valve on the apparatus, and the maximum night pressure is controlled by a small subsidiary governor. The principle of the small governor, which thus plays an important part in regulating large flows of gas, will be explained under consumers' governors, the apparatus being shown in section in fig. 18 below.

Supply Pipes.—The street main and service pipes are tubes of malleable or of cast iron, the gauge of which must be arranged according to the quantity of gas to be supplied, the length it has to travel, and the pressure under which it is carried forward. Practical gas-engineers possess elaborated tables of data for the regulation of the size of their various supply pipes. Notwithstanding the utmost care and accuracy in the laying and fitting of street mains, leakage at joints is a constant source of annoyance. Under the most favorable conditions there is a discrepancy of from 7 to 8 per cent. between the gas made and the amount accounted for by consumption, and the greater part of that loss is due to leakage in street pipes. To convey the gas from the main pipes and distribute it in houses, pipes of lead or of block tin are generally used.

Consumers' Meters.—Of these there are two forms in actual use, the "wet" and the "dry." The former, the invention of Mr. Clegg, is represented in the two sections (figs. 15 and 16) where *cc* represents the outside case, having the form of a flat cyclinder; *a* is the inlet tube and *b* the outlet pipe; *g*, *g* are two pivots, and *h* a toothed wheel fixed upon the pivots and connected with a train of wheel-work to register its revolutions. The pivots are fixed to and support a cylindrical drum-shaped vessel *ddd*, having openings *e*, *e*, *e*, *e*, internal partitions *ef*, *ef*, *ef*, *ef*, and a centre piece *ffff*. The machine is filled with water, which is poured in at *h* up to the level of *i*; and, on gas being admitted under a small pressure at *a*, it enters into the upper part of the centre piece, and forces its way through such of the openings *f* as are from time to time above the surface of the water. By its action upon the partition which curves over the opening *a*, a rotatory motion is communicated to the cylinder—the gas from the opposite chamber being at the same time expelled by one of the openings *e*, and afterwards escaping at *b*, as already mentioned. Wet meters work easily, and, when well set and properly supplied with water, measure the gas with much accuracy. But excess or deficiency of water impairs their measuring power, which may also be affected by the metre being lifted off the level. The freezing of the water also frequently occasions trouble, and the action of the water on the gas passing through it by dissolving out part of the valuable illuminating hydrocarbons on the one hand, and diffusing watery vapor through it on the other, doubly affects its illuminating power.

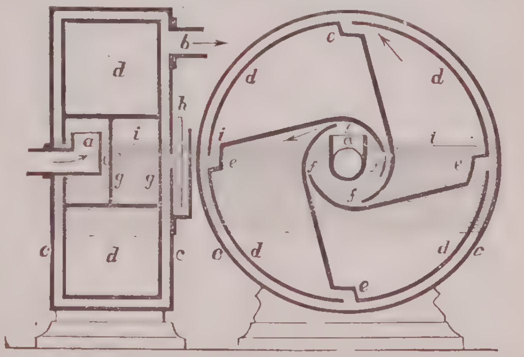


Fig. 15. Fig. 16.

The dry meter is free from the defects just mentioned, but does not pass the gas with such steadiness as the wet meter. The ordinary dry meter consists of an oblong box enclosing two measuring cylinders, with leather sides which contract and expand as they are being emptied and filled, on the principle of ordinary bellows. The pressure of the gas entering this meter is sufficient to keep it in operation, and by a system of valves the one cylinder is in process of filling as the other is being emptied through the service pipe. The chambers communicate by means of lever arms with a crank which turns a train of wheels in connection with the indicator dials on the face of the machine.

Consumers' Governor.—In order to consume gas in a perfectly uniform and economical manner, it is essential that the pressure at the burners should be always invariably the same. That pressure is liable, however, to variation from a number of causes, such as fluctuation in the number of lights in use, either in the house or in the neighborhood, or the application or withdrawal of pressure at the works' governor. And as all good burners are fitted with regard to a fixed standard quality and pressure of gas to be consumed, if this is not maintained the conditions of maximum illuminating power are lost. A consumers' governor secures uniformity of pressure at all the burners supplied by the pipe on which it is placed. The principle of the governor is identical with that of the station governor already described, increased pressure in both cases causing the orifice through which the gas escapes to be contracted. The mechanical arrangements by which this contraction of orifice is effected are various. In some instances they are in direct contact with the separate burners, while other governors are applied to the supply pipes of a whole establishment. They are separable into pressure governors, which, like the station governors, give a constant or uniform pressure under all variations of consumption, and volumetric governors which pass a constant volume or amount of gas under all variations of pressure.

Of pressure governors the forms devised by Sugg and Bruce Peebles are in extensive use, the latter especially being much applied to street lamps. In Sugg's consumers' governor (fig. 17) the gas enters at the inlet, and following the course indicated by the arrows, passes through the regulating plate of the governor into the gas-holder, and thence, by the opening provided for it, it reaches the outlet. The gas-holder has suspended from a disc in the crown a half-ball valve, which closes or opens the opening in the regulating plate as the gas-holder rises or falls. A weight placed on the top of the holder fixes the pressure required to raise it. As a consequence, if the pressure of the gas on the inlet is greater than that required to lift the holder, then the latter rises carrying the half-ball valve with it, till such time as the opening left between the sides of the valve of the regulating plate is sufficient to allow the passage of the necessary quantity of gas to balance the holder. On the other hand, if the pressure at the inlet falls below that required to lift the holder, the full opening of the regulating plate allows all the gas there is to pass through the governor to the burners. Where a very perfect control is desirable, the parts of the governor are made in duplicate, and a double control is thus established. With certain structural differences the action of the Bruce Peebles governor (fig. 18) is the same.

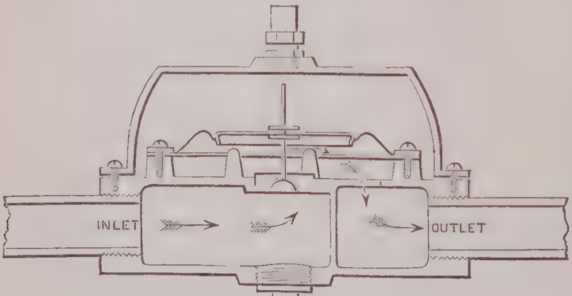


Fig. 17.—Sugg's Consumers' Governor.

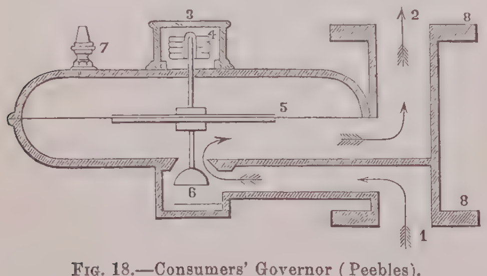


Fig. 18.—Consumers' Governor (Peebles).

The gas enters at 1, and passes out at 2 into the pipe leading to the burners. To adjust the governor the brass cap 3 is unscrewed, and the weights 4 taken off or put on until the desired pressure, of say 5-tenths, at the burners is obtained, when the brass cap is again screwed to its place. The weights now keep the valve 6 open so long as 5-tenths pressure is not exceeded in the main; but any variations in the main above that pressure act at once on the diaphragm 5, and partly close or open the valve, thus maintaining under all circumstances a steady outlet pressure.

Of volumetric governors the best known is Giroud's glycerin rheometer, which consists of a closed cylindrical casing containing a very light metal dome or ball dipping into a circular channel filled with glycerin. In the upper part of the dome is a small orifice through which the gas passes, and on its top is fixed a conical valve which works in a seat at the top of the casing. As the pressure from the supply side rises or falls, the bell responsively moves up or down, opening or closing by the conical valve the orifice by which the gas passes outward; and so delicately is this compensation adjusted that the gas passed is the same in amount however different the pressure. Bruce Peebles has invented a simple and inexpensive form of volumetric governor (fig. 19), in which the use of glycerin is dispensed with. It consists of a conical dome resting on a needle-pointed stud, the cone having an orifice at C, and there is besides a variable consumption channel at the side A B A, which can be controlled by the external screw. As soon as the stopcock is opened the gas fills the interior of the cone and momentarily closes the valve; but, finding its way by the vertical passage, or through the hole C, in the cone, it reaches the chamber above the cone. The cone is therefore now surrounded by gas at the same pressure, and, having nothing to support it, falls, and lets gas pass to the burner. But this only takes place to an extent that allows a differential pressure to be established sufficient to support the cone, which is then equilibrated between two pressures, and the difference between these two pressures remains constant, however much the initial pressure of the gas may vary, unless, of course, it gets so low as not to be able to raise the cone.

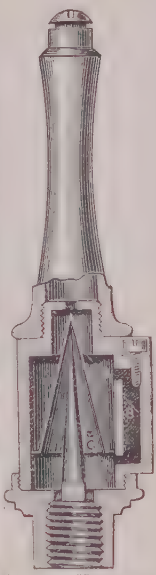


Fig 19.—Volumetric Governor (Peebles.)

Burners.—The question of the arrangements by which the maximum illuminating power may be developed in the consumption of gas, being one which principally affects individual consumers, has not received the attention which their importance merits. As a rule, gas-fitters are ignorant of the principles involved in the economical use of gas, and are often prejudiced by the assertions of certain inventors; and thus it happens that, owing to defective fittings, unregulated pressure, and imperfect burners, an enormous loss of illuminating power is suffered. In their report to the Board of Trade in 1869, the referees under the City of London Gas Act state, of a large number of burners examined by them, that

> "The diversity as to illuminating power was surprisingly great, and such as will appear incredible to any one who has not ascertained the facts by careful experiment. They also found the kinds of burners in common use are extremely defective, thereby entailing upon the public a heavy pecuniary loss, as well as other disadvantages. In order to examine this important matter more fully, the referees, with the ready permission of the proprietors, inspected several large establishments in the city, where, owing to the prevalence of night work, an unusually large amount of gas was consumed. The inspection in every case confirmed the apprehensions which the referees had formed from their examination of the burners which they had procured from the leading gas-fitting establishments. In the offices of two of the leading daily newspapers (establishments which consume more gas than any other), they found that the burners principally in use gave only 55 per cent. of light compared with the Sugg-Letheby burner, or with Leoni's Albert Crutch burner, and yet the price of the last-named burner is almost identical with that of the very bad burners employed in these offices. Tested by the Bengel burner, or by Sugg's new burner, the amount of light given by these imperfect burners is only between 47 and 49 per cent. of what is obtainable from the gas."

In a communication to the Philosophical Society of

Glasgow in 1874 Dr. Wallace, the official gas examiner of that city, dealing with the rich cannel gas of a minimum illuminating power of 25 candles there supplied, estimated that there is in ordinary consumption a loss of 40 per cent. of illuminating power which, under favorable circumstances, might be obtained, and that in practice, while not more than 16-candle power is procured, from 20 to 23-candle illumination ought to be readily obtainable.

This universal wasteful misuse of gas is not merely a question of economy, although the aggregate pecuniary loss must be very great. It affects in no small degree the health and comfort of the consumers of gas; the products of combustion of the purest gas vitiate the atmosphere, and overheat the apartments in which it is burned. Moreover, the light from gas properly burned is much steadier and purer, and less trying to the eyesight, than that wastefully consumed.

The principal circumstances which demand attention in the fitting of burners are the average pressure and illuminating power of the gas to be consumed. How pressure may be controlled has already been shown in connection with governors. The quality or illuminating power of gas has a most important bearing on the nature of burners proper for use, so that a clear distinction must be drawn between common coal-gas and cannel-gas, the burners for the one kind being quite unsuited for the other variety. The maximum amount of light is obtained from any gas just at that point where the flame is on the verge of smoking, and the conditions under which 14-candle gas would be perfectly consumed would, with 26- or 30-candle gas, produce a large amount of smoke. Indeed, the richer gas is, the greater is the difficulty in developing its full illuminating power, and at all times it must be burned in a much thinner sheet or stream than is proper in the case of poor gas, which requires less access of air for its complete luminiferous combustion. The opening or slit in burners used for common gas is therefore much larger than in those devoted to the consumption of cannel-gas.

There are two principal kinds of burners in use—Argand and flat-flame burners. The Argand burner in its usual form is useful only for common or low illuminating power gas, and it has, in the hands of various inventors, especially by Mr. William Sugg of London, been so improved that for amount and steadiness of light it leaves little further improvement to be hoped for. The common Argand consists of an annular tube with a circle of small holes pierced in the end of the ring. It thus produces a circular or tubular flame, which requires to be protected with a glass chimney, by which the admission of air is regulated. The burner made by Sugg in 1869, known as the Sugg-Letheby, or Sugg's No. 1, is the standard burner adopted for the United Kingdom in Acts of Parliament, and the same standard has been adopted in the United States, in Canada, and in various European states. At the time it was made, the Sugg No. 1 was esteemed the best known burner, but since that time Mr. Sugg has perfected his London Argand, whereby with London gas results equal to about 2 candles better than the standard are obtained. Fig. 20 is a sectional view of Sugg's London Argand with the latest improvements.

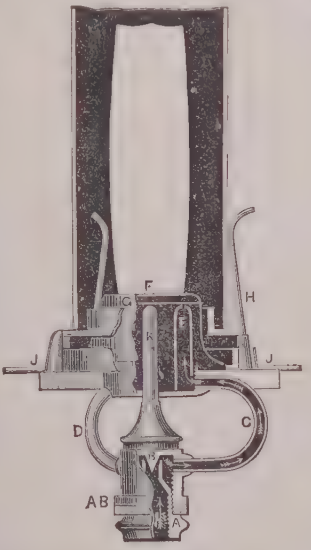


Fig. 20.—Sugg's London Argand Burner.

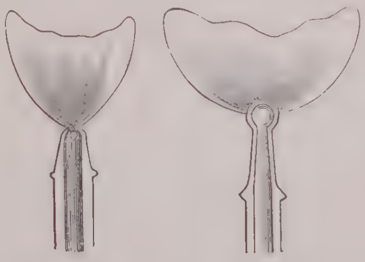
At the point at which the gas enters is a brass nose-piece A, screwed to fit the usual three-eighth thread, intended by the manufacturers of all kinds of gas fittings to receive the burner. This is drilled through its length, and slightly trumpeted at the top so as to fit the cone-shaped piece of metal projecting from the roof of the inlet chamber B. The outside of the upper portion of the nose-piece A is screwed to fit the inside of the inlet chamber B, and thus, by an adjustment of this screw by means of paper washers put on the shoulder at AB, it is possible to enlarge or decrease the area of the passage through which the gas has to pass in order to supply three tubes (two of which, C and D, only are shown in the drawing), by which it is further conducted to the combustion chamber E. This chamber is made of steatite, a material which is capable of resisting the corroding action of heat or damp, and is a good non-conductor of heat. It is pierced with a number of holes, so arranged as regards size and number that the quantity of gas the burner is required to consume shall pass out at an inappreciable or the least possible pressure. This is in order that the oxygen of the atmosphere, slowly ascending through the centre opening F, the annulus formed by the edge of the air cone G, and the outside of the combustion chamber E, shall combine with the burning gas by natural affinity only, leaving the nitrogen to pass freely out at the top of the flame. H is one of the three springs which are intended to keep the chimney glass steady in its place. JJ are two of three stubs or rests for a screen, globe, or moon; and K is a peg to steady the current of air which passes up the centre opening F.

With the view of competing in illuminating power with the electric light, Mr. Sugg has recently devised a modified form of Argand burner calculated to yield a large illuminating power by increased but still economical consumption of gas. These burners are made of two or more concentric Argand rings, the outer being of large diameter, and in operation they give out a large solid, white, steady flame. With London gas, a two-ring burner consuming 19 feet per hour yields 80-candle light; 3-ring burners which consume 23 feet give 100 candles; 4-ring burners fed with 45 feet of gas gave an illumination equal to 200 candles.

As regular pressure is essential for the proper use of these burners, a self-acting governor is frequently fitted to them. The pressure at which the best results are obtained with London gas is about .7 inch. In a series of experiments with Argand burners made by Mr. John Pattinson of Newcastle-on-Tyne the following results were obtained:—

Burner.	Cubic feet per hour.	Illuminating power in Candles.	Illuminating power per 5 cubic feet per hour.
Sugg-Letheby Standard	5·0	14·10	14·10
Sugg's London Argand..	5·0	15·90	15·90
Sugg's Improved London Argand.............	4·5	16·08	17·86
Silber's Argand...........	5·0	17·80	17·80
Common Argand	5·0	11·20	11·20
do do	7·0	17·80	12·70

Flat-flame burners, or burners which spread their flame in a broad thin sheet, are of two principal kinds known respectively as "fishtail" (fig. 21) and "batwing" (fig. 22) burners. The fishtail or union burner has two orifices drilled in its surface, which are inclined towards each other at an angle of 90°, so that the issuing currents impinge and spread the flame in a broad sheet. The gas in the batwing issues from a narrow slit cut right across the surface. In the best forms of all kinds of burners now in use steatite or adamas (pottery) tops are employed. In Sugg's Christiania burner the slit is circular, and the light issues in two thin sheets which coalesce in their upper luminiferous part, producing a most beneficial result when common gas is consumed. The common metal and steatite-tipped burners in use permit the current of gas to strike against their orifices



Figs. 21, 22.—Flat-flame Burners.

without any control or regulation, but in the numerous patented forms of both fishtail and batwing jets certain mechanical obstructions, or small governors, are inserted, which break or retard the current. Screws, wire gauze, calico, cotton wool, iron filings, and constriction of the lower part of the burner are all devices in use. Of all these one of the simplest and most effective is the plan on which the Brönner burner is constructed, which is simply to have the opening at the lower part of the burner smaller than the upper orifice. For different qualities and pressures of gas the Brönner burner presents a great variety of combinations by having several distinct sizes of lower constriction which can be adjusted to a large number of tip orifices. Thus, with six distinct openings at each end, 36 combinations can be made. As Argand burners are not suited for measuring the illuminating power of rich cannel-gas, flat flame-burners have to be employed; and in the Act of Parliament under which the Glasgow Corporation supplies gas, it is provided that "all the gas supplied by the corporation shall be at least of such quality as to produce from a union jet burner, capable of consuming 5 cubic feet of gas per hour under a pressure equal to a column of water ·5 of an inch in height, a light equal in intensity to the light produced by 25 sperm candles of 6 in the pound, burning 120 grains per hour."

Dr. Wallace in a communication on the "Economical Combustion of Coal-Gas" (*Proc. Phil. Soc. Glasgow*, vol. ix.), tabulates an extensive series of experiments made with flat-flame burners of various sizes with about 28-candle gas at different degrees of pressure. The general result of these experiments shows that, to obtain the highest luminiferous effect with burners of small aperture, a low pressure of gas (not more than ·5 inch) must be maintained, although, as the size of the jet increases within certain limits, the pressure may be increased with favorable results. With 9 sizes of Bray's regulator fishtail (a burner having an obstruction consisting of a double fold of cotton cloth) Dr. Wallace obtained the following results, calculated to 5 cubic feet per hour:—

Burner	0	1	2	3	4	5	6	7	8
At ½-inch pressure.	14·5	17·4	20·0	23·6	25·0	26·15	27.0	28·16	28·08
At 1-inch "	11·7	13·3	17·6	20·6	23·6	26·2	28·7	30·2	32·0
At 1½-inch "	8·8	9·8	13·9	17·5	19·4	23·7	25·9	gas	blows.

The gas used in the ½-inch experiments was 27·72-candle standard, for the 1-inch series it was 29·05, and for the 1½-inch set it was 28·61-candle. With 30 combinations of Brönner burners Dr. Wallace obtained from 28·2-candle gas at 1 inch pressure an average of 25·7, and at 1½-inch 25·8-candle power, most of the combinations giving fairly equal results.

Of all burners the ordinary fishtails, and they are the most frequently used, give the most inferior results when used for burning common coal-gas. The results tabulated below are derived from the series of experiments by Mr. Pattinson of Newcastle already quoted. The experiments were made with 14·10-candle gas, from which it must be remembered 17·86-candle power was developed in Sugg's improved London Argand:—

	Cubic feet per hour.	Illuminating power.	Illuminating power at 5 ft. per hour.
Fishtail, No. 3, steatite top..	4	3·0	3·75
" " metal top....	3·5	4·10	5·85
" No. 4, steatite top..	4·9	5·20	5·31
" No. 5, " ..	5·0	7·80	7·80
Batwing, metal top.............	5·0	9·26	9·26
Fishtail, Bray's, No. 4.........	4·0	5·02	6·28
" " No. 8.........	5·0	11·80	11·80
" " "	7·0	14·21	10·15
Batwing, Brönner's, No. 4...	4·0	10·10	12·62
" " " ...	5·0	11·60	11·60
" Sugg's, " ...	4·0	8·40	10·50
" " " ...	5·0	10·90	10·90

From these experiments it appears that there are burners in common use which, consuming the same amount of gas, differ in light-giving effect from 3·75 to 12·62-candles, one giving more than three times as much light as the other; and if we take the best Argand burner into account, the range of variation is from 3·75 to 17·80, or as one to five nearly. Another important deduction from these observations is that large-sized burners as a rule give much more illuminating power than the smaller sizes. Thus a burner passing 7 feet of gas per hour will almost invariably distribute more light than two each burning 3·5 feet.

Gas Testing.—The universally recognized and practised method of valuing gas is by comparing its light with that yielded by a standard light, which can be obtained as nearly as possible of an unvarying intensity. In making such a photometric comparison it is essential that the conditions under which the lights to be compared are burned shall be uniform, and that the materials be consumed at a definite rate. The standard recognized by legislative authority in Great Britain and America is the burning of a sperm candle 6 to the ℔ consuming at the rate of 120 grains of sperm per hour, compared with gas burning at the rate of 5 cubic feet per hour. The burner prescribed for common gas is the Sugg-Letheby-Argand, in Acts of Parliament defined as a 15-holed Argand with a 7-inch glass chimney; and for rich cannel-gas a union or fishtail jet passing 5 feet per hour is employed. The apparatus employed for making the comparison is generally the Bunsen photometer, or some modification of that instrument; and the ratio of comparative illumination is established by the well-known principle that the intensity of light diminishes in inverse proportion to the square of the distance from its source. The Bunsen photometer consists of a bar of wood 98 inches long, with a candle holder at one end and at the other the standard gas burner. A balance for weighing the candle as it burns, an indexed meter for the gas, and a clock are also provided. The bar is graduated from the centre to each end, and on it is set a sliding holder into which a screen of prepared paper is placed. The screen is so prepared that a spot or disc is more opaque than the remainder of the paper, so that when light passes through it from one side, that particular spot is seen distinctly darker than the rest. When, however, equal amounts of light fall on it from both sides the spot disappears, and the whole surface presents a uniform appearance. Therefore, with both candle and gas burning under the stipulated conditions in a darkened chamber, by moving the screen on the graduated bar from the one light and towards the other till the dark spot on the paper disappears, the comparative illuminating power of the light is ascertained by the position of the screen on the graduated bar, or by a simple arithmetical calculation. Thus, the lights being 100 inches apart, if at the conclusion of the experiment the screen is 20 inches from the candle and 80 from the gas jet, since 80^2 is 16 times 20^2, the gas is 16 candle power.

Comparisons of the quality of gas are also made by the jet photometer, an apparatus which depends on the principle that gas of uniform quality burned at invariable pressure, through a small orifice, yields a flame of uniform height. If the flame is to be maintained at a uniform height the pressure in the pipes must increase as the quality of the gas decreases. The jet photometer forms a ready and convenient means of ascertaining any variations in the quality of gas supply; but it is not available for purposes of comparison.

Analysis of gas does not yield so satisfactory evidence of its illuminating value as photometric comparisons, but various methods of ascertaining the proportion of luminiferous olefines contained in any gas are occasionally practised. The absorption of the heavy hydrocarbons by chlorine or by bromine, and Dr. Fyfe's durability test, are of theoretical rather than practical importance.

Residual Products.—Under this term are embraced coke, ammoniacal liquor, and gas-tar, all of which are sources of income in the gas manufacture. Indeed the value of these products has increased so rapidly of late years, and they now form the basis of manufactures of such consequence, that the residual products can scarcely be regarded as of secondary importance, and they will certainly play no small part in determining the future maintenance of gas-lighting in the face of other competing systems. The change in the valuation of ammonia and tar liquors is well illustrated by the circumstance that, during the year 1878, the corporation of Bradford was offered £10,000 per annum for these products, which about eight years previously had been disposed of for a yearly payment of £800.

Coke is a substance which varies much in value, according to local circumstances, and the nature of the coal distilled. When shale is used, there remains in the retorts an ashy residue which is absolutely worthless; and the coke of cannel coal is also comparatively of little value, owing to the amount of ash it yields. Indeed, in Scotch works where ashy cannel alone is distilled, the retorts have to be partly fired with common coal. The coke obtained from the distillation of caking coal, on the other hand, is of high value, and after a supply is set aside for heating the retorts there generally remains from 65 to 85 per cent. of the whole amount to be disposed of by sale.

Ammoniacal liquor is more abundantly produced by the distillation of cannel than by common coal, from 18 to 22 lb of ammonia, as sulphate, being obtained from each ton of cannel distilled, as against about 16 lb derived from ordinary coal. Gas liquor is now almost the sole source of ammonia, which, among other purposes, is very largely employed as an agricultural fertilizer.

Tar liquor yields by destructive distillation a wide range of products possessing a great and increasing industrial value. The cannel coals, and other varieties rich in volatile matter, are also the kinds which yield the largest proportion of tar. In the distillation of coal-tar, after some ammoniacal and watery vapors have been given off, there is distilled over a proportion of highly volatile fluid hydrocarbons which consist principally of benzol; and afterwards a large amount of a light oil, known as coal naphtha (also a mixture of various hydrocarbons), is obtained. At this point the residue in the retort is called artificial asphalt, and as such is a commercial article; but if the heat is forced, and the distillation continued, a large amount of "heavy" or "dead oils" is obtained, and the mass left in the still is "hard pitch." The heavy oils are a mixture of naphthalin, phenol (carbolic acid), cresol (cresylic acid), and anthracene, etc. The benzol obtained in the first stage of the distillation is the basis of aniline and its various dyes; naphtha is used as a solvent, and for lighting and other purposes; carbolic acid, in addition to its employment as an antiseptic, is the basis of many valuable dyes; anthracene forms the source of the now most important dye, artificial alizarin; and most of the substances have other applications of minor importance.

The relative position and value of the various products of the gas manufacture is exhibited by the following condensed statement of the position and operations of the various London gas companies during the year 1875:—

Total capital of the companies	£12,516,009
[illegible]	[illegible]
[illegible]	[illegible]
Cost of coal	1,455,407
Receipts for coke and breeze	492,927
" for tar	162,151
" for ammonia	[illegible]

Gas produced	14,888,133	thousand feet.
Gas sold	13,622,639	" "
Coal carbonized (4 per cent. cannel).	1,505,000	tons.
Coke produced, 34 bushels per ton..	1,417,654	chaldrons.
Coke used as fuel in retorts, 31 per ct.	440,685	"
Coke sold, 69 per cent	976,969	"
Average yield of gas per ton of coal.	9,892	cubic feet.

GAS FROM SOURCES OTHER THAN COAL.

Petroleum-Gas.—Petroleum being a substance obtained in great abundance, notably in America, is used, not only directly as an illuminating agent, but also for the production of gas; and as an enricher of common coal-gas it is applied at several works in New York and Brooklyn. Its preparation is effected by distilling it first at a low temperature into a rich vapor, which, when passed into highly heated retorts, is converted into permanent gas of an illuminating power about five times greater than common gas, and which is, moreover, absolutely free from ammonia, sulphur compounds, and carbonic acid. On account of its great richness, petroleum-gas must be consumed in special burners of very fine aperture, at a rate varying from 5 to 2 feet per hour.

Oil-Gas.—In the early stages of gas manufacture many attempts were made to substitute gas distilled from inferior oils for coal-gas. The oil was distilled by allowing it to percolate into highly heated retorts, in which a quantity of coke or a like porous solid was placed, and the distillate was a richly luminiferous gas free from hurtful impurities. Although oil in this form yields a convenient and powerful illuminant, its direct combustion is much more economical; and as all oils and fats are highly valuable for many purposes besides illumination, they cannot compete with gas coal as a source of gas. Nevertheless the New York Gas Light Company manufactured oil-gas exclusively from 1824 till 1828, and sold their product at $10 per 1000 feet. The distillation of suint from wool washing, and of recovered spent soap, are examples of the application of oleaginous substances for gas-making.

Resin-Gas.—In its treatment and results resin, as a source of gas, is very similar to oil. It yields a pure gas of great illuminating power, and for twenty years (1828–48) it was supplied in New York at $7 per 1000 feet. Previous to the civil war of 1861–65 it was a good deal used on the European continent.

Wood-Gas.—The original experiments of Lebon, it will be remembered, were made with wood-gas, but he failed to obtain from his product an illuminating power that would compare with that of coal-gas. Lebon's failure was in later years shown to arise from distilling at a temperature which gave off chiefly carbonic acid with non-luminous carbonic oxide and light carburetted hydrogen, leaving in the retort a tar which the application of a higher heat would have resolved into highly luminiferous gases and vapors. Pettenkofer, who pointed out the fact, devised a system of wood-gas making in which the products of the low-heat distillation were volatilized by passing through a range of red-hot pipes; but now it is found that ordinary retorts, properly heated and fed with small charges, answer perfectly well for the operation. Wood-gas, owing to its high specific gravity and the proportion of carbonic oxide it contains, must be burned at considerable pressure, in specially constructed burners with a large orifice. It is largely used in Germany, Switzerland, and Russia, where wood is more easily obtained than coal. It was used at Philadelphia gas-works in 1856, where it was affirmed to be cheaper and of greater luminosity than coal-gas.

Peat-Gas is evolved under circumstances the same as occur in connection with the wood-gas manufacture, but the amount of moisture contained in peat is a serious obstacle to its successful use in this as in most other directions. Earnest and persistent efforts have been made to use peat as a source of gas, but these have met but little commercial success. To a limited extent it is used in various German factories which happen to be situated in the immediate neighborhood of extensive peat deposits.

Carburetted Gas.—Under this head may be embraced all the methods for impregnating gaseous bodies with vapors of fluid or solid hydrocarbons. The objects aimed at in the carburetting processes are—(1) to increase the illuminating power of ordinary coal-gas; (2) to render non-luminous combustible gases, such as water-gas, luminiferous; and (3) so to load non-combustible gases with hydrocarbon vapor as to make the combination at once luminiferous and a supporter of combustion. The plans which have been proposed, and the patents which have been secured for processes of carburetting, coming under one or other of these heads, have been almost endless; and while the greater part of them have failed to obtain commercial success, they are sufficient to indicate that there is still a possibility of doing much to increase the effect and cheapen the cost of production of gas. Further, although for extensive use none of the gas-making plans can compete with coal-gas manufacture, some of them are of much value for private establishments, country houses, factories, and similar places, where connection with coal-gas works cannot be obtained.

The carburetting of common coal-gas with the vapor of benzol obtained by the distillation of gas-tar was originally suggested by Lowe as early as 1832, and subsequently by the late Charles Mansfield, who showed that by passing gas over sponge saturated with benzol a very great addition was made to the illuminating power; and he introduced an apparatus by which common gas could thus be benzolized at a point very near the burner. The facts, however, that benzol is a highly inflammable liquid, that the benzolized gas varied in richness owing to the gas taking up much more benzol when the carburetter was newly charged than it did afterwards, and consequently that it often produced a smoky flame, and that sulphur compounds accumulated in the carburetter, as well as the trouble connected with charging the apparatus, all combined to prevent the extensive introduction of the process. In later times the value of benzol for aniline manufacture and other purposes would have been a serious bar to its use. Mr. Bowditch introduced the use of a heavier hydrocarbon—a mixture of naphthalin with cymol—which he called carbolin, and which possesses the advantage of giving off no inflammable vapor at ordinary temperatures, and is, moreover, a substance for which no commercial demand exists. The carburetting appliance had to be placed in immediate proximity to the burners, and either heated by them direct, or by a small subsidiary jet, as the vapor of naphthalin solidifies on a very small fall of temperature and chokes up pipes. Carburetting by means of a solid block of naphthalin introduced into a gas-tight box, and partly volatilized by a strip of copper passing from the burner flame into the box, has recently been proposed, and is now being carried into effect with every prospect of great increase of illuminating power, and consequent economy, by the Albo-Carbon Light Company.

The efforts to introduce carburetted water-gas have been numerous and persistent; and the sanguine statements of the various inventors have led to the loss of much capital through experiments undertaken on a great scale which have always resulted unfavorably. The whole of the proposed processes depended on the decomposition of water by passing it over highly-heated surfaces in presence of glowing charcoal, whereby free hydrogen, carbonic oxide, and carbonic acid gases are produced, the carbonic acid being eliminated by a subsequent process of purification. The combustible gas so obtained was in earlier experiments charged with luminiferous hydrocarbons by being passed into a retort in which coal, resin, or oil was being distilled, as in Selligue's and other processes; or, as in White's hydrocarbon process, both steam and coal were treated together in a special form of retort. Since the introduction of American petroleum, however, most methods of carburetting water-gas have been by impregnating it with the vapor of gasolin, the highly volatile portion of petroleum which comes over first in its distillation for the preparation of "kerosene" lamp oil. Water-gas has been proposed, not only as an illuminating agent, but at least as much as a source of heat; but the heat expended in the decomposition of water is much greater than can in practice be given out by the resulting gases.

Several of the processes introduced for rendering ordinary atmospheric air at once combustible and luminiferous, by saturating it with the vapor of gasolin, have been so satisfactory that this air-gas is now largely used both in America and Europe for lighting mansions, churches, factories, and small rural districts. The general principle of the air-machines will be understood from the following description of the "sun auto-pneumatic" apparatus (Hearson's patent), which is in extensive use throughout Great Britain. Hearson's machine is cylindrical in form (fig. 23), and is surmounted by two turrets. Internally the cylinder is divided into two compartments by a transverse portion, one being occupied by a rotary blower, an apparatus similar in construction to the drum of a water-meter, and the other by an elevator or dipper wheel the function of which is to raise gasolin into the blower chamber, where the gasolin must be maintained at a constant level. The blower and the elevator mechanism are set in operation by being mounted on a spindle which passes through and outside the cylinder, and is turned either by a weight attached to a length of steel wire or, where convenient, by hydraulic power. The turrets contain (1) a gas-holder which supplies gas while the machine is being wound up, should any light be then burning, and (2) a governor to regulate the pressure of the issuing gas. The apparatus works only when gas is being burned, and moves in proportion to the demand on it up to its limit of production. There is therefore no necessity for storing, as indeed would be impracticable with this form of carburetted gas. The function of the blower is not only, by its revolution, to press forward the gas into the supply pipes, but also to carburet the air by exposing continually renewed thin films of the liquids to its influence on the moist metallic surfaces. The revolution of the blower, moreover, maintains an unceasing agitation in the gasolin, vaporizes the liquid in an equal and uniform manner, and keeps the entire volume at the same temperature throughout. The quantity of gasolin operated on being comparatively large, the temperature of the liquid decreases only slowly, and is in ordinary conditions sufficiently recouped from the external air to keep it in good working order throughout any length of time.

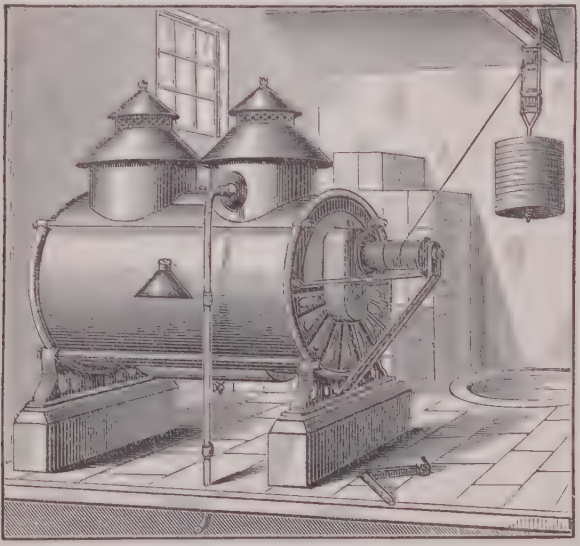


Fig. 23.—Sun Auto-Pneumatic Apparatus.

M. Tessie du Motay, who for many years advocated a modified system of lime-light, latterly abandoned that system in favor of a form of carburetted gas. His system necessitates two sets of pipes and a special form of burner,—one pipe supplying ordinary coal-gas or highly carburetted hydrogen, and the other leading in a supply of oxygen, whereby a powerful, steady, white light is maintained at the burner. Philipps of Cologne has also utilized oxygen in a comparatively pure state for burning in a lamp with a wick a mixture of heavy hydrocarbons, which in common air would burn with a very smoky flame.

Other sources of gas, such as tar, and even fæcal matters, have been proposed; and many modified forms of gaseous illumination have been brought forward which, even to name here, would occupy space out of proportion to their importance.

The Future of Coal-Gas.

The processes involved in the preparation, distribution, and consumption of coal-gas still remain essentially the same as when the system was first elaborated; but in all details of the industry numerous improvements have been introduced, resulting in marked economy and efficiency of the system. In the mean time new applications of importance have been found for coal-gas in connection with heating and cooking, and as a motive power in gas-engines. Further, collateral industries have been superadded to the gas manufacture, which in themselves are of such value and importance that, were the distillation of coal as a source of artificial light to cease, it would certainly continue to be practised as a source of the raw materials of the coal-tar colors, and of carbolic acid, etc. Were coal-gas to cease to be made primarily and principally for artificial illumination, and to become more a heating and cooking agent, or were it to fall into the position of being a mere collateral product of the manufacture of tar, it is certain that the manufacturing processes would be very materially modified. Costly cannel-gas, with its high illuminating power, is no better suited for a gas engine than common gas; and for heating purposes a much greater yield of gas might be obtained, which, in burning, would evolve more heat than is sought in making illuminating gas. But as matters now stand, the fact that illumination, heat, motive power, and dye-stuffs are all obtained by means of the manufacture as at present conducted is a consideration of much weight in dealing with rival systems of artificial lighting.

Throughout the whole experience of gas manufacture the efforts of inventors have been directed, not only to improve the manufacture of coal-gas, but also to supersede its ordinary processes, and to supplant it by gas yielded by other raw materials or by new systems of illumination. The persistent efforts which have been made to improve coal-gas, and the success which many of the plans exhibit in their experimental stage, warrant the conclusion that the processes and results of the manufacture are still susceptible of much improvement. When it is considered how exceedingly small is the total proportion of illuminants in coal-gas to the bulk of the materials dealt with, it is not difficult to imagine that modifications of processes may be devised whereby a great increase of lighting effect might be practically available, and at the same time a greater percentage of the total heat-giving power of the coal secured for domestic and manufacturing purposes. Notwithstanding the confessed imperfections of the system of coal gas-making,—the evil odors which attach to the works, the yet more offensive exhalations given off from streets through which the main pipes are led, the destructive accidents which occasionally occur from gas explosions, and the heat and sulphurous fumes evolved during its combustion,—not one of the numerous substitutes which have been proposed has been able to stand in competition against it in any large town or city where coal is a marketable commodity. As against the system of electric lighting, which is now being brought into competition with it, the ultimate fate of gas may be different. It may be regarded as already demonstrated that for busy thoroughfares—almost, it may be said, for open-air lighting generally—and for large halls and enclosed spaces, electric lighting will, in the near future, supersede gas. The advantages of the electric light for such positions in brilliancy, penetration, and purity are so manifest that its use must ultimately prevail, irrespective of the question of comparative cost, and of the fact that municipalities and wealthy corporations have an enormous pecuniary stake in gas-property. That the electric light will be equally available for domestic illumination is, however, not yet so certain; and until it is demonstrated that a current may be subdivided practically without limit, that the supply can adapt itself to the demand with the same ease that the pressure of gas is regulated, and that the lights can be raised and lowered equally with gas-lights—till these and other conditions are satisfied, the disuse of gas-lighting is still out of sight. Should these conditions, however, be satisfied, there can be little doubt that gas-lighting will enter on a period of severe competition and struggle for existence; and in the end the material which at one time was regarded as a most troublesome and annoying waste—the gas-tar—will, in all probability, exercise a decisive influence on the continuance of the gas manufacture.

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GASCOIGNE, GEORGE (*c.* 1535–1577), one of the great pioneers of Elizabethan poetry, was born about 1535—as is believed, in Westmoreland. He was the son and heir of Sir John Gascoigne. He studied at Cambridge, and was admitted to Gray's Inn in 1555. His youth was unsteady, and his father disinherited him. In 1565 he had written his tragi-comedy of *The Glass of Government*, not printed until 1576. In 1566 his first published verses were prefixed to a book called *The French Littleton*, and he brought out on the stage of Gray's Inn two very remarkable dramas, *Supposes*, the earliest existing English play in prose, and *Jocasta*, the first attempt to naturalize the Greek tragedy. Of the latter only the second, third, and fourth acts were from his hand. Soon after this he married. In 1572 there was published *A Hundred Sundry Flowers bound up in one small Posy*, a pirated collection of Gascoigne's lyrics, he having started in March of that year to serve as a volunteer under the Prince of Orange. He was wrecked on the coast of Holland and nearly lost his life, but obtained a captain's commission, and acquired considerable military reputation. An intrigue, however, with a lady in the Hague, nearly cost him his life. He regained his position, and fought well at the siege of Middleburg, but was captured under the walls of Leyden, and sent back to England after an imprisonment of four months. In 1575 he issued an authoritative edition of his poems under the name of *Posies*. In the summer of the same year he devised a poetical entertainment for Queen Elizabeth, then visiting Kenilworth; this series of masques was printed in 1576 as *The Princely Pleasures*. Later on in 1575 he greeted the queen at Woodstock with his *Tale of Hemetes*, and presented her on next New Year's day with the MS. of the same poem, which is now in the British Museum. He completed in 1576 his two most important works, *The Complaint of Philomene*, and *The Steel Glass*, the first of which had occupied him since 1562; they were printed in a single volume. Later on in the same year he published *A delicate Diet for dainty-mouthed Drunkards*. He fell into a decline and died at Stamford on the 7th of October, 1577. We are indebted for many particulars of his life to a rare poem published in the same year by George Whetstone, and entitled *A Remembrance of the Well-employed Life and Godly End of George Gascoigne, Esquire*. In his poem of *The Steel Glass*, in blank verse, Gascoigne introduced the Italian style of satire into our literature. He was a great innovator in point of metrical art, and he prefixed to the work in question a prose essay on poetry, which contains some very valuable suggestions. His great claim to remembrance was well summed up in the next generation by Thomas Nash, who remarked in his preface to Greene's *Menaphon*, that "Master Gascoigne is not to be abridged of his deserved esteem, who first beat the path to that perfection which our best poets aspired to since his departure, whereto he did ascend by comparing the Italian with the English." The works of Gascoigne were collected in 1587, and partly republished in 1810 and 1821. The best modern edition of the principal poems is that edited, with full bibliographical notes, by E. Arber in 1868.

GASCOIGNE, SIR WILLIAM, was chief-justice of England in the reign of Henry IV. Both history and tradition testify to the fact that he was one of the great lawyers who in times of doubt and danger have asserted the principle that the head of the state is subject to law, and that the traditional practice of public officers, or the expressed voice of the nation in parliament, and not the will of the monarch or any part of the legislature, must guide the tribunals of the country. The judge was a descendant of an ancient Yorkshire family. The date of his birth is uncertain, but it appears from the Year Books that he practised as an advocate in the reigns of Edward III. and Richard II. On the banishment of Henry of Lancaster, Gascoigne was appointed one of his attorneys, and soon after Henry's accession to the throne was made chief-justice of the Court of King's Bench. After the suppression of the rising in the north in 1405, Henry eagerly pressed the judge to pronounce sentence upon Scrope, the archbishop of York, and the earl marshal Thomas Mowbray, who had been implicated in the revolt. The judge absolutely refused to do so, asserting the right of the prisoners to be tried by their peers. Although both were afterwards executed, the chief-justice had no part in the transaction. The often told tale of his committing the Prince of Wales to prison has of course been doubted by modern critics, but it is both picturesque and characteristic. The judge had directed the punishment of one of the prince's riotous companions, and the prince who was present and enraged at the sentence struck or grossly insulted the judge. Gascoigne immediately committed him to prison, using firm and forcible language, which brought him to a more reasonable mood, and secured his voluntary obedience to the sentence. The king is said to have approved of the act, but there appears to be good ground for the supposition that Gascoigne was removed from his post or resigned soon after the accession of Henry V. He died in 1419, and was buried in the parish church of Harewood in Yorkshire. Some biographies of the judge have stated that he died in 1412, but this is clearly disproved by Foss in his *Lives of the Judges*; and although it is clear that Gascoigne did not hold office long under Henry V., it is not absolutely impossible that the scene in the fifth act of the second part of Shakespeare's *Henry IV.* has some historical basis, and that the judge's resignation was voluntary.

GASCONY, an old province in the S. W. of France, nearly identical with the *Novempopulania* or *Aquitania Tertia* of the Romans. Its original boundaries cannot be stated with perfect accuracy, but it included what are now the departments of Landes, Gers, and Hautes-Pyrénées, and parts of those of Haute-Garonne and Ariége. Its capital was Auch. About the middle of the 6th century there was an incursion into this region of *Vascons* or *Vasques* from Spain, but whether of a hostile kind or not is uncertain; but as the original inhabitants, in common with those of the rest of Aquitaine, were also *Vasques*, it is probable that the province owes its name Gascony less to this new incursion than to the fact that its inhabitants continued so long to maintain their independence. In 602 they suffered defeat from the Franks and were compelled to pay tribute, but they continued to be governed by their own hereditary dukes, and gradually extended the limits of their dominions to the Garonne. The province was overrun by Charlemagne but never completely subdued, and in 872 it formally renounced the authority of the French kings; but through the extinction of the male line of hereditary dukes of Gascony in 1054 it came into the possession of the dukes of Guienne (or Aquitaine), with which province its history was from that time identified (see AQUITANIA and GUIENNE).

GASKELL, ELIZABETH CLEGHORN (1810-1865), one of the most distinguished of England's women-novelists, was born at Cheyne Row, Chelsea, September 29, 1810. She was the second child of William Stevenson, of whom an account is given in the *Annual Biography and Obituary* for 1830. Mr. Stevenson, who began life as classical tutor in the Manchester Academy, and preached also at Doblane, near that town, afterwards relinquished his ministry and became a farmer in East Lothian; and later, on the failure of his farming enterprises, he kept a boarding-house for students in Drummond Street, Edinburgh, where he also became editor of the *Scots Magazine*, and contributed largely to the *Edinburgh Review*. At the time of his daughter's birth Mr. Stevenson had been appointed Keeper of the Records to the Treasury, and was living in Chelsea, still a diligent contributor to various periodicals of the day. Mrs. Stevenson, Mrs. Gaskell's mother, was a Miss Holland, of Sandlebridge in Cheshire, an aunt of the late Sir Henry Holland. She died at the birth of her daughter, who was in a manner adopted, when she was only a month old, by her mother's sister, Mrs. Lumb. This lady had married a wealthy Yorkshire gentleman, but a few months after her marriage, and before the birth of her child, discovered that her husband was insane, and fled from him to her old home in the little market town of Knutsford, in Cheshire. Mrs. Lumb's own daughter having died, she transferred all her affection to the little Elizabeth, between whom and her there existed through life the strongest bond of affection. During Elizabeth's childhood at Knutsford she was visited now and then by her sailor-brother; but while she was still a girl he went to India, where he somewhat mysteriously, and without any apparent motive, disappeared, and all further trace of him was lost. She was afterwards sent for about two years to a school kept by a Miss Byerley at Stratford-on-Avon, and on leaving school went for a time to live with her father, who had married again. Under his guidance she continued her studies, reading with him in history and literature, and working, chiefly by herself, at Latin, Italian, and French, in all of which she was in later life proficient. Having tenderly nursed her father in his last illness, she returned to her aunt at his death in 1829; and, with the exception of one or two visits to Newcastle, London, and Edinburgh, she continued to live at Knutsford till her marriage. She had at this time a reputation for great beauty; and even in later life her exquisitely-shaped soft eyes retained their light, and her smile its wonderful sweetness. Her marriage to the Rev. William Gaskell, M. A., of Cross Street Chapel, Manchester, took place August 30, 1832, at Knutsford church; and during the earlier years of her married life Mrs. Gaskell lived very quietly in Manchester, surrounded by a few intimate and cultured friends, and devoting all her time and abilities to the cares of a necessarily frugal household. Among these friendships, that with Miss Catherine Winkworth and her sisters was perhaps the longest and most cherished. From the first, although she never visited the poor as a member of any organized society, she sought by all means in her power to relieve the misery which, in a town like Manchester, she was constantly witnessing. She gave the most devoted help and tender sympathy to such cases of individual distress as came under her notice. She assisted Mr. Travers Madge in his missionary work amongst the poor, and was the friend and helper of Thomas Wright, the prison philanthropist. She also made several individual friendships among poor people, and knew personally one or two types of the Chartist working-man. She was specially interested in the young working-women of Manchester, and for some years held a weekly evening class at her own house for talking with them and teaching them. Of Mrs. Gaskell's seven children, two were still-born, and another, her only son, born between the third and fourth of her four living daughters, died at the age of ten months. The death of this baby is said to have been the cause of Mrs. Gaskell's beginning to write, when she was urged by her husband to do so, in order to turn her thoughts from her own grief. She began by writing a short paper called "An Account of Clopton Hall," for William Howitt's *Visits to Remarkable Places*. This was followed by one or two short stories, such as the "Sexton's Hero," for the *People's Journal*; and then she wrote *Mary Barton, a Tale of Manchester Life*. On its completion, she sent it to one publisher in London who rejected it unread, and then to Messrs. Chapman and Hall, who, after keeping the manuscript for a year without acknowledgment, wrote to her accepting the novel for publication, and offering the authoress £100 for the copyright. The appearance of *Mary Barton* in 1848 caused great excitement in Manchester, and a strong partisanship was felt for and against its anonymous author. After its publication Mrs. Gaskell paid several visits in London, where she made many friends, among whom we may mention Dickens, Forster, Mrs. Jameson, Lord Houghton, Mrs. Stowe, Ruskin, and Florence Nightingale. Her friendship with Charlotte Bronte also dates from about this time, when the two authoresses met at the house of Sir James and Lady Kay Shuttleworth, near Bowness, in Westmoreland, and Mrs. Gaskell received her first impressions of the shy "little lady in a black silk gown," who afterwards became personally her dear friend,—although, from a literary point of view, they could hardly help being rivals,—and the story of whose life, when it was ended, Mrs. Gaskell was destined to write with such consummate care and tender appreciation. But *Mary Barton* was to prove only the first of a series of scarcely less popular publications, which appeared either independently or in periodicals, such as *Household Words*. It was followed in 1850 by *The Moorland Cottage*. *Cranford* and *Ruth* appeared in 1853; *North and South*, in 1855; *The Life of Charlotte Bronte*, in 1857; *Round the Sofa*, in 1859; *Right at Last*, in 1860; *Sylvia's Lovers*, in 1863; and *Cousin Phillis* and *Wives and Daughters*, in 1865.

During these years—years of increasing worldly prosperity and literary distinction—Mrs. Gaskell often went abroad, chiefly to Paris and Rome, but once for a long visit to Heidelberg, and once also to Brussels, to collect information about Charlotte Bronte's school-days. In Paris her genius was warmly appreciated; and, while she was a guest among them, Guizot, Montalembert, and Odillon Barrot vied in doing her honor. Of her visits in England some of the pleasantest were to Oxford, where she counted among her friends Mr. Jowett and Mr. Stanley (dean of Westminster). At other times, when she was busy writing one of her novels, she would leave home with one or two of her children, and carry her manuscript to some quiet country place, where she could write undisturbed. When she was at home, although she was enthusiastically interested in the political questions of the day, and her warm, impulsive nature made her ready at any time to give personal help and sympathy where it seemed to be needed, Mrs. Gaskell refrained from taking active part in public movements or social reforms, if we except, indeed, the great sewing-school movement in Manchester at the time of the cotton famine in 1862. Her life was thoroughly literary and domestic. She read much: Goldsmith, Pope, Cowper, and Scott were the favorite authors of her girlhood; in later life she admired Ruskin and Macaulay extremely, and delighted in many old French memoirs of the time of Madame de Sévigné, whose life she often planned to write. It is remembered of her that one day, when she was reading George Eliot's first anonymous story *Amos Barton*, she looked up and said, "I prophesy that the writer of this will be a great writer some day." The prospect of the awful cotton famine in Manchester in 1862 set Mrs. Gaskell anxiously thinking what could be done to relieve the coming distress, and she decided, "without any suggestions from others, on a plan of giving relief and employment together to the women mill-hands, which was an exact prototype of the great system of relief afterwards publicly adopted, namely, the sewing-schools." When these were formed, Mrs. Gaskell "merged her private scheme in the public one, and worked most laboriously in the sewing-school nearest her home." This was but three years before her death. Still busy writing her novel *Wives and Daughters*, she was staying with her children at Holybourne, Alton, in Hampshire, a house which she had just purchased as a surprise and gift to her husband, when she died suddenly of heart disease, about 5 o'clock on Sunday evening, November 12, 1865. Her remains were carried to the churchyard of the Old Presbyterian Meeting-house at Knutsford, where her childhood and girlhood had been spent, and which she had left as a bride, three-and-thirty years before. A memorial tablet in memory of Mrs. Gaskell was erected by her husband's congregation, in Cross Street Chapel, Manchester—a tribute not only to her genius, and the spirit in which it was exercised, but to the "tenderness and fidelity" of the wife and mother who had lived long amongst them.

With this knowledge of the facts of Mrs. Gaskell's life, it is not difficult to trace the sources of her inspirations. Some of her shorter tales, it is true, seem to have been suggested merely by her readings; and, carefully as she collected their materials, these are the least satisfactory of her writings. But by far the most of what she wrote was founded on observation and experience. Mrs. Gaskell has reproduced, with slight variations, in her novel *North and South*, the incident in her father's youth, when he and his friend and fellow-student, the Rev. George Wicke of Monton, believing it wrong to be "hired teachers of religion," resigned their ministries and sought a livelihood otherwise. The beautiful story in "Mary Barton" of the two working-men who brought the baby from London to Manchester is a version of an anecdote about Mrs. Gaskell's own infancy, of her being taken to Knutsford, after her mother's death, by a friend who chanced to be travelling that way. The little county town of "Cranford"—with its population of widows and maiden ladies, and its horror of the masculine portion of society—is Knutsford, so long Mrs. Gaskell's home. In *Cranford* every character, if not every incident, is real; and the pathetic little story of *Poor Peter* can have been suggested only by the disappearance of that sailor brother who used to visit Mrs. Gaskell in her girlhood, and whose mysterious loss also must have interested her always afterwards in "disappearances"—the title of one of her papers in *Household Words*. Pleasant months spent at Morecambe Bay and Silverdale initiated her in the mysteries of rural and farm life. Her visits to France were the origin of her tales of the Huguenots and the French refugees at the time of the Revolution. The Edinburgh of her girlhood appears in one or two of her stories, briefly but vividly sketched. Her schooldays at Stratford-on-Avon are remembered in *Lois the Witch;* and, if only in a little story like the visit to Heppenheim, we can trace her excursions from Heidelberg along the broad, white Bergstrasse. But it is most of all in *Mary Barton*, a story of the trials and sorrows of the poor in Manchester, whom she had had so many opportunities of observing, that Mrs. Gaskell gave her personal knowledge and experience to the world. Her severest critic, Mr. W. R. Greg, admits Mrs. Gaskell's knowledge of her subject, but objects to the impression left by the novel on the mind of the reader as inaccurate and harmful. "Were *Mary Barton*," he says, "to be only read by Manchester men and master manufacturers, it could scarcely fail to be serviceable, because they might profit by its suggestions, and would at once detect its exaggerations and mistakes;" but on the general public he fears its effect will be "mischievous in the extreme." One doubts whether a calm solution of a great economic difficulty, such as that which Mrs. Gaskell treats of, could ever be given in a novel; and certainly the warm-hearted, impulsive authoress of *Mary Barton* had no such aim in view. It is probable that she wrote without any distinct economic theories. Earnest, benevolent intentions she no doubt had, but she was far more of an artist than a reformer. Had it not been so, *Mary Barton* would not rank so high in the literature of fiction as it does. It is no work of occasion, the chief interest of which departs when the occasion itself is over. It is a thoroughly artistic production, and for power of treatment and intense interest of plot has seldom been surpassed. It is as the authoress of *Mary Barton* that Mrs. Gaskell will be remembered. Of her other works, *Ruth* is singularly inferior to its predecessor; but *North and South*, which takes the side of the master manufacturers, as *Mary Barton* did that of the men, has been scarcely less popular with the public. Perhaps the two best of Mrs. Gaskell's productions, each in its own way, are the exquisitely humorous *Cranford* and *Cousin Phillis*, which has been fitly called an idyll in prose. *Wives and Daughters*, even in its uncompleted state, is artistically almost faultless, and full of a quiet restful beauty entirely its own. George Sand was a great admirer of this novel, and Mrs. Gaskell's family still cherish a saying of hers about it:—"It is a book," she once said to Lord Houghton, "that might be put into the hands of an innocent girl, while at the same time it would rivet the attention of the most *blasé* man of the world." Her one work which is not a novel—her *Life of Charlotte Bronte*—it is difficult to praise too highly, either as a biography proper, or as a narrative written with the consummate skill of the novelist. Some people, indeed, have thought that Mrs. Gaskell transgressed the bounds of the biographer in publishing so many details of Miss Bronte's domestic and private life; but the case was a peculiar one. The character of Charlotte Bronte's writings made it advisable that her reader, in order properly to understand her, should be admitted to some of the hitherto hidden facts of her short, sad life. Mrs. Gaskell, knowing and esteeming Charlotte Bronte in the character of friend, daughter, and wife, hoped in some degree to justify to the world the morbid, unhealthy tone which pervaded her genius; and surely, if any hand was to draw the curtain, none could have done it more tenderly than that of her friend. (F. M.)

GASSENDI, PIERRE (1592–1655), one of the most eminent French philosophers, was born of poor but respectable parentage at Champtercier, near Digne, in Provence, on the 22d January, 1592. At a very early age he gave indications of remarkable mental powers, and at the instance of his uncle, the curé of his native village, he was sent to the college at Digne. He made rapid progress in his studies, showing particular aptitude for languages and mathematics, and it is said that at the age of sixteen he was invited to lecture on rhetoric at the college. He cannot have retained this post for any length of time, for soon afterwards he entered the university of Aix, to study philosophy under Fesaye. In 1612 he was called to the college of Digne to lecture on theology. Four years later he received the degree of doctor of theology at Avignon, and in 1617 he took orders as a priest. In the same year he was called to the chair of philosophy at Aix, and seems gradually to have withdrawn from theological study and teaching.

At Aix he lectured principally on the Aristotelian philosophy, conforming as far as possible to the orthodox methods. At the same time, however, he prosecuted his favorite studies, physics and astronomy, and by the discoveries of Galileo, Kepler, and others became more and more dissatisfied with the Peripatetic system. It was, indeed, the very period of violent revolt against the authority of Aristotle, and Gassendi shared to the full the practical and empirical tendencies of the age. He, too, began to draw up in form his objections to the Aristotelian philosophy, but did not at first venture to publish them. The portion shown to his friends Peiresc and Gautier, however, was so vehemently approved by them that in 1624, after he had left Aix for a canonry at Grenoble, he printed the first part of his *Exercitationes paradoxicæ adversus Aristoteleos*. A fragment of the second book was published later (1659), but the remaining five, requisite to complete the work, were never composed, Gassendi apparently thinking that after the *Discussiones Peripateticæ* of Patricius little field was left for his labors.

The *Exercitationes* on the whole seem to have excited more attention than they deserved. They contain little or nothing beyond what had been already advanced against Aristotle by the more vigorous of the Humanists, by Valla and Vives, by Ramus and Bruno. The first book expounds clearly, and with much vigor, the evil effects of the blind acceptance of the Aristotelian dicta on physical and philosophical study; but, as is the case with so many of the anti-Aristotelian works of this period, the objections do not touch the true Aristotelian system, and in many instances show the usual ignorance of Aristotle's own writings. The second book, which contains the review of Aristotle's dialectic or logic, is throughout Ramist in tone and method.

After a short visit to Paris in 1628, Gassendi travelled for some years in Flanders and Holland with his friend Luillier. During this time he wrote, at the instance of Mersenne, his examination of the mystical philosophy of Robert Fludd (*Epistolica dissertatio in qua præcipua principia philosophiæ Ro. Fluddi deteguntur*, 1631), an essay on parhelia (*Epistola de Parheliis*), and some valuable observations on the transit of Mercury which had been foretold by Kepler. He returned to France in 1631, and two years later received the appointment of provost of the cathedral church at Digne. Some years were then spent in travelling through Provence with the duke of Angoulême, governor of the department. The only literary work of this period is the *Life of Peiresc*, which has been frequently reprinted, and was translated into English. In 1642 he was again engaged by Mersenne in controversy, on this occasion against the celebrated Descartes. His objections to the fundamental propositions of Descartes were published in 1642; they appear as the fifth in the series contained in the works of Descartes. In these objections Gassendi's already great tendency towards the empirical school of speculation appears more pronounced than in any of his other writings. In 1645 he was invited by the archbishop of Lyons, brother of Cardinal Richelieu, to the chair of mathematics in the Collége Royal at Paris. He accepted this post, and lectured for many years with great success. In addition to some controversial writings on physical questions, there appeared during this period the first of the works by which he is best known in the history of philosophy. He evidently found himself more in harmony with Epicurus than with any other philosopher of antiquity, and had collected much information regarding the Epicurean system. In 1647 Luillier persuaded him to publish some of his works, which took the form of the treatise *De Vita, Moribus, et Doctrina Epicuri libri octo*. The work was well received, and two years later appeared his commentary on the tenth book of Diogenes Laertius (*De Vita, Moribus, et Placitis Epicuri, seu Animadversiones in X. librum Diog. Laer.*). In the same year the more important *Syntagma philosophiæ Epicuri* was published.

In 1648 Gassendi had been compelled from ill-health to give up his lectures at the Collége Royal. He travelled for some time in the south of France, spending nearly two years at Toulon, the climate of which suited him. In 1653 he returned to Paris and resumed his literary work, publishing in that year his well-known and popular lives of Copernicus and Tycho Brahe. The disease from which he suffered, lung complaint, had, however, established a firm hold on him. His strength gradually failed, and he died at Paris on the 24th October, 1655, in the sixty-third year of his age.

His collected works, of which the most important is the *Syntagma Philosophicum* (*Opera*, i. and ii.), were published in 1655 by Montmort (6 vols. fol., Lyons). Another edition, also in 6 folio volumes, was published by Averanius in 1727. These volumes sufficiently attest the wide extent of his reading and the versatility of his powers. The first two are occupied entirely with his *Syntagma Philosophicum;* the third contains his critical writings on Epicurus, Aristotle, Descartes, Fludd, and Lord Herbert, with some occasional pieces on certain problems of physics; the fourth, his *Institutio Astronomica*, and his *Commentarii de Rebus Celestibus;* the fifth, his commentary on the tenth book of Diogenes Laertius, the biographies of Epicurus, Peiresc, Tycho Brahe, Copernicus, Peurbach, and Regiomontanus, with some tracts on the value of ancient money, on the Roman calendar, and on the theory of music, to all which is appended a large and prolix piece entitled *Notitia Ecclesiæ Diniensis;* the sixth volume contains his correspondence. The *Lives*, especially those of Copernicus, Tycho, and Peiresc, have been justly admired. That of Peiresc has been repeatedly printed; it has also been translated into English. Gassendi was one of the first after the revival of letters who treated the *literature* of philosophy in a lively way. His writings of this kind, though too laudatory and somewhat diffuse, have great merit; they abound in those anecdotal details, natural yet not obvious reflections, and vivacious turns of thought, which made Gibbon style him, with some extravagance certainly, though it was true enough up to Gassendi's time—"le meilleur philosophe des litterateurs, et le meilleur litterateur des philosophes."

Gassendi will always retain an honorable place in the history of physical science. He certainly added little original to the stock of human knowledge, but the clearness of his exposition and the manner in which he, like his greater contemporary, Bacon, urged the necessity and utility of experimental research, were of inestimable service to the cause of science. To what extent any place can be assigned him in the history of philosophy is more doubtful. His anti-Aristotelian writing has been already noticed. The objections to Descartes—one of which at least, through Descartes's statement of it, has become famous—have no speculative value, and in general are the outcome of the crudest empiricism. His labors on Epicurus have a certain historical value, but the inherent want of consistency in the philosophical system raised on Epicureanism is such as to deprive it of all genuine worth. Along with strong expressions of empiricism (*nihil in intellectu quod non prius fuerit in sensu*) we find him holding doctrines absolutely irreconcilable with empiricism in any form. For while he maintains constantly his favorite maxim "that there is nothing in the intellect which has not been in the senses," and while he contends that the imaginative faculty, "phantasia," is the counterpart of sense, that, as it has to do with material images, it is itself, like sense, material, and essentially the same both in men and brutes, he at the same time admits that the intellect, which he affirms to be immaterial and immortal—the most characteristic distinction of humanity—attains notions and truths of which no effort of sensation or imagination can give us the slightest apprehension (*Op.*, ii. 383). He instances the capacity of forming "general notions;" the very conception of universality itself (*ib.*, 384), to which he says brutes, who partake as truly as men in the faculty called "phantasia," never attain; the notion of God, whom he says we may imagine to be corporeal, but understand to be incorporeal; and lastly, the reflex action by which the mind makes its own phenomena and operations the objects of attention.

The *Syntagma Philosophicum*, in fact, is one of the eclectic systems which unite, or rather place in juxtaposition, irreconcilable dogmas from various schools of thought. It is divided, according to the usual fashion of the Epicureans, into logic (which, with Gassendi as with Epicurus, is truly *canonic*), physics, and ethics. The logic, which contains at least one praiseworthy portion, a sketch of the history of the science, is divided into theory of right apprehension (*bene imaginari*), theory of right judgment (*bene proponere*), theory of right inference (*bene colligere*), theory of right method (*bene ordinare*). The first part contains the specially empirical positions which Gassendi afterwards neglects or leaves out of account. The senses, the sole source of knowledge, are supposed to yield us immediately cognition of individual things; phantasy (which Gassendi takes to be material in nature) reproduces these ideas; understanding compares these ideas, which are particular, and frames general ideas. Nevertheless, he at the same time admits that the senses yield knowledge—not of things—but of qualities only, and holds that we arrive at the idea of thing or substance by induction. He holds that the true method of research is the analytic, rising from lower to higher notions; yet he sees clearly, and admits, that inductive reasoning, as conceived by Bacon, rests on a general proposition not itself proved by induction. He ought to hold, and in disputing with Descartes he did apparently hold, that the evidence of the senses is the only convincing evidence; yet he maintains, and from his special mathematical training it was natural he should maintain, that the evidence of reason is absolutely satisfactory. The whole doctrine of judgment, syllogism, and method is a mixture of Aristotelian and Ramist notions.

In the second part of the *Syntagma*, the physics, there is more that deserves attention; but here, too, appears in the most glaring manner the inner contradiction between Gassendi's fundamental principles. While approving of the Epicurean physics, he rejects altogether the Epicurean negation of God and particular providence. He states the various proofs for the existence of an immaterial, infinite, supreme Being, asserts that this Being is the author of the visible universe, and strongly defends the doctrine of the foreknowledge and particular providence of God. At the same time he holds, in opposition to Epicureanism, the doctrine of an immaterial, rational soul, endowed with immortality and capable of free determination. It is altogether impossible to assent to the supposition of Lange (*Gesch. des Materialismus*, 3d ed., i. 233), that all this portion of Gassendi's system contains nothing of his own opinions, but is solely introduced from motives of self-defence. The positive exposition of atomism has much that is attractive, but the hypothesis of the *calor vitalis*, a species of *anima mundi* which is introduced as physical explanation of physical phenomena, does not seem to throw much light on the special problems which it is invoked to solve. Nor is his theory of the weight essential to atoms as being due to an inner force impelling them to motion in any way reconcilable with his general doctrine of mechanical causes.

In the third part, the ethics, over and above the discussion on freedom, which on the whole is indefinite, there is little beyond a milder statement of the Epicurean moral code. The final end of life is happiness, and happiness is harmony of soul and body, *tranquillitas animi et indolentia corporis.* Probably, Gassendi thinks, perfect happiness is not attainable in this life, but it may be in the life to come.

The *Syntagma* is thus an essentially unsystematic work, and clearly exhibits the main characteristics of Gassendi's genius. He was critical rather than constructive, widely read and trained thoroughly both in languages and in science, but deficient in speculative power and original force. Even in the department of natural science he shows the same inability steadfastly to retain principles and to work from them; he wavers between the systems of Brahe and Copernicus. That his revival of Epicureanism had an important influence on the general thinking of the 17th century may be admitted; that it has any real importance in the history of philosophy cannot be granted.

Gassendi's life is given by Sorbière in the first collected edition of the works, by Bugerel, *Vie de Gassendi*, 1737 (2d ed., 1770), and by Damiron, *Mémoire sur Gassendi*, 1839. An abridgment of his philosophy was given by his friend, the celebrated traveller, Bernier (*Abrégé de la Philosophie de Gassendi*, 8 vols., 1678; 2d ed., 7 vols., 1684). The most complete surveys of his work seem to be those of Buhle (*Geschichte der neuern Philosophie*, iii., 1, 87–222), and Damiron (*Mémoires pour servir à l'Histoire de Philosophie au 17me Siècle*). See also Ritter, *Geschichte der Philosophie*, x. 543–571); Feuerbach, *Gesch. d. neu. Phil. von Bacon bis Spinoza*, 127–150. (R. AD.)

GASTEIN, a beautiful and picturesque valley in the Austrian duchy of Salzburg, celebrated for its mineral springs. It is a side valley of the upper Salzach valley, and is about 25 miles long and 1¼ miles broad. It has an elevation of between 3000 and 3500 feet. Behind it, to the south, tower the mountains Malnitz or Nassfeld-Tauern, 7820 feet high, and the Ankogel, 10,700 feet high, and from the right and left of these mountains two smaller ranges run northwards forming its two side walls. The river Ache traverses the valley, and near Wildbad-Gastein forms two magnificent waterfalls, the upper, the Kesselfall, 200 feet, and the lower, the Bärenfall, 280 feet in height; and near these falls another called the Schleierfall, 250 feet high, is formed by the stream which drains the Pockhart-See. The principal villages are Böckstein, Hof-Gastein, and Wildbad-Gastein, and the population of the whole valley is about 3800. Hof-Gastein, with a population of about 1000, possesses gold and silver mines which in the 16th century yielded 1180 ℔ of gold and 9500 ℔ of silver annually. They are now, however, much neglected and many of the old mines are covered by glaciers. The village contains a military hospital, and in the open platz there is a bust of the emperor Francis I., who, in 1828, caused a conduit of upwards of 5 miles long to be constructed for the purpose of conveying the mineral waters thither from Wildbad. Wildbad, the principal watering-place, is visited by upwards of 3000 persons annually, and among its visitors is the present emperor of Germany. The thermal springs, which were known as early as the 7th century, issue from the granite mountains, and have a temperature of 117° Fahr. They are made use of in cases of nervous affections, general debility, and skin diseases; but the reason of their efficacy is somewhat mysterious, as chemical analysis discovers only a slight difference in the ingredients from those of ordinary spring water. The village is formed chiefly of wooden houses rising above one another in terraces. A number of stone houses have, however, been built of late; and there are several fine villas, one of which was constructed by the archduke John of Austria, and has a botanical garden.

The baths of Gastein first came into fame through a successful visit paid to them by Duke Frederick of Austria in 1436. The valley from the 11th century belonged to the dukes of Peilstein, and on the extinction of their line in 1219 it came into possession of Bavaria, whence it passed in 1297 by purchase to Salzburg. A convention was held at Wildbad-Gastein in August, 1865, between the emperor Francis Joseph of Austria and King William of Prussia, at which an arrangement was signed in reference to the relations of Austria and Prussia to Schleswig-Holstein and Lauenburg (see AUSTRIA).

The principal books on Gastein are Reissacher, *Der Kurort Wildbad-Gastein*, 1865; Bunzel, *Bad-Gastein*, 1872; Hönigsberg, *Gastein*, 1873; and *A Month at Gastein*, London, n. d.

GATAKER, THOMAS (1574–1654), a learned English divine, was born in London in 1574, and educated at St. John's College, Cambridge. From 1601 to 1611 he held the appointment of preacher to the society of Lincoln's Inn, which he resigned on obtaining the rectory of Rotherhithe. In 1642 he was chosen a member of the Assembly of Divines at Westminster. The parts of the Assembly's annotations upon the Bible which were executed by him are those on Isaiah, Jeremiah, and the Lamentations. At Westminster he disapproved of the introduction of the Covenant, and declared himself in favor of Episcopacy. He was also one of the forty-seven London clergymen who disapproved of the trial of Charles I. He died in 1654. His principal works, besides some volumes of sermons, are —*On the Nature and Use of Lots*, 1616, a curious treatise which gave rise to much controversy; *Dissertatio de Stylo Novi Testamenti*, 1648; *Cinnus, sive Adversaria Miscellanea, in quibus Sacræ Scripturæ primo, deinde aliorum Scriptorum, locis aliquam multis lux redditur*, 1651, to which was afterwards subjoined *Adversaria Posthuma;* and his edition of *Marcus Antoninus*, which, according to Hallam, is the "earliest edition of any classical writer published in England with original annotations," and for the period at which it was written possesses remarkable merit. The best edition of his works is that published at Utrecht in 1668.

GATCHINA, a town of Russia, in the government of St. Petersburg and district of Tsarskoselo, 29 miles W. of St. Petersburg, in 59° 34′ N. lat., and 30° 6′ E. long. It is situated in a flat, well-wooded, and partly marshy district, and on the south side of the town are two lakes, distinguished as the White and the Black. Among its more important buildings are the imperial palace, which was founded in 1770 by Prince Orloff, and executed according to the plans of the Italian architect Rinaldi, the four Greek churches, the Protestant church, a foundling asylum, a military orphanage founded in 1803 by Maria Feodorina, a school for horticulture, a public hospital for 1500 patients, founded by Paul I., an asylum for the families of twenty blind men, and another for fifty poor peasants. In one of the Greek churches are preserved several relics originally brought from Rhodes to Malta by the grand-master Lille Adam; and the so-called priory is shown where the knights of Malta assembled under the mastership of the emperor Paul I. Gatchina is a junction on the railway between St. Petersburg and Warsaw, but its trade is of no great development. Among the few industrial establishments is a porcelain factory. The inhabitants in 1860 numbered 9184, of whom 2255 were members of the National Church, 1431 Protestants, 182 Catholics, and 50 Jews. By 1867 the total had sunk to 8337; but according to the *St. Petersburg Calendar* for 1878 it has again risen to 8890.

GATES, HORATIO (1728–1806), an American general, was born at Maldon in Essex, England, in 1728. He entered the English army at an early age, and soon obtained considerable promotion. He was severely wounded while accompanying General Braddock in his unfortunate expedition against the French settlements on the Ohio in 1755, and he took part in the expedition against Martinico in January, 1762. After the peace of 1763 he purchased an estate in Virginia, where he resided till the commencement of the revolutionary war in 1775, when he was named by congress adjutant-general. In 1776 he was appointed to command the army on Lake Champlain; but, his conduct there not having been approved of, he was superseded in the following spring; yet in August he was sent to oppose General Burgoyne, whom he totally defeated on the 16th of October, and compelled to surrender his whole army,—an achievement which was, however, largely due to the previous manœuvres of Schuyler, whom Gates superseded. After obtaining the chief command in the southern districts, Gates was totally defeated at Camden, in South Carolina, by Lord Cornwallis, on the 16th of August, 1780. On this account he was superseded by General Greene; but an investigation into his conduct terminated in acquitting him fully and honorably of all blame, on the ground that his defeat had been unavoidable in the disorganized state of the army under his command. After this he again retired to his Virginian estate, whence he removed to New York in 1800. On his arrival he was immediately admitted to the freedom of the city, and then elected a member of the State legislature. Before his departure from Virginia he granted emancipation to his slaves, accompanying their manumission with a provision for those who needed assistance. He died on the 10th of April, 1806.

GATESHEAD, a municipal and parliamentary borough and market-town of England, county of Durham, is situated on the right bank of the Tyne, opposite Newcastle, of which it practically forms a part, being united with it by three bridges. The town consists of two principal and nearly parallel streets, from which others diverge in various directions. A great fire which occurred in 1854 was taken advantage of for the carrying out of improvements in the old part of the town, and it is now much less crowded than formerly. In the suburbs there are a considerable number of fine mansions. The parish church, recently restored, is an ancient cruciform edifice surmounted by a lofty tower; and several of the other churches and chapels are handsome buildings. The Wesleyan and Primitive Methodists, the Congregationalists, Baptists, Presbyterians, and Roman Catholics are all represented. The town possesses a fine cemetery, a well laid out public park, a new town-hall, a grammar school, a hospital (St. Edmund's) for fifteen indigent persons, a reformatory, a mechanics' institute, and a dispensary. There are large iron works (including foundries and factories for engines, boilers, chains, and cables), shipbuilding yards, glass manufactories, chemical, soap, and candle works, brick and tile works, breweries and tanneries. The town also contains the principal depôt of the North-Eastern Railway, with large stores and locomotive works. Extensive coal mines exist in the vicinity; and at Gateshead Fell are large quarries for grindstones, which are much esteemed and are exported to all parts of the world.

The large number of Roman relics found at Gateshead would seem to indicate that it was originally an outwork of the Roman station at Newcastle. The name is mentioned as early as 1080, and in 1164 the bishop of Durham granted to its burgesses equal privileges with those of Newcastle. On the dissolution of the see of Durham in 1552, an Act was passed for uniting the town to the borough of Newcastle, but on the restoration of the rights of the bishopric it was again placed under that jurisdiction, being governed from 1317 to 1695, with the exception of that short intermission by a bailiff nominated by the bishop. From 1695 to 1826, when it became a municipal borough, it was governed by two stewards, elected by the inhabitants. Gateshead returns one member to parliament. The population of the municipal borough, which in 1861 was 33,587, was 48,627 in 1871.

GATH, one of the five chief cities of the Philistines. Its site appears to have been known in the 4th century, but the name is now lost. Eusebius (in the *Onomasticon*) places it near the road from Eleutheropolis (Beit Jibrîn) to Diospolis (Ludd) about 5 Roman miles from the former. The Roman road between these two towns is still traceable, and its milestones remain in places. East of the road at the required distance rises a white cliff, almost isolated, 300 feet high, and full of caves. On the top is the little mud village of Tell-es-Sâfi ("the shining mound"), and round it are the mounds which mark the site of the crusading castle of Blanchegarde (Alba Custodia), built in 1144. Tell-es-Sâfi was known by its present name as far back as the 12th century, but it appears probable that the strong site here existing represents the ancient Gath. The cliff stands on the south bank of the valley of Elah, and Gath appears to have been near this valley (1 Sam. xvii. 2, 52). The name Gath, meaning a "winepress," designates several other places in Palestine.

GATTY, Mrs. Alfred (1809–1873), daughter of the Rev. Dr. Scott, chaplain to Lord Nelson, was born at Burnham, Essex, in 1809. In 1839 Margaret Scott was married to the Rev. Alfred Gatty, D. D., vicar of Ecclesfield near Sheffield, sub-dean of York cathedral, and the author of various works both secular and religious. In 1842 she published in association with her husband a life of her father, the Rev. Dr. Scott; but her first independent work was *The Fairy Godmother and other Tales*, which appeared in 1851. This was followed in 1855 by the first of five volumes of *Parables from Nature*, the last being published in 1871. It is under the *nom de plume* of Aunt Judy, as a pleasant and instructive writer for children, that Mrs. Gatty is most widely known. Previous to commencing *Aunt Judy's Magazine* in May, 1866, she had brought out *Aunt Judy's Tales* and *Aunt Judy's Letters;* and among the other children's books which she subsequently published, were *Aunt Judy's Song Book for Children* and *The Mother's Book of Poetry*. Besides other excellences her children's books are specially characterized by wholesomeness of sentiment and cheerful humor. Her miscellaneous writings include, in addition to several volumes of tales, *The Old Folks from Home*, an account of a holiday ramble in Ireland; *The Travels and Adventures of Dr. Wolff the Missionary*, in which she was assisted by her husband; *British Sea Weeds; Waifs and Strays of Natural History; A Book of Emblems;* and *The Book of Sun-Dials*. She died October 3, 1873.

GAUDEN, John (1605–1662), the reputed author of the *Eikon Basilike*, was born in 1605 at Mayfield in Essex, of which parish his father was vicar. He was educated at Bury St. Edmunds, and afterwards at St. John's College, Cambridge. He obtained about 1630 the vicarage of Chippenham in Cambridgeshire, and the rectory of Brightwell in Berkshire. At the breaking out of the civil war he was domestic chaplain to Robert Rich, second earl of Warwick, one of the parliamentary leaders, and, being selected to preach before the House of Commons in 1640, was presented with a silver tankard for his discourse. In 1641 he was appointed by the parliament to the deanery of Bocking, in Essex. He became master of the Temple in 1659, in succession to Dr. Ralph Brownrigg, bishop of Exeter, and after the Restoration in November, 1660, was appointed to the same diocese. Between 1642, the date of his first printed work, and 1660 he published some thirteen or more books, of which number, however, only one appeared prior to the execution of the king. Soon after his appointment to the see of Exeter, he privately laid claim to the authorship of the *Eikon Basilike*, a work commonly attributed at the time to Charles I. This claim Gauden put forth in a correspondence with the Lord Chancellor Hyde, earl of Clarendon, and the earl of Bristol, from 21st December, 1660, to 31st March, 1662. The letters of Gauden among them have been published in Dr. Maty's *Review* in 1782, and again in the Appendix to vol. iii. of the *Clarendon Papers*. In the year 1693 a Mr. Arthur North of London, who had married a sister of Dr. Gauden's daughter-in-law, published a series of letters which he had found among his sister-in-law's papers, and which added materially to the strength of the bishop's claim. They consisted of the other side of the correspondence referred to above, viz., a letter from Secretary Sir Edward Nicholas to Gauden in January, 1660–1, two from the bishop to Chancellor Hyde in December, 1661, and the duke of York in January, 1661–2, and one from Hyde to the bishop in March, 1661–2. These letters, however, have been regarded with considerable suspicion by late writers on the subject, and have even been pronounced to be forgeries by some, who have pointed out that the two letters written by Gauden himself to Clarendon and the duke of York were found in the bishop's house, not among the papers of the persons to whom they were directed. The letter also from Clarendon to Gauden, though written nine months after his obtaining his earldom, is signed Edward Hyde, a blundering anachronism which points to the unskilful hand of a forger. The whole question of the claims of Charles I. and Dr. Gauden was discussed at great length and with considerable ability and ingenuity from 1824 to 1829 by Dr. Christopher Wordsworth, master of Trinity College, Cambridge, on behalf of the king, and the Rev. H. J. Todd on the side of Dr. Gauden. Fresh evidence, however, has lately turned up in the shape of letters and papers of Charles II. and his ministers, written soon after the execution of the king, which go far to invalidate if not entirely destroy the claim of Dr. Gauden, and prove that those persons to whom he most confidently appealed in support of his pretensions were the strongest upholders of the king's authorship at the time immediately subsequent to the appearance of the work. In 1662, on the death of Brian Duppa, bishop of Winchester, Dr. Gauden applied to be translated from Exeter to that see, but his claims were set aside in favor of George Morley, bishop of Worcester, and the vacancy thus created was filled by the bishop of Exeter. He only lived four months after this last promotion, and dying on 20th September, 1662, was buried in Worcester Cathedral. His will is preserved in the Prerogative Office of Canterbury.

He left a widow, the daughter of Sir William Russell of Chippenham, who after her husband's death wrote a letter to her son John on the subject of the king's book, and enclosed in it a narrative of the whole claim. This was published with the correspondence mentioned above by Mr. North in 1693. She also erected a monument to the bishop's memory in Worcester Cathedral, representing him with the *Eikon Basilike* in his hand.

GAUDICHAUD-BEAUPRÉ, Charles (1789–1854), a French botanist, was born at Angoulême, September 4, 1789. He studied pharmacy first in the shop of a brother-in-law at Cognac, and then under Professor Robiquet at Paris, where from Desfontaines and L. C. Richard he acquired a knowledge of botany. In April, 1810, he was appointed dispenser in the military marine, and from July, 1811, to the end of 1814 he served at Antwerp. In September, 1817, he joined the corvette "Uranie," as pharmaceutical botanist to the circumpolar expedition commanded by De Freycinet (see vol. ix. p. 682). The wreck of the vessel on the Falkland Isles, at the close of the year 1819, deprived him of more than half the botanical collections he had made in various parts of the world. In 1830–33 he visited Chili, Peru, and Brazil, and in 1836–37 he acted as botanist to "La Bonite" during its circumnavigation of the globe. His theory accounting for the growth of plants by the supposed coalescence of elementary "phytons" involved him, during the latter years of his life, in much controversy with his fellow-botanists, more especially M. de Mirbel. He died January 16, 1854.

Besides his *Botanique du Voyage autour du Monde, exécuté pendant les Années* 1836–1837, 4 vols. fol., with plates, which included several previous works, Gaudichaud-Beaupré wrote "Lettres sur l'Organographie et la Physiologie," *Arch. de Botanique*, ii., 1833; "Recherches générales sur l'Organographie," etc. (prize essay, 1835), *Mém. de l'Académie des Sciences*, t. viii., and kindred treatises, besides memoirs on the potato-blight, the multiplication of bulbous plants, the increase in diameter of dicotyledonous vegetables, and other subjects; and *Réfutation de toutes les Objections contre les nouveaux Principes Physiologique*, 1852. See *Biographie Universelle*, t. xvi., 1856.

GAUERMANN, Friedrich (1807–1862), an Austrian painter, son of the landscape painter Jacob Gauermann (1773–1843), was born at Wiesenbach near Gutenstein, in Lower Austria, 20th September, 1807. It was the intention of his father that he should devote himself to agriculture, but the example of an elder brother, who, however, died early, fostered his inclination towards art, and though he had enjoyed no special instruction his first attempts at copying nature were so successful that his father was persuaded to permit him to choose a profession which seemed so much to accord with his natural bent. Under his father's direction he began studies in landscape, and he also diligently copied the works of the chief masters in animal painting which were contained in the academy and court library of Vienna. In the summer he made art tours in the districts of Styria, Tyrol, and Salzburg. Two animal pieces which he exhibited at the Vienna Exhibition of 1824 were regarded as remarkable productions for his years, and led to his receiving commissions in 1825 and 1826 from Prince Metternich and Caraman, the French ambassador. His reputation was greatly increased by his picture The Storm, exhibited in 1829, and from that time his works were much sought after and obtained correspondingly high prices. His Field Laborer was regarded by many as the most noteworthy picture in the Vienna Exhibition of 1834, and his numerous animal pieces have entitled him to a place in the first rank of painters of that class of subjects. The peculiarity of his pictures is the representation of human and animal figures in connection with appropriate landscapes and in characteristic situations so as to manifest nature as a living whole, and he particularly excels in depicting the free life of animals in wild mountain scenery. Along with great mastery of the technicalities of his art, his works exhibit patient and keen observation, free and correct handling of details, and bold and clear coloring. He died at Vienna, 7th July, 1862. Many of his pictures have been engraved, and after his death a selection of fifty-three of his works was prepared for this purpose by the Austrian *Kunstverein* (Art Union).

GAUGE, in the mechanical arts, is the name applied to a great variety of instruments, of which the object may be broadly stated to be the affording of increased facilities for comparing any two dimensions or distances. Wherever it is necessary for this to be done with a degree of accuracy unattainable by such means as the ordinary measuring rule affords, or for the same dimensions to be frequently measured with a maximum of speed and certainty, there will the hand-craftsman at once avail himself of some form of gauge. At the present day a due appreciation of the value of gauges is of growing importance to the mechanician, since they enable him greatly to improve the "fit" of the several portions of his machinery, whilst at the same time the labor expended in fitting is materially reduced. Indeed the system of making all similar parts "to gauge" so that in any number of machines they are interchangeable, is now effecting more than any other single cause for the improvement and cheapening of mechanical substitutes for manual labor.

The gauges which come within the province of this article differ in two main particulars, according as they refer the measurements which can be made by them to some definite and established standard of length, or take cognizance only of an arbitrary or haphazard one. The obvious advantage of being able to record, and at any time again obtain with certainty, the thickness of a plate of metal, or any other gauged dimension, would have led one to suppose that for all except mere temporary purposes the gauges used would invariably be of the first kind,—Standard Gauges, as we shall distinguish them. But the fact is unhappily far otherwise, at least as regards the important manufactures of sheet metal and wire (which cannot be easily measured without some form of gauge), the result being that the thickness and diameters of these are expressed by various complicated and irregular series of numbers and letters, which have no reference either to each other or to any standard system of measurement. Of these arbitrary series the B. W. G. or Birmingham Wire Guage may be taken as the type. The largest size of which it takes account is known as No. 0000, after which come 000, 00, 0, and then the numerals from 1 to 36, which last is the smallest size. It is frequently used for gauging the thickness of sheet metal as well as for wire, in spite of the existence of the Birmingham Plate Gauge, which has an equally arbitrary series of its own, consisting of the same numbers (from 1 to 36) used in the reverse manner, the low numbers being the small sizes. Other arbitrary wire gauges also tend to add to the general confusion, amongst which may be mentioned the Lancashire Gauge, which takes an alphabet and a half, in addition to the numerals up to 80, for expressing the sizes of steel wire which are referred to it, but which nevertheless does not apply to "music wire," or "needle-wire," or sundry other special kinds of wire, which are favored with separate gauges of their own. Of late years careful comparisons have more than once been independently made with a view to ascertaining the standard value of these incongruous systems, but the discrepancies in the results only prove what might have been predicted, viz., that errors have crept in, and that those which profess to be alike differ amongst themselves, whilst there exists no satisfactory means of rectifying these errors. Their gradual and entire abolition therefore seems to be the only chance of real improvement, and it is earnestly to be hoped that the Standard Gauge originally suggested by Sir J. Whitworth, which is now largely employed, may soon entirely supersede them. In this system the sizes are directly referred to the English imperial standard of length, each being expressed by the number of thousandth parts of an inch which it contains. Thus No. 36 wire means wire ·036 of an inch in diameter. Under the old systems this might have been either No. 20, No. 62, No. 3, or No. 18.

Examples of some of the usual forms of gauges are given below. For wire the simplest gauge consists of a steel plate with a series of holes drilled through it, each hole being numbered according to the series to which the gauge refers. By means of the Notched Gauge (fig. 1) sheet metal can be gauged by a similar mode of obtaining a more or less accurate fit. Rough gauges on the same principle are constantly employed also in workshop practice for comparing together internal or external diameters, etc.; and they serve the purpose well enough so long as the object is a mere comparison, without taking account of the amount of any minute difference which may exist. When a measurement of such differences is required, or direct reference to a standard system, recourse must be had to some form of gauge provided with means for enlarging them sufficiently to be readily recognizable. Sliding or Calliper Gauges, such as fig. 3, fulfil this requirement by having the graduated scale affixed to one of their arms and a vernier in connection with the other. A V-gauge, which, instead of a series of notches round its edge, has only one long tapering notch, by the graduations of which the diameter of any wire that will enter it can be read off, is simple and tolerably efficient. So also is the kindred arrangement (fig. 5), in which a wire or plate can be inserted between a fixed pin and the edge of a revolving cam with graduated face. But perhaps on the whole the best and handiest form is the Micrometer Gauge (fig. 2), which, by means of a micrometer screw with a divided head, measures to the one-thousandth part of an inch, and in careful hands can render visible even smaller fractions. Gauges consisting of two arms jointed together like pincers are also used in certain trades, minute differences in the width of the jaws being magnified and rendered visible on a graduated arc at the opposite ends of the arms.

FIG.1

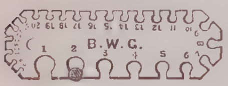


FIG.2

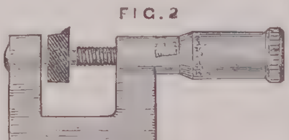
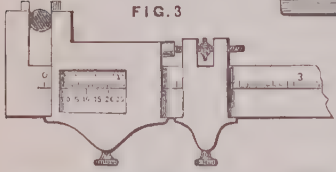


FIG.3



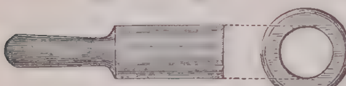


FIG.4

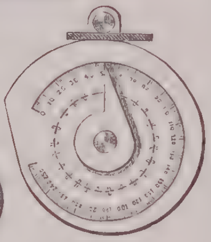


FIG.5

For special purposes gauges of many other forms are employed, some of which are of much greater delicacy, but these cannot be described here. The only others which remain to be mentioned are those of which the Plug and Collar Gauges (fig. 4) are the type, sets of which are now to be found in almost all mechanical workshops where the value of standard dimensions is recognized. Each gives only the one external or internal dimension for which it is made, but it gives that with the highest attainable accuracy, so that by carefully preserving a comparatively small number of these for reference, and using them in conjunction with measuring machines, the most minute differences can be measured and noted in terms of the standard, so that exact sizes can at any future time be again obtained without appreciable error. (C. P. B. S.)

GAUHÁTI, a town in Kámrúp district, Assam, the chief town of the province, situated on the left or south bank of the Brahmaputra, lat. 26° 11′ 18″ N., long. 91° 47′ 26″ E. Gauháti, which is the most populous town in the Brahmaputra valley, was the seat of the British administration of Assam up to 1874, when the headquarters were removed to Shillong in the Khási hills, 67 miles distant, with which it is connected by an excellent cart road. Gauháta is an important centre of river trade, and the largest seat of commerce in Assam. A regiment of native infantry is permanently cantoned there. Two much frequented places of Hindu pilgrimage are situated in the immediate vicinity, the temple of Kámákhyá on a hill 2 miles west of the town, and the rocky island of Umánánda in the mid-channel of the Brahmaputra. Population (1872), 11,492; municipal revenue, £2727.

GAUL, the name given by the Romans to the country lying between the Rhine and the Pyrenees. When the Greeks first became acquainted with the south-west of Europe they applied to the whole of it, in a somewhat vague sense, the term Celtice (ἡ Κελτική), calling its inhabitants Celts (Κελτοί). Later we find Galatia (Γαλατία) and Gallia (Γαλλία), with the corresponding Galati (Γαλάται) and Galli (Γάλλοι), used as nearly synonymous with the earlier name. The shorter of these two forms the Romans adopted; and in the opening chapter of Cæsar's well-known *Commentaries*, we have our first definite account of the limits of the country and its divisions, as then understood. According to this authority, Gaul was in his day divided among three peoples, more or less distinct from one another, the Aquitani, the Gauls, who called themselves Celts, and the Belgæ. The first of these extended from the Pyrenees to the Garumna (Garonne); the second from that river to the Sequana (Seine) and its chief tributary the Matrona (Marne), reaching eastward presumably as far as the Rhenus (Rhine); and the third from this bounding line to the mouth of the last-named river, thus bordering on the Germans. By implication Cæsar recognizes a fourth division, the Provincia, lying to the south in the basin of the Rhodanus (Rhone), and stretching westwards as far as Tolosa (Toulouse) in the basin of the Garonne—a portion of Gaul that had been subdued and made a Roman province about fifty years before Cæsar entered on his career of conquest there. By far the greater part of the country was a plain watered by numerous rivers, the chief of which have already been mentioned, with the exception of its great central stream, the Liger or Ligeris (Loire). Its principal mountain ranges were Cebenna or Gebenna (Cevennes) in the south, and Jura, with its continuation Vosegus or Vogesus (Vosges), in the east. The tribes inhabiting Gaul in Cæsar's time, and belonging to one or other of the three races distinguished by him, were numerous. Prominent among them, and dwelling in the division occupied by the Celts, were the Helvetii, the Sequani, and the Ædui, in the basins of the Rhodanus and its tributary the Arar (Saône), who, he says, were reckoned the three most powerful nations in all Gaul; the Arverni in the mountains of Cebenna; the Senones and Carnutes in the basin of the Liger; the Veneti and other Armorican tribes between the mouths of the Liger and Sequana. The Nervii, Bellovaci, Suessiones, Remi, Morini, Menapii, and Aduatici were Belgic tribes; the Tarbelli and others were Aquitani; while the Allobroges inhabited the north of the Provincia, having been conquered in 121 B. C.

The ethnological relations of Cæsar's three great Gallic races have given rise to much discussion. Greek writers, who, in consequence of the planting of the colony of Massilia (Marseilles) on its southern coast at so early a period as 600 B. C., had gained some knowledge of Gaul before the Romans, speak of its inhabitants as Ligurians; and it is certain that a people of this name occupied at one time the coast-line of Europe from the western slopes of the maritime Alps to the Rhone. By many these Ligurians are regarded as having once spread themselves over a much wider area, peopling extensive tracts of Europe as well as Northern Africa. Subsequently, another race, coming probably across the Pyrenees from Spain, subdued south-western Gaul and ruled as far north as the Garonne—the Basques of the two slopes of these mountains remaining to our own day their lineal representatives. Later still, but at a date which history does not venture to fix, one of those great waves of population that are believed to have rolled in succession from east to west brought into northern and central Gaul, it may be at an interval of centuries, the two great branches of the Celtic race, the Gadhelic or Gaelic and the Cymric—the one represented in Britain by the Irish and Scottish Highlanders, the other by the Welsh. Reading Cæsar's brief statements by the light thus afforded, ethnologists now generally hold that his Aquitani were Iberians, largely intermingled with intrusive Gauls; that his Gauls belonged to the Gaelic division of the Celtic race, and his Belgæ to the Cymric (both of them, however, being affected by the presence of races whose territory they had overrun, and the latter by the addition of a German element derived from their proximity to the Rhine); and that the natives of the Provincia were Ligurians, with so large an intermixture of Celts as to make the latter the dominant race. Neither the Greek colony of Massilia, nor those colonies sent out by it, can be supposed to have seriously affected the Gaulish nation from the point of view we are now discussing. It was in a different manner, as a civilizing agency, that they made their presence felt.

Such, it would appear, was Gaul ethnologically when made a part of the Roman empire by Julius Cæsar shortly before the commencement of the Christian era; and, as has often been remarked, such in the main it is still. Some recent scientific inquirers find grounds, however, for concluding that the opinion so prevalent not only in England but in France itself, that the physical and mental characteristics of the modern Frenchman are chiefly derived from the ancient Gauls, is only in part well founded. The Gauls, they say, like the Romans after them, were strong enough to impose their language on a race or races they had subjugated; but in the attempt to absorb them they themselves have suffered and continue to suffer so much that the day may yet come when the older race will all but regain its superiority. Slowly but surely, according to the researches of M. Roget, Baron de Belloguet, the blue-eyed, fair-haired, long-headed Celt has for many generations been giving place throughout France, in a direction proceeding from south to north, to a more ancient, dark-eyed, black-haired round-headed man—a similar phenomenon being also noticeable among the Germans.

Northern Italy, in consequence of an intrusion of Gauls at some early date, received from the Romans the name of Gallia Cisalpina or Citerior, to distinguish it from Gaul proper, called also Gallia Transalpina or Ulterior. Afterwards when the Roman element gained the upper hand, Togata was sometimes substituted for Cisalpina; while in contradistinction, Gallia Braccata was applied to the Provincia from the *braccæ* or trousers worn by the natives, and Gallia Comata to the rest of the country, from the inhabitants wearing their hair long. The Gaulish emigrations into Spain on the one hand, and into Britain on the other, scarcely come under the present article; still less can we refer here to the inroads of that restless race into various parts of eastern Europe and western Asia. But it may be remarked in passing that so extensive were the conquests of the Gauls that, in the beginning of the third century before our era, their empire, if much less compact, was scarcely less extensive than that of Rome in her palmiest days.

For some time after the death of Cæsar little attention could be paid to Gaul by the ruling powers at Rome; but in 27 B. C. Augustus, now master of the Roman world, took measures to Romanize it thoroughly. The old division into four provinces was retained, and made subservient to administrative purposes. The Provincia, however, received the name of Gallia Narbonnensis, from the Roman town of Narbo (Narbonne); the boundaries of Aquitania were extended to the Liger; what remained of Cæsar's Gauls were constituted the province of Gallia Lugdunensis, so named from its capital, the new settlement of Lugdunum (Lyons); and the northern division was called Gallia Belgica. This arrangement remained nearly unchanged till the 4th century, when the four provinces were broken up into seventeen, each with a capital and a number of other towns of more or less importance, the names of which may be found in the larger geographical and historical works that treat of the period. While an integral part of the Roman empire Gaul often played no mean part in the contests that took place for the imperial purple; and it was during one of these that Claudius Civilis, a Romanized Gaul, made a gallant attempt to achieve the independence of his country. His efforts, however, were not supported by the mass of the people, and the movement was crushed by Vespasian. Perhaps the most noteworthy event of those centuries was the insurrection of the Bagaudæ or peasant banditti, in the reign of Diocletian. Ruined and driven to despair by the exactions of the imperial treasury, men scoured the country in marauding bands, plundering wholesale. Though the revolt was suppressed, the lesson it ought to have taught Rome was unheeded, and thus the seeds of future troubles remained in the soil. In the declining days of the empire Gaul became a prey to the Visigoths in the south, the Burgundians in the east, and the Franks in the north-east. When order had arisen out of the confusion that ensued, the country was found to have taken under a new name a still more conspicuous place in the political system of Europe.

What is known of the ancient religion of the Gauls will be found under DRUIDISM (vol. vii. p. 412), and brief notices of their institutions and customs, as well as some particulars regarding the introduction of Christianity among them, are given in the article FRANCE (vol. ix. p. 466).

See Dom Martin, *La Religion des Gaulois*, Paris, 1727, 2 vols. 4to; Pelloutier, *Hist. des Celtes*, Paris, 1771, 2 vols. 4to; D. Schæpflinus, *Vindiciæ Celticæ*, Strasburg, 1754, 4to; Amédée Thierry, *Hist. des Gaulois*, Paris, 1828, 3 vols. 8vo; Henri Martin, *Hist. de France*, vol. i., Paris, 8vo; Walckenaer, *Géographie Ancienne historique et comparée des Gaules Cisalpine et Transalpine*, Paris, 1839, 3 vols. 8vo; Ukert, *Geographie der Griechen und Römer*, vol. ii., pt. ii., Weimar, 1832; Holtzman, *Kelten und Germanen*, Heidelberg, 1855, 8vo; Article "Gallia" (by G. Long), in Dr. W. Smith's *Dictionary of Greek and Roman Geography*, vol. i., London, 1869, 8vo; Roget, Baron de Belloguet, *Ethnogénie Gauloise*, Paris, 1868–1875, 4 vols. 8vo; E. Desjardins, *Géographie historique et administrative de la Gaule Romaine*, Paris, 1877, 4 vols. 8vo. (J. M'D.)

GAUNT, JOHN OF. See LANCASTER, DUKE OF.

GAUR, or, more commonly, GOUR, the name of a mediæval city in Bengal, of which the scattered relics cover a large area in the district of Malda, commencing not far south of the modern civil station of that name.

The name Gaur is a form of the ancient *Gauḍa* (meaning the country "of sugar"), a term which was applied to a large part of modern Bengal, and specifically to that part in which these remains lie. We have the names of dynasties, and partial lists of the kings of these dynasties, which bore the title of *Gaureshara*, lord of Gaur, or Gauḍa, before the first Mahometan invasion. The last of these dynasties, that of the Senas, or of the Vaidyas, superseded its predecessor, the dynasty of the Pálas, about the middle of the 11th century. The most eminent of this dynasty, by name Lakshmanasena, who flourished at the end of the century, is alleged in inscriptions to have extended his conquests to Kanauj (in the Doab), to Nepaul, and to the shores of Orissa; and this king is said by tradition to have founded the royal city in Gauḍa which in later days reverted to a form of this ancient name (Gaur), but which the founder called after his own name *Lakshmanavati*, or as it sounded in the popular speech *Lakhnaoti*. The fifth from this king, according to Lassen's (more or less imperfect) list, Lakshmaniya (*c.* 1160–1198), transferred the royal residence to Navadvípa, *hod.* Nadiya (on the Hoogly river 70 miles above Calcutta), possibly from apprehension of the rising tide of the Mahometan power; but here it overtook him. Nadiya was taken about 1198–99 (the precise date is disputed) by Mahommed Bakhtiyár Khilji, the general of the slave king Kutbuddín Aibak of Delhi, who became established as governor of Bengal, and fixed his capital at Lakhnaoti. Here he and his captains are said to have founded mosques, colleges, and monasteries. Lakhnaoti continued for the most part to be the seat of the rulers who governed Bengal and Behar, sometimes as confessed delegates of the Delhi sovereigns, sometimes as practically independent kings, during the next 140 years. From about the year 1338, with the waning power of the Delhi dynasties, the kingdom of Bengal acquired a substantive independence which it retained for more than two centuries. One of the earliest of the kings during this period, by name Iliyás (Elias) Sháh, whose descendants reigned in Bengal with brief interruptions for nearly 150 years, transferred the seat of government to Pandua (*c.* 1350), a place about 16 miles N. by E. of Gaur, and to the neighboring fortress of Ekdála, a place often named in Mahometan notices of the history of Bengal down to the 16th century. At Pandua several kings in succession built mosques and shrines, which still exhibit architecture of an importance unusual in Bengal proper. After some occasional oscillation the residence was again (*c.* 1446) transferred to Gaur, by which name the city is generally known thenceforward, that of Lakhnaoti disappearing from history. The 24th and last of those whom history recognizes as independent kings of Bengal was Mahmúd Sháh (1533–4 to 1538–9). In his time the city more than once changed hands, during the struggles between the Afghan Sher Sháh and the (so-called) "Great Moghul" Humayún, son of Báber; and on one occasion (1537–8), when Sher Sháh was operating against Gaur, we first hear of the Portuguese in the inner waters of Bengal. A party of that nation who had been sent with presents to the court of Gaur, had been detained as prisoners by the suspicious Mahmúd. But in the straits arising during his resistance to Sher Sháh, the Frank prisoners were able to render him good service.

Mahmúd was followed by several Pathán adventurers, who temporarily held the provinces of the delta with more or less assertion of royal authority. One of these, Suleimán Kirání (1564–5), abandoned Gaur for Tanda, a place somewhat nearer the Ganges. It is mentioned by Ralph Fitch, the earliest of English travellers in India, who calls it "Tanda in the land of Gouren," standing a league from the Ganges. Mu'ním Khán, Khánkhánán, a general of Akbar's, when reducing these provinces in 1575, was attracted by the old site, and resolved to re-adopt it as the seat of local government. But a great pestilence (probably cholera) broke out at Gaur, and swept away thousands, the general-in-chief being himself among the victims. On his death the deprived Pathán prince, Dáúd, set up his standard again. But he was defeated by the forces of Akbar in a battle at Rajmahl, and taken prisoner. After him no other assumed the style of king of Bengal. Tanda continued for a short time to be the residence of the governors under the "Great Moghuls," but this was transferred successively to Rajmahl and Dacca, in repeated alternation, and finally to Moorshedabad. Gaur cannot have been entirely deserted, for the Nawab Shújá-uddín, who governed Bengal 1725–1739, built a new gate to the citadel. But in history Gaur is no longer heard of, till its extensive remains attracted the curiosity of the English,—the more readily as the northern end of the site approaches within 4 miles of the important factory that was known as English Bazar (among the natives as Angrezábád), which is said to have been built of bricks from the ruins, and which is now the nucleus of the civil station of Malda.

The first specific notice of the city of Gaur, from actual knowledge, is contained in the Persian history called *Tabaqát-i-Násirí*, which has been partially translated in Elliot's *History of India* (ed. by Dowson), and is in course of complete translation by Major H. G. Raverty. The author, Minháj-i-Saráj, visited Lakhnaoti in 1243, but the only particular regarding the city that he mentions is that Ghiyás-uddín 'Iwaz, the fourth Mahometan ruler of Lakhnaoti (who called himself sultan, and according to this writer, struck coin in his own name), besides founding mosques, etc., carried embanked roads across the low country east and west of the city for a space of ten days' journey. These works in part still exist. "Radiating north, south, and east of the city, . . . embankments are to be traced running through the suburbs, and extending in certain directions for 30 or 40 miles" (Ravenshaw, p. 3).

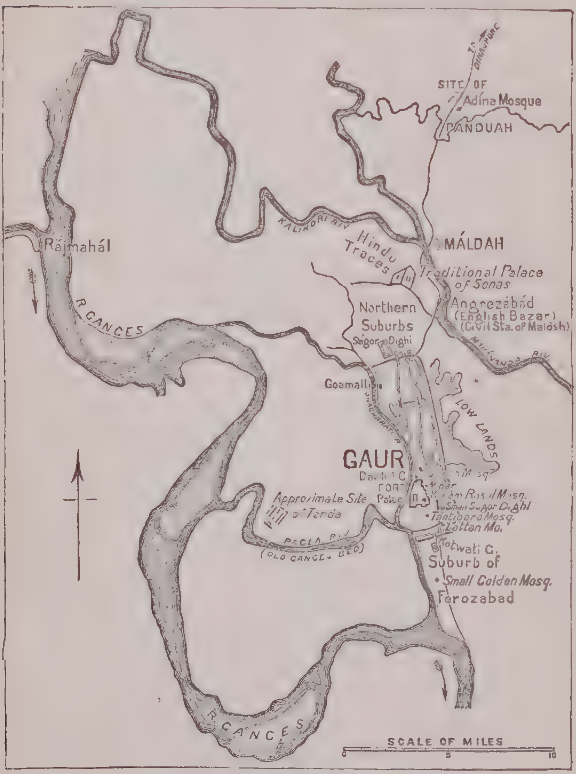


Chart of Gaur and its Environs.

The extent of ground over which the remains of Gaur are spread is astonishing; and a large part of it would appear to be still, as when described a century ago, covered with dense wood or with rank jungle of grass and reeds, though in later years cultivation has somewhat extended over the site. What may be called the site of Gaur proper is a space of an oblong form, extending from north to south 7½ miles, with a breadth varying from 1½ to 2 miles. This area is washed on one of its long sides (the western) by a stream called the Bhagirathi, which undoubtedly occupies a former bed of the Ganges (not to be confounded with the Bhagirathi further south, contributing to form the Hoogly on which Calcutta stands). Roughly parallel to the eastern side, but at a distance varying from 2 to 6 miles, runs the river Mahánanda, whilst extensive swamps and sheets of water are interposed between this river and the city. The extensive area of which we speak has been defended on north, west,[1] and south, by a rampart and ditch, whilst on the east side there is a double embankment of great size, with two ditches of immense width, and in some parts three. It is not quite clear from the descriptions in what degree these latter great works were intended respectively for defence or for protection from floods; but the latter must have been the main purpose. The Ain-i-Akbari (*c.* 1590) alludes to the fact that "if the earthen embankment broke, the town was under water." The position of the city, midway between two rivers of deltaic character, is low, and any rise in those rivers would raise the level of the marshes. Still the mass of these banks, as much as 200 feet thick at base, and 40 feet in height, is greater than any present exposure to flood seems sufficient to explain. It has sometimes been supposed that the Ganges, since the foundation of Gaur, has flowed to the eastward, in what is now the bed of the Mahánanda. If this were so, the massive character of the embankments would be more intelligible. It would appear, however, that the positive testimony to this circumstance, which was at one time supposed to exist, depended on a mistaken reading of the passage, referred to above, of the *Tabaqát-i-Násirí*.

These great embankments have been originally faced throughout with masonry, whilst the crest shows numerous traces of edifices; but the whole of the earthworks are now overgrown with dense jungle. The Ganges now flows at a distance varying between 5 and 12 miles to the west of the enclosed area of the city, but there seems to be no doubt that in the earlier centuries of its occupation the great river washed its western wall, where now the Bhagirathi flows.

On this side, near the southern end, stood the citadel or royal fortress, stretching for a mile along the river bank, and marked out by the remains of a huge rampart of irregular trace, 180 feet wide at the base, and once faced with masonry, with numerous circular bastions. Shapeless masses of ruin fill the interior. The palace itself formed a rectangular inner enclosure of 2100 feet by 750, girt by a splendid brick wall, 18 feet thick at bottom, 8½ feet thick at top, and 42 feet in height. To the northward the western embankment is prolonged far beyond the northern limit of the city, and about 3 miles north of the latter we encounter a vast line of earthwork stretching from the prolongation just mentioned, in an irregular curve eastward and then south-eastward to the vicinity of the Mahánanda river, in all for more than 6 miles. This also was probably intended chiefly as a defence against inundation of the suburbs. A huge excrescence protruding from the line, and overgrown with forest trees, encloses an area of nearly a square mile, which tradition points out as the palace of one of the Sena kings. Still north of this, and extending to the banks of the Kalindri river, some 3 miles further, are found traces of ancient Hindu buildings.

Turning again to the southern extremity of Gaur, for 6 or 7 miles to the south of the city there seems to have extended, still under the protection of a western embankment, a continuous chain of suburbs. In the northern portion, at least, of these, "prostrate domes, mingled with carved lintels and innumerable bricks, are seen lying in confusion on all sides, and show how dense has been the population" (Ravenshaw, p. 26). Thus from north to south, the whole extent of ground bearing indications of urban occupancy is hardly less than 20 miles. We may, however, feel confident that, as in the case of Delhi, these traces comprehend a space within which the royal city occupied various localities in various ages. Traditions, collected by Dr. Francis Buchanan, placed the residence of the older Sena kings on the sites at the extreme north near the Kalindri. The southern part of the fortified area of Gaur, with the citadel and palace, was evidently, as we shall see from the dates of the buildings, the seat of the later kings who immediately preceded the absorption of Bengal into the Moghul empire in the last half of the 16th century. The exact site occupied by Mahommed Bakhtiyár Khilji and his successors does not seem to have been determined.

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[1] This was so according to Buchanan; but Mr. Ravenshaw says "the western face is now open, and probably always was so, having been well protected by the Ganges . . . which ran under its walls." The plans *all* show an *embankment* on this side, and Creighton gives a section of it, 30 feet high.

Throughout the interior length of Gaur run embanked roads, whilst the whole area is thickly dotted with excavated tanks of all sizes, up to the great *Ságar Dighí* (or "Ocean Tank"), a rectangular sheet of water measuring little short of a mile by half a mile. This vast work is probably to be referred to the Hindu age. The former existence of six ghauts of masonry can be traced on its banks, which are densely wooded to the water's edge. Numerous excavated channels also run in every direction, the earth from which appears to have served to raise the inhabited surface. The remaining buildings of importance are scattered at wide intervals over the area, but the soil is throughout covered with fragments of brick, etc., in a manner which leaves no doubt of the former density of population. But Gaur has repeatedly been a quarry of building material. The old Lakhnaoti was robbed to build the mediæval capital of Pandua, and the later Gaur probably to build Rajmahl, whilst in more recent times their brick and stone were transported as merchandise to Malda, Moorshedabad, Hoogly, Rungpore, and even (as regards the more valuable kinds of stone) to Calcutta. In the revenue returns of Bengal, at the time of its transfer to the Company, there was an entry of an annual levy of 8000 rupees, as "Gaur brick royalty," from landholders in the neighborhood of Gaur who had the exclusive right of dismantling its remains. The bricks of Gaur, Rennell says, are of extraordinary solidity of texture and sharpness of edge. The facilities which the site affords for water carriage during the rainy season greatly aided this systematic spoliation. That no Hindu buildings remain from the earlier cities is probably to be accounted for by this process of destruction.

We have quoted a Mahometan visitor to Gaur in the middle of the 13th century. The next such mention perhaps occurs in the travels of the Venetian Nicolo Conti, who somewhat early in the 14th century ascended the Ganges 15 days' voyage to a city of great size and wealth called *Cernove*. On both banks of the stream were most charming villas, and plantations, and gardens. The name looks like *Shahr-i-nao*, which we know from coins to have been the name of a royal city of Bengal about 1380–85, and which Mr. Ed. Thomas believes to have been merely that given to one of the re-foundations of Gaur. A more detailed and certain account is given by De Barros, when describing the adventures of the Portuguese party in 1537–38, to which allusion has been made above (dec. iv. liv. ix. cap. i.):—

> "The chief city of this kingdom (of Bengala) is called *Gouro*. It is situated on the waters of the Ganges, and is said to be three of our leagues in length, and to contain 200,000 inhabitants.[1] On the one side it has the river for its defence, and on the landward faces a wall of stone and lime of great height, besides having, where the river comes not, a great ditch full of water, in which great boats can swim. The streets are broad and straight, and the main streets have trees planted in rows along the walls, to give shade to the passengers. And the population is so great, and the streets so thronged with the concourse and traffic of people, especially of such as come to present themselves at the king's court, that they cannot force their way past one another, and thus such as hap to fall among the horsemen, or among the elephants which are ridden by the lords and noblemen, are often killed on the spot, and crushed under the feet of those beasts. A great part of the houses of this city are stately and well wrought buildings."

The earliest detailed notice of the ruins that we hear of is a MS. one, by Mr. Reuben Burrows, the mathematician (1787), which is quoted by the editor of Creighton's drawings as being in the India Library. Rennell gives some account of the ruins in his *Memoir of a Map of Hindustan* (1788), and the plan of them is roughly laid down, on a small scale, in his Bengal Atlas (No. 15). Mr. Henry Creighton, who for many years managed an indigo factory among the ruins (1786–1806), made many drawings of them, with notes and a detailed map, on a large scale. Dr. Buchanan states that engravings from Creighton's drawings had been published by a Mr. Moffat in Calcutta before the compilation of his own statistical work. Of this we have seen no copy. It is probably the same as "the set of eight views of the ruins of Gour and Rajmehal," which is advertised in the *Calcutta Gazette*, 6th December, 1798 (see Seton Karr's *Selections*, vol. iii. p. 529). A work, however, was published in London in 1817, from the materials left by Mr. Creighton, called the *Ruins of Gour Described*, etc.; and this contained the most accessible data on the subject till Mr. Ravenshaw's work. There is in the India Office a MS. volume (1810) by Major William Francklin of the Bengal army, containing notices of the remains and translations of a good many inscriptions. The MS. purports to have been accompanied by maps and drawings, but these are not now forthcoming. Dr. Francis Buchanan has described the remains, with his usual somewhat dry precision, in his statistical survey of northern Bengal and Behar, executed between 1809 and 1816, but only published, with a title-page that bears the name of Montgomery Martin, and no reference to the real author, in 1838 (*Eastern India*, etc., vol. iii. pp. 68 *sq.*). Mr. James Fergusson has a short chapter, containing the only critical account of the architecture of Gaur, in his *History of Indian Architecture*. Lastly, since the greater part of this article was compiled, there has been published a splendid volume (*Gaur: its Ruins and Inscriptions*, 4to) from the photographs and notes of the late J. A. Ravenshaw of the Bengal Civil Service.

Before concluding we may indicate a few of the most notable remaining buildings.

1. One of the most pleasing remains, as regards architectural design, is a minaret or tower of stone and brick, standing immediately west of the citadel. It is 84 feet in height and 21 in diameter at the base. For two-thirds of the height the form is that of a 12-sided polygon, and above that circular, the two forms being divided by a bold cornice. There is now no inscription attached, but tradition assigns it to Firoz Shah, and a native history of Bengal compiled in the last century attributes it specifically to a king of that name, who reigned 1488–1490. Mr. Fergusson indeed considers the architecture to belong to an earlier period; and it is remarkable that the researches of Mr. E. Thomas in coins, and of the late Mr. Henry Blochmann in lapidary inscriptions, have recently established the existence of a King Shamsuddín Firoz, whose coinage at Lakhnaoti shows his reign to have extended from 1302 to 1318. If the work be really due to this prince, it is by much the oldest building of importance now remaining at Gaur. But the point is very doubtful.

2. The *Dákhil Darwáza*, or Gate of Entrance, is the northern gate of the citadel. It is a noble structure, though entirely built of small bricks. The tunnel under the rampart is 112 feet long by 14 wide, and the height of the archway is 34 feet. An inscription copied by Francklin ascribes the work to Bárbak Sháh, and the erection to 1466. The grandiose palace wall is believed to be of the same period.

3. The *Lattan* (?), or the *Painted Masjid*, a quadrangular edifice in the southern part of the city, cased inside and out with bricks beautifully enamelled in blue, green, and white. It is covered by one large dome. The work is ascribed to 1470–1481.

4. The *Tánti-Pára Masjid*, or Mosque of the Weaver's Quarter. This is now much dilapidated, but Ravenshaw's photograph indicates it to have been one of the most beautiful buildings in Gaur. The niched panels in carved brickwork which adorn its piers are very rich and delicate. It is also, if an inscription given by Francklin be justly assigned to it, the work of Yúsuf Shah, 1475–76.

5. The *Sona Masjid*, or Golden Mosque. This is probably the most important structure remaining in Gaur. It stands in the city to the north of the citadel, within a spacious court enclosed by a stone wall. The material is described as a dark grey stone, approaching to black, with sculpture in beautiful flower-work. The mosque measures 180 feet by 80, and the interior architecture consists of massive intersecting arcades, each intersection being covered by a dome, of which domes there were 44 altogether. In spite of the extraordinary solidity of the building it appears to have suffered greatly since Franck-

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[1] So in De Barros, Lisbon edition of 1777, vol. viii. p. 458, "duzentos mil vizinhos." But in the English version of Faria y Sousa's *Asia Portuguesa* by Stevens (1695), i. p. 417, a passage abridged from De Barros has "*one million* and two hundred thousand *families*." The last word is probably a mistranslation, but the *million* seems required.

lin described it in 1810. The date is fixed by an inscription which existed in his time to 1525.

6. Tombs of Shah Husain (d. 1521), and of his son Nasrat Shah, the builder of No. 5 (d. 1533–34). Of the tombs themselves nothing remains, and their materials are said to have been carried to Fort William in the last century. In Creighton's time, though the tomb of Husain Shah was already gone, there remained a beautiful edifice which had formed the gateway of the enclosure, faced with brick-work richly moulded, and glazed with blue and white. Of Shah Husain (reigned 1494–1521) Dr. Blochmann says, "Whilst the names of other Bengal kings scarcely ever occur in legends, and remain even unrecognized in the geographical names of the country, the name of 'Husain Shah the Good' is still remembered from the frontier of Orisa to the Brahmaputra" (*Proc. As. Soc. Bengal*, 1873, p. 291).

7. The mosque of the *Qadam Rasúl*, or Footstep of the Prophet, so named from a representation of Mahomet's footmark in stone which was formerly enshrined there. The work of Nasrat Sháh, 1530.

We thus see that all the buildings, with the very doubtful exception of the minaret, go back no further than the last half of the 15th century. If the age of the architecture is disappointing, the better knowledge of details which we derive from Mr. Ravenshaw's book enhances our appreciation of it. The buildings are in brick, in stone, and in both combined. Excepting the great gateways, they lack height enough for stateliness; the character is rather decorated solidity. The façades generally present a series of pointed arches, with very massive piers between, which are sometimes complicated polygons, but more usually rectangular; the mouldings have little relief, but the surfaces are adorned with panels filled with beautiful "embossed brick-work." These seem to be rich floral patterns moulded in terra-cotta, and probably finished with the chisel. The curvilinear roof, imitated from the use of the bamboo, of which Mr. Fergusson speaks as an unpleasing characteristic of architecture in Bengal, is little seen in Gaur,—almost the only indication of it being a slight upward camber in the upper lines of the façade, in which the versed-sine is about $\frac{1}{30}$th of the chord. In some of the buildings great brilliance has been produced by the profuse use of encaustic tiles in bright colors. The art of making these exists now in India nowhere nearer than in Sind; but indeed the manufacture of terra-cotta, or of ordinary brick of the superior character which Rennell attributes to Gaur, is equally a lost art in Bengal. Where the facing is entirely of stone, as in the Great Golden Mosque, and in a smaller one bearing the same name, the ornamentation seems imitated from the terra-cotta work; the relief, however, is much less, owing probably to the hardness of the material. What this material is, or whence, is not quite clear. The older accounts speak of black and other marbles; Buchanan and later writers of "black hornblende," "potstone," and what not; Mr. Ravenshaw, in the case of one building, of "granite and marbles." The black stone is probably basalt from the Rajmahl hills, but more precise information is desirable.

In conclusion, we may notice briefly the other neighboring sites occupied as capitals, which may be regarded as appendages of Gaur.

Pandua, commonly called *Parruah* or *Porruah*, was so occupied, with occasional intervals, for nearly a century. Its ruins and tanks extend over a narrow area of nearly 6 miles in length, which is now more of a wilderness than even the site of Gaur. The high road from Malda to Dinajpore passes through it from end to end, but the forest which besets the ruins is so dense on both sides, and so infested with tigers, that single travellers shun the road by night. Mr. Ravenshaw employed a gang of 200 men to clear the jungle for his photographs, but even then could only get partial views. The buildings exhibit the same general character as at Gaur, but most of them are older, and seem (for most of them are absolutely overgrown and penetrated by jungle-growth) to show the style in a freer and purer form. Many of them also contain fragments of older Hindu buildings, very probably pillaged from old Lakhnaoti. By far the finest and most important building in the whole Gaur group of cities, and indeed in Bengal, is the Adina mosque at Pandua, standing close to the high road. It is a quadrangular cloister of two stories, measuring externally 500 feet by 300, of brick-work faced throughout with "black hornblende." The cloisters are divided by pillars into intersecting aisles, and each intersection has been covered by a dome. Of these domes there have been originally 375, but most have fallen. According to Buchanan's description the carved windows have been borrowed from Buddhist structures, but judging from the poor drawings which he gives, and from the photographs of Mr. Ravenshaw made under great difficulties, the combination has been carried out with good artistic effect. The edifice must no doubt be monotonous, but from what we can see is far from deserving the condemnation which Buchanan passes on it. The Adina is the work of Sikandar Sháh, the son of Iliyás (1358–1390), and his tomb is in an adjunct of the mosque. There is a curious notice of it in Valentijn's (Dutch) *East Indies* (v. p. 169).

Ekdálah, which was the fortified retreat of the kings who ruled at Pandua, has been lately identified by Mr. E. V. Westmacott, as still bearing the name, near Chiramon, in the Dinajpore district, about 20 miles north of Pandua. It stands on high ground rising like an island out of the inundated plain; it exhibits traces of embankments and buildings, and is about 5 miles distant from one of the ancient embanked roads running towards Pandua and Gaur. *Tanda*, the last city of the Gaur group occupied as a capital, stood a few miles west of the citadel of Gaur, as may be gathered from Rennell and Buchanan. Dr. Hunter (*New Statist. Acc. of Bengal*, vii. p. 65) says its very site has not been accurately determined. It is possible that it may have been cut away by the waters of the Ganges, a branch of which has flowed near; but Buchanan had evidently visited it, and Creighton marks the rampart roughly in his map of Gaur. *Jannatábád* was a name given by Humáyún to Gaur; and other names of royal cities appear on coins, such as *Firuzábád*, *Husainábád*, *Shahr-i-nao*, etc., which are probably names officially attached to new foundations of portions of the great Gaur group of cities, but which gained no popular currency.

In addition to the works quoted in this article, the papers of Mr. E. Thomas and Mr. H. Blochmann in the journals of the Royal and Bengal Asiatic Societies have been consulted.

(H. Y.)

GAUSS, **Carl Friedrich** (1777–1855), an eminent German mathematician, was born of humble parents at Brunswick, April 23, 1777, and was indebted for a liberal education to the notice which his talents procured him from the reigning duke. His name became widely known by the publication, in his twenty-fifth year (1801), of the *Disquisitiones Arithmeticæ*. In 1807 he was appointed director of the Göttingen observatory, an office which he retained to his death: it is said that he never slept away from under the roof of his observatory, except on one occasion, when he accepted an invitation from Humboldt to attend a meeting of natural philosophers at Berlin. In 1809 he published at Hamburg his *Theoria Motus Corporum Cœlestium*, a work which gave a powerful impulse to the true methods of astronomical observation; and his astronomical workings, observations, calculations of orbits of planets and comets, etc., are very numerous and valuable. He continued his labors in the theory of numbers and other analytical subjects, and communicated a long series of memoirs to the Royal Society of Sciences at Göttingen. His first memoir on the theory of magnetism, *Intensitas vis magneticæ terrestris ad mensuram absolutam revocata*, was published in 1833, and he shortly afterwards proceeded, in conjunction with Professor Wilhelm Weber, to invent new apparatus for observing the earth's magnetism and its changes; the instruments devised by them were the declination instrument and the bifilar magnetometer. With Weber's assistance he erected in 1833 at Göttingen a magnetic observatory free from iron (as Humboldt and Arago had previously done on a smaller scale), where he made magnetic observations, and from this same observatory he sent telegraphic signals to the neighboring town, thus showing the practicability of an electro-magnetic telegraph. He further instituted an association (Magnetische Verein), composed at first almost entirely of Germans, whose continuous observations on fixed term-days extended from Holland to Sicily. The volumes of their publication, *Resultate aus der Beobachtungen des Magnetischen Vereins*, extend from 1836 to 1839; and in those for 1838 and 1839 are contained the two important memoirs by Gauss, *Allgemeine Theorie der Erdmagnetismus*, and the *Allgemeine Lehrsätze*—on the theory of forces attracting according to the inverse square of the distance. The instruments and methods thus due to him are substantially those employed in the magnetic observatories throughout the world. He co-operated in the Danish and Hanoverian measurements of an arc and trigonometrical operations (1821–48), and wrote (1843, 1846) the two memoirs *Ueber Gegenstände der höhern Geodäsie*. Connected with observations in general we have (1812–26) the memoir *Theoria combinationis observationum erroribus minimis obnoxia*, with a second part and a supplement. Another memoir of applied mathematics is the *Dioptrische Untersuchungen*, 1840. Gauss was well versed in general literature and the chief languages of modern Europe, and was a member of nearly all the leading scientific societies in Europe. He died at Göttingen early in the spring of 1855. The centenary of his birth was celebrated (1877) at his native place, Brunswick.

Gauss's collected works have been recently published by the Royal Society of Göttingen, in 7 vols. 4to, Gött., 1863–71, edited by E. J. Schering,—(1) the *Disquisitiones Arithmeticæ*, (2) *Theory of Numbers*, (3) *Analysis*, (4) *Geometry and Method of Least Squares*, (5) *Mathematical Physics*, (6) *Astronomy*, and (7) the *Theoria Motus Corporum Cœlestium*. They include, besides his various works and memoirs, notices by him of many of these, and of works of other authors in the *Göttingen gelehrte Anzeigen*, and a considerable amount of previously unpublished matter, *Nachlass*. Of the memoirs in pure mathematics, comprised for the most part in vols. ii., iii., and iv. (but to these must be added those on *Attractions* in vol. v.), it may be safely said there is not one which has not signally contributed to the progress of the branch of mathematics to which it belongs, or which would not require to be carefully analyzed in a history of the subject. Running through these volumes in order, we have in the second the memoir, *Summatio quarundam serierum singularium*, the memoirs on the theory of biquadratic residues, in which the notion of complex numbers of the form $a+bi$ was first introduced into the theory of numbers; and included in the *Nachlass* are some valuable tables. That for the conversion of a fraction into decimals (giving the complete period for all the prime numbers up to 997) is a specimen of the extraordinary love which Gauss had for long arithmetical calculations; and the amount of work gone through in the construction of the table of the number of the classes of binary quadratic forms must also have been tremendous. In vol. iii. we have memoirs relating to the proof of the theorem that every numerical equation has a real or imaginary root, the memoir on the *Hypergeometric Series*, that on *Interpolation*, and the memoir *Determinatio Attractionis*—in which a planetary mass is considered as distributed over its orbit according to the time in which each portion of the orbit is described, and the question (having an implied reference to the theory of secular perturbations) is to find the attraction of such a ring. In the solution the value of an elliptic function is found by means of the *arithmetico-geometrical mean*. The *Nachlass* contains further researches on this subject, and also researches (unfortunately very fragmentary) on the lemniscate-function, etc., showing that Gauss was, even before 1800, in possession of many of the discoveries which have made the names of Abel and Jacobi illustrious. In vol. iv. we have the memoir *Allgemeine Auflösung*, on the graphical representation of one surface upon another, and the *Disquisitiones generales circa superficies curvas*. And in vol. v. we have a memoir *On the Attraction of Homogeneous Ellipsoids*, and the already mentioned memoir *Allgemeine Lehrsätze*, on the theory of forces attracting according to the inverse square of the distance. (A. CA.)

GAUSSEN, FRANÇOIS SAMUEL ROBERT LOUIS (1790–1863), a Protestant theological writer of some repute, was born at Geneva on the 25th of August, 1790. His father Georges Marc Gaussen, a member of the council of two hundred, was descended from an old Languedoc family which had been scattered at the time of the religious persecutions in France. At the close of his university career, Louis was ordained in 1816 to the ministry of the Swiss Reformed Church at Satigny near Geneva, where he formed intimate relations with J. E. Cellérier, who had preceded him in the pastorate, and also with the members of the dissenting congregation at Bourg-de-Four (Église du temoignage), which had been formed under the influence of the preaching of the Haldanes in 1817. In 1819 he published in conjunction with Cellérier a French translation of the second Helvetic Confession, with a preface expounding the views he had reached upon the nature, use, and necessity of confessions of faith; and in 1830, for having discarded the official catechism of his church as being insufficiently explicit on the divinity of Christ, original sin, and the doctrines of grace, he was censured and suspended by his ecclesiastical superiors. In the following year, for having taken part in the formation of a Société Évangélique, which contemplated, among other objects, the establishment of a new theological hall, he was finally deprived of his charge. After some time devoted to travel in Italy and England, he returned to Geneva and ministered to an independent congregation until 1836, when he became professor of systematic theology in the college which he had helped to found. This post he continued to occupy until 1857, when he retired from the active duties of the chair. His death occurred at Les Grottes, Geneva, on the 18th of June, 1863. His best known work, entitled *La Théopneustie ou Pleine Inspiration des Saintes Écritures*, an elaborate defence of the doctrine of "plenary inspiration," was originally published at Paris in 1840, and rapidly gained a wide popularity in France, as also, through translations, in England and America. It was followed in 1860 by a supplementary treatise on the canon (*Le Canon des Saintes Écritures au double point de vue de la Science et de la Foi*), which, though also popular, has hardly been so widely read. Gaussen was also the author of two published series of sermons, of an exposition of Daniel, and of a variety of occasional publications of a missionary or polemical character. His lectures on Genesis, Exodus, Joshua, Jonah, and Luke were published posthumously.

GAUTIER, THÉOPHILE (1811–1872), was born at Tarbes in the year 1811. He was educated at the grammar school of that town, and afterwards at the Collége Charlemagne in Paris, where it does not appear that he particularly distinguished himself, though in later life his remarkable literary faculty and instinct enabled him to give to much of his work an air of scholarship and almost of erudition. He very early devoted himself to the study of the older French literature, especially that of the 16th and the early part of the 17th century. This study qualified him well to take part in the romantic movement, and enabled him to astonish Sainte-Beuve by the phraseology and style of some literary essays which, when barely eighteen years old, he put into the great critic's hands. In consequence of this introduction he at once came under the influence of the great romantic *cénacle*, to which, as to Victor Hugo in particular, he was also introduced by his gifted but ill-starred schoolmate Gérard de Nerval. With Gérard, Petrus Borel, Corot, and many other less known painters and poets whose personalities he has delightfully sketched in the articles latterly collected under the titles of *Histoire du Romantisme, etc.*, he formed a minor romantic clique who were distinguished for a time by the most extravagant eccentricity. A flaming crimson waistcoat and a great mass of waving hair were the outward signs which qualified Gautier for a chief rank among the enthusiastic devotees who attended the rehearsals of *Hernani* with red tickets marked "Hierro," performed mocking dances round the bust of Racine, and were at all times ready to exchange word or blow with the *perruques* and *grisâtres* of the classical party. In Gautier's case, however, whatever they might be in others, these freaks were not inconsistent with real genius and real devotion to sound ideals of literature. He began (like Thackeray, to whom he presents in other ways some striking points of resemblance) as an artist, but soon found that his true powers lay in another direction. His first considerable poem, *Albertus* (1830), displayed a good deal of the extravagant character which accompanied rather than marked the movement, but also gave evidence of uncommon command both of language and imagery, and in particular of a descriptive power hardly to be excelled. The promise thus given was more than fulfilled in his subsequent poetry, which, in consequence of its small bulk, may well be noticed at once and by anticipation. The *Comédie de la Mort*, which appeared soon after (1832), is one of the most remarkable of French poems, and though never widely read has received the suffrage of every competent reader. Minor poems of various dates, published in 1840, display an almost unequalled command over poetical form, an advance even over *Albertus* in vigor, wealth, and appropriateness of diction, and abundance of the special poetical essence which is so often absent in the most finished poetical work. All these good gifts reached their climax in the *Émaux et Camées*, first published in 1856, and again, with additions, just before the poet's death in 1872. These poems are in their own way such as cannot be surpassed. Gautier's poetical work contains in little an expression of his literary peculiarities. There are, in addition to the peculiarities of style and diction already noticed, an extraordinary feeling and affection for beauty in art and nature, and a strange indifference to anything beyond this range—an indifference nearly absolute, and which has doubtless injured the popularity of his work to almost as great a degree as that in which it has increased its special excellence and its charm to those who have a taste for it.

But it was not, after all, as a poet that Gautier was to achieve either profit or fame. Thrown as he was into circles which were nothing if not literary, it was natural that he should attempt all literary forms, and certain, considering his powers, that he should be successful in all. For the theatre, however, he had but little gift, and his dramatic efforts (if we except certain masques or ballets in which his exuberant and graceful fancy came into play) are by far his weakest. For a time he acted as secretary to Balzac, but found this occupation uncongenial enough, though it left some traces in his independent work. His first novel of any size, and in many respects his most remarkable work, was *Mademoiselle de Maupin* (1835). Unfortunately this book, while it establishes his literary reputation on an imperishable basis, was unfitted by its subject, and in parts by its treatment, for general perusal, and created even in France a prejudice against its author which he was very far from really deserving. During the years from 1833 onwards, his fertility in novels and tales was very great. *Les Jeune France* (1833), which may rank as a sort of prose *Albertus* in some ways, displays the follies of the youthful romantics in a vein of humorous and at the same time half-pathetic satire. *Fortunio* (1838) perhaps belongs to the same class. *Jettatura*, written somewhat later, is less extravagant and more pathetic. A crowd of minor tales display the highest literary qualities, and rank with Mérimée's at the head of all contemporary works of the class. First of all must be mentioned the ghost story of *La Morte Amoureuse*, a gem of the most perfect workmanship. For many years Gautier continued to write novels. *La Belle Jenny* (1864) is a not very successful attempt to draw on his English experience, but the earlier *Militona* (1847) is a most charming picture of Spanish life. In *Spirite* (1866) he endeavored to enlist the fancy of the day for supernatural manifestations, and a *Roman de la Momie* (1856) is a learned study of ancient Egyptian ways. His most remarkable effort in this kind, towards the end of his life was *Le Capitaine Fracasse* (1863), a novel of the school of Dumas projected nearly thirty years before. This book contains some of the finest instances of his literary power.

It was, however, neither in poems nor in novels that the main occupation of Gautier as a literary man consisted. He was early drawn to the more lucrative task of feuilleton writing, and for more than thirty years he was among the most expert and successful practitioners of this art. Soon after the publication of *Mademoiselle de Maupin*, in which he had not been too polite to journalism, he became irrevocably a journalist. The rest of his life was spent either in Paris or in travels of considerable extent to Spain, the Netherlands, Italy, Turkey, England, Algeria, and Russia, all undertaken with a more or less definite purpose of book making. Having absolutely no political opinions, he had no difficulty in accepting the second empire, and received from it considerable favors, in return for which, however, he in no way prostituted his pen, but remained a literary man pure and simple. He died in October, 1872. Accounts of his travels, criticisms of the theatrical and literary works of the day, obituary notices of his contemporaries, and above all art criticism, occupied him in turn. In the last department he has never had a superior, nor perhaps, except in the cases of Diderot and a great living English critic, an equal. It has sometimes been deplored that this engagement in journalism should have diverted Gautier from the performance of more capital work in literature. Perhaps, however, this regret springs from a certain misconception. Gautier's power was literary power pure and simple, and it is as evident in his slighest sketches and criticisms as in *Émaux et Camées* or *La Morte Amoureuse*. On the other hand, his weakness, if he had a weakness, lay in his almost total indifference to the matters which usually supply subjects for art and therefore for literature. He was neither immoral, irreligious, nor unduly subservient to despotism, but morals, religion, and politics (to which we may add science and material progress) were matters of no interest to him. He was to all intents a humanist, as the word was understood in the 15th century. But he was a humorist as well, and this combination, joined to his singularly kindly and genial nature, saved him from some dangers and depravations as well as some absurdities to which the humanist temper is exposed. As time goes on it may be predicted that, though Gautier may not be widely read, yet his writings will never cease to be full of indescribable charm and of very definite instruction to men of letters. Besides those of his works which have been already cited, we may notice *Une larme du Diable* (1839), a charming mixture of humor and tenderness; *Les Grotesques*, a volume of early criticisms on some oddities of 17th century literature; *Caprices et Zigzags*, miscellanies dealing in part with English life; *Constantinople, Voyage in Russie, Voyage in Espagne*, brilliant volumes of travel; *Ménagerie Intime* (1869), and *Tableaux de Siège* (1872), his two latest works, which display his incomparable style in its quietest but not least happy form. (G. SA.)

GAUZE, a light, transparent, silken fabric, woven in an open manner with very fine yarn. It is said to have been originally made at Gaza in Palestine, whence the name. In the weaving of gauze the warp threads, in addition to being crossed as in plain weaving, are twisted in pairs from left to right and from right to left alternately, after each shot of weft, thereby keeping the weft threads at equal distances apart, and retaining them in their parallel position. The textures are woven either plain, striped, or figured; and the material receives many designations, according to its appearance and the purposes to which it is devoted. A thin cotton fabric, woven in the same way, is known as leno, to distinguish it from muslin made by plain weaving. Silk gauze was a prominent and extensive industry in the west of Scotland during the second half of the 18th century, but on the introduction of cotton weaving it greatly declined. In addition to its use for dress purposes silk gauze is much employed for bolting or sifting flour and other finely ground substances. The term gauze is applied generally to transparent fabrics of whatever fibre made, and to the fine woven wire-cloth used in safety-lamps, sieves, window-blinds, etc.

GAVARNI, French caricaturist, was born at Paris in 1801, and died in 1866. His true name was Chevalier (Sulpice Guillaume), and he is said to have taken the *nom de plume* under which he is known from the place where he made his first published sketch. His parents were poor, and he started in life as a workman in an engine-building factory. At the same time he attended the free school of drawing. Here his natural talent was developed, and he acquired that training of the hand without which an artist is unable to work up his best inspirations. In his first attempts to turn his abilities to some account he met with many disappointments, but was at last entrusted with the drawing of some illustrations for a journal of fashion. Gavarni was then thirty-four years of age. His sharp and witty pencil gave to these generally commonplace and unartistic figures a life-likeness and an expression which soon won for him a name in fashionable circles. Gradually he gave greater attention to this more congenial work, and finally ceased working as an engineer to become the director of the journal *Les Gens du Monde*. His ambition rising in proportion to his success, Gavarni from this time followed the real bent of his inclination, and began a series of lithographed sketches, in which he portrayed the most striking characteristics, foibles, and vices of the various classes of French society. The letterpress explanations attached to his drawings were always short, but were forcible and highly humorous, if sometimes trivial, and were admirably adapted to the particular subjects. The different stages through which Gavarni's talent passed, always elevating and refining itself, are well worth being noted. At first he confined himself to the study of Parisian manners, more especially those of the Parisian youth. To this vein belong *les Lorettes, les Actrices, les Coulisses, les Fashionables, les Gentilshommes bourgeois, les Artistes, les Débardeurs, Clichy, les Étudiants de Paris, les Baliverneries Parisiennes, les Plaisirs Champêtres, les Bals masqués, le Carnaval, les Souvenirs du Carnaval, les Souvenirs du Bal Chicard, la Vie des jeunes hommes, les Patois de Paris*. He had now ceased to be director of *Les Gens du Monde;* but he was engaged as ordinary caricaturist of *Le Charivari*, and, whilst making the fortune of the paper, he made his own. His name was exceedingly popular, and his illustrations for books were eagerly sought for by publishers. *Le Juif Errant*, by Eugène Sue (1843, 4 vols. 8vo), the French translation of Hoffman's tales (1843, 8vo), the first collective edition of Balzac's works (Paris, Houssiaux, 1850, 20 vols. 8vo), *Le Diable à Paris* (1844–46, 2 vols. 4to), *Les Français peints par eux-mêmes* (1840–43, 9 vols. 8vo), the collection of *Physiologies* published by Aubert in 38 vols. 18mo (1840–42),—all owed a great part of their success at the time, and are still sought for, on account of the clever and telling sketches contributed by Gavarni. A single frontispiece or vignette was sometimes enough to secure the sale of a new book. Always desiring to enlarge the field of his observations, Gavarni soon abandoned his once favorite topics. He no longer limited himself to such types as the *lorette* and the Parisian student, or to the description of the noisy and popular pleasures of the capital, but turned his mirror to the grotesque sides of family life and of humanity at large. *Les Enfants terribles, les Parents terribles, les Fourberies de femmes, la Politique des femmes, les Maris vengés, les Nuances du sentiment, les Rêves, les Petits Jeux de Société, les Petits malheurs du bonheur, les Impressions de ménage, les Interjections, les Traductions en langue vulgaire, les Propos de Thomas Vireloque*, etc., were composed at this time, and are his most elevated productions. But whilst showing the same power of irony as his former works, enhanced by a deeper insight into human nature, they generally bear the stamp of a bitter and even sometimes gloomy philosophy. This tendency was still more strengthened by a visit to England in 1849. He returned from London deeply impressed with the scenes of misery and degradation which he had observed among the lower classes of that city. In the midst of the cheerful atmosphere of Paris he had been struck chiefly by the ridiculous aspects of vulgarity and vice, and he had laughed at them. But the debasement of human nature which he saw in London appears to have affected him so forcibly that from that time the cheerful caricaturist never laughed, or made others laugh again. What he had witnessed there became the almost exclusive subject of his drawings, as powerful, as impressive as ever, but better calculated to be appreciated by cultivated minds than by the public, which had in former years granted him so wide a popularity. Most of these last compositions appeared in the weekly paper *L'Illustration*. In 1857 he published in one volume the series entitled *Masques and Visages* (1 vol. 12mo), and in 1869, about two years after his death, his last artistic work, *Les Douze Mois* (1 vol. fol.), was given to the world. Gavarni was much engaged, during the last period of his life, in scientific pursuits, and this fact must perhaps be connected with the great change which then took place in his manner as an artist. He sent several communications to the Académie des Sciences, and till his death, which happened on the 23d of November, 1866, he was eagerly interested in the question of aerial navigation. It is said that he made experiments on a large scale with a view to find the means of directing balloons; but it seems that he was not so successful in this line as his fellow-artist, the caricaturist and photographer, Nadar.

Gavarni's *Œuvres choisies* were edited in 1845 (4 vols. 4to) with letterpress by J. Janin, Th. Gautier, and Balzac, followed in 1850 by two other volumes named *Perles et Parures;* and some essays in prose and in verse written by him were collected by one of his biographers, Ch. Yriarte, and published in 1869. The book written by E. and J. de Gonwurt, *Gavarni l'homme et l'œuvre* (1873, 8vo), must be mentioned here. J. Claretie has also devoted to the great French caricaturist a curious and interesting essay. A catalogue *raisonné* of Gavarni's works has been published by J. Armelhault and E. Bocher, Paris, 1873, 8vo.

GAVELKIND is a peculiar system of tenure prevailing chiefly in the county of Kent, but found also in other parts of England. In Kent all land is presumed to be holden by this tenure until the contrary is proved. It is more correctly described as socage tenure, subject to the custom of gavelkind. The chief peculiarities of the custom are the following. (1.) A tenant can aliene his lands by feoffment at fifteen years of age. (2.) There is no escheat on attainder for felony, or as it is expressed in the old rhyme—

> "The father to the bough,
> The son to the plough."

(3.) Generally the tenant could always dispose of his lands by will. (4.) In case of intestacy the estate descends not to the eldest son but to all the sons in equal shares. "Every son is as great a gentleman as the eldest son is." It is to this remarkable peculiarity that gavelkind no doubt owes its local popularity. The 4 & 5 Vict. c. 35, for commuting manorial rights in respect of lands of copyhold and customary tenure, contains a clause specially exempting from the operation of the Act "the custom of gavelkind as the same now exists and prevails in the county of Kent." Gavelkind is one of the most interesting examples of the customary law of England, and it is no doubt correctly traced to the Saxon land-law prevailing before the Conquest. Its survival in this instance in one part of the country is regarded as a concession extorted from the Conqueror by the superior bravery of the men of Kent.

GAVIAL. See Crocodile.

GAY, John (1688–1732), one of the most eminent of the secondary English poets, was a native of Devonshire, born in 1688 at Frithelstock, near Torrington, where his family had been long settled. His father dying when the future poet was only about six years of age, and leaving four children, the prospects of the family were unpromising; and John, after receiving his education at the grammar school of Barnstaple, was put apprentice to a silk mercer in London. He disliked the employment, obtained his discharge, and embarked in a literary life, varied only by incessant efforts to obtain the patronage of the great. How he lived up to his twenty-second year is not stated. In 1710 he published his poem of *Wine*, an enumeration of the charms of the "enlivening grape," written in the grave, mock-heroic, and minutely descriptive style, which he afterwards displayed with greater power in his *Trivia*. In 1712 he was received into the household of the duchess of Monmouth in the capacity of secretary. Next year he published his *Rural Sports*, inscribed to Pope; and this seems to have led to a friendship between the poets uninterrupted and sincere. The superiority of Pope was freely conceded. There could be no rivalry on the part of Gay, and Pope appears to have exerted himself on every occasion to serve his friend. Gay's ambition was limited to a life of ease, fine-dressing, and a luxurious table, in all of which he had marvellous success, but little contentment. In the years 1713 and 1714, besides the *Rural Sports*, he produced a comedy, *The Wife of Bath*, which was acted only three nights; *The Fan*, a poem; and *The Shepherd's Week*, a series of six pastorals drawn from English rustic life. Pope is believed to have incited his friend to this task in order to cast ridicule on the Arcadian pastorals of Ambrose Philips, who had been lavishly praised in the *Guardian* (ignoring the claims of Pope) as the first pastoral writer of the age, and the true English Theocritus. The malicious wit was completely successful, but Gay's ludicrous pictures of the English swains and their loves were found to be interesting and amusing without reference to their sarcastic origin. The poem was popular, and the author's reputation considerably advanced. In this fortunate year Gay was appointed secretary to the earl of Clarendon, ambassador to the court of Hanover; but the death of Queen Anne, August 1, 1714, soon put an end to his hopes of permanent official employment. He then tried the drama, and produced his farce of *What d'ye Call it?* which was acted with little success in February, 1714–15. In 1716 appeared his *Trivia, or the Art of Walking the Streets of London*, a poem in three books, for which he acknowledged having received several hints from Swift. It is an excellent *town* poem, containing graphic and humorous descriptions of the London of that period. In January, 1716–17, the comedy of *Three Hours after Marriage* was brought on the stage, and emphatically condemned. In this piece Gay was assisted by Pope and Arbuthnot. Pope is distinctly visible in his allusions to Dennis the critic; and it is remarkable that three such men should have produced a play so dull, unnatural, and gross. Gay was taken to Aix by Mr. Pulteney in 1717. In 1720 he collected his poems and published them by subscription, by which he is said to have realized £1000. Secretary Craggs also presented him with some South Sea stock; and Gay called in his friends to advise as to the investment of his riches. Erasmus Lewis, according to Johnson, advised him to intrust his money to the funds, and live upon the interest; Arbuthnot bade him intrust it to Providence, and live upon the principal; while Pope directed him, and was seconded by Swift, to purchase an annuity. This was Pope's own prudent system; but Gay, like many others who ask advice, followed none, but took his own way. He embarked all in South Sea stock; and, refusing to sell out before the bubble burst, he lost the actual principal as well as the anticipated profit. The calamity overwhelmed him; his life was despaired of; but his friends exerted themselves to cheer and succor the desponding bard. Lord Burlington entertained him for months in his princely house at Chiswick; and Pope, Arbuthnot, and the other members of the circle were unceasing in their attentions. By the beginning of 1724 he had a new play ready, a tragedy called the *Captives*, which was patronized by the Princess (afterwards Queen) Caroline and the Prince of Wales. In 1726 he published his famous *Fifty-one Fables in Verse.* His next work was the *Beggar's Opera*, performed in 1727, written in ridicule of the Italian Opera, which for a time it drove off the English stage. Swift suggested the subject, and Pope is believed to have added some poignancy to the satirical songs; but Gay's own *bonhomie* and voluptuous style color the whole. The play ran to the end of the season, sixty-two nights, four of which were for the benefit of the author, and produced to him the handsome sum of £693, 13s. 6d. The same year he sold his copyright of the *Opera*, with that of the *Fables*, for 90 guineas. The success of *The Beggar's Opera* induced Gay to attempt a continuation of the operatic style. He wrote another piece, *Polly*, with no satirical design, as he states: but the lord chamberlain prohibited its representation. The poet then resorted in 1729 to publication by subscription; his friends were again active —the duchess of Queensberry even bearding royalty in resentment of the refusal of the license; and Gay must have cleared above £1000 by what was deemed his oppression. The duke of Queensberry received Gay into his house, and the duchess treated him with equal respect for his talents and character. This clever, beautiful, and eccentric woman—the idol of the poets—appears nowhere to more advantage than in her affectionate patronage of Gay, and her long-cherished regret for his loss. The poet died, after a short illness, December 4, 1732, and the duke and duchess of Queensberry honored his remains with a splendid funeral and monument in Westminster Abbey. A week before his death another opera, *Achilles*, had been brought out with applause, and this, with a new volume of *Fables*, was published in 1733, the profits going to his sisters, two widow ladies, who inherited by the poet's death no less than £6000. As late as 1743 appeared the posthumous comedy of *The Distrest Wife* and the farce of *The Rehearsal at Gotham* in 1753. Pope and Swift—always ready to blame the court and courtiers, though far from averse to their society—have censured Mrs. Howard, afterwards countess of Suffolk, for not more zealously promoting the interests of Gay by her supposed influence with the king. One offer was made to the poet,—the situation of gentleman-usher to the Princess Louisa, a child,—but he declined it on account of his being, as he writes to Swift, so far advanced in life. He was only thirty-nine; but all Gay's friends seem to have treated the offer as an indignity. When the queen's establishment was made up in 1727, they expected some more important office for their favorite associate, though it is not easy to discover what appointment about the court could have been better adapted to one so easy, so natural, and helpless. Mrs. Howard, it is now known, had very little influence with her royal master. The real power was in the hands of the queen, and the philosophical Caroline was content that his Majesty (who hated *bhoetry* and *bhainting*, and looked upon poets as mechanics) should possess what mistresses he pleased, provided that the state power and patronage continued with herself and Walpole. But it may be safely said that no man could have acquired such a body of great and accomplished friends as those which rallied round Gay and mourned his loss, without the possession of many valuable and endearing qualities. His poetry is neither high nor pure; but he had humor, a fine vein of fancy, and powers of observation and local painting which bespeak the close poetical student and the happy literary artist. (R. CA.)

GAY, MARIE FRANÇOISE SOPHIE, MADAME (1776–1852), daughter of M. Nichault de Lavalette (who was attached to the household of Monsieur, afterwards Louis XVIII.), and of Francesca Peretti, a Florentine lady, was born at Paris, 1st July, 1776. Under the guidance of her father, a man of taste and culture, she received a very careful education. In 1793 she was married to M. Liottier, an exchange broker, but she was divorced from him in 1799, and shortly afterwards was married to M. Gay, receiver-general of the department of the Roër or Ruhr. This union brought her into more intimate relations with many distinguished personages whom she had previously known; and her circle of acquaintanceship gradually extended, until her *salon* came to be frequented by all the distinguished litterateurs, musicians, actors, and painters of the time, among whom she made herself remarked by her beauty, her vivacity, and her sprightly wit tempered by fine tact and genuine amiability. Her first literary production was a letter written in 1802 to the *Journal de Paris*, in defence of Madame de Stael's novel *Delphin;* and in the same year she published anonymously her first novel *Laure d'Estell*. *Léonie de Montbreuse*, which appeared in 1813, is considered by Sainte-Beuve her best work; but *Anatolie*, which appeared in 1815, has perhaps a higher reputation. These and several of her other works, amongst which may be specially named *Les Salons célèbres*, possess an interest beyond their intrinsic merits—chief of which are purity and elegance of style—for their portraitures of French society especially during the period of the directory and the consulate, and of many of the distinguished personages whose intimacy she enjoyed. Madame Gay wrote several theatrical pieces which had considerable success. She was also an accomplished player on the pianoforte and harp, and composed both the words and music of a number of *romances*. For an account of her daughter Delphine Gay, Madame de Girardin, see GIRARDIN.

Besides the works already mentioned, she is the author of *Les Malheurs d'un amant heureux*, 1818; *Théobald, épisode de la guerre de Russie*, 1828; *Le Moqueur amoureux*, 1830; *Un Mariage sous l'Empire*, 1832; *Scènes du jeune âge*, 1833; *Physiologie du ridicule*, 1833; *La Duchesse de Châteauroux*, 1834; *Souvenirs d'une vieille femme*, 1834; *La Comtesse d'Egmont*, 1836; *Marie de Mancini*, 1840; *Marie-Louise d'Orléans*, 1842; *Ellénore*, 1844–46; *Le Faux Frère*, 1845; *Le Comte de Guiche*, 1845; and *Le Mari confident*, 1849. See Theophile Gautier, *Portraits Contemporains;* and Sainte-Beuve, *Causeries du Lundi*, vol. vi.

GAYÁ, a district of British India in the Patná division, under the lieutenant-governor of Bengal, situated between 24° 17′ and 25° 19′ N. lat., and between 84° 4′ and 86° 5′ E. long. It is bounded on the N. by Patná, on the E. by Monghyr, on the S. E. and S. by Hazáribágh, and on the W. by Sháhábád districts. Generally speaking, Gayá consists of a level plain, with a ridge of prettily wooded hills along the southern boundary, whence the country falls with a gentle slope towards the Ganges. Rocky hills occasionally occur, either detached or in groups, the loftiest being Máher hill about 12 miles S. E. of Gayá town, with an elevation of 1620 feet above sea-level. The eastern part of the district is highly cultivated; the portions to the north and west are less fertile; while in the south, the country is thinly peopled, and consists of hills, the jungles on which are full of wild animals. The principal river is the Son, which marks the boundary between Gayá and Sháhábád, navigable by small boats throughout the year, and by craft of 20 tons burden in the rainy season. The other rivers are the Pímpún, Phálgú, and Jamná, and a number of smaller streams. Two branches of the Son canal system, the eastern main canal and the Patná canal, intersect the district.

The census of 1872 takes the area of Gayá district at 4718 square miles, and returns the population at 954,129 males and 995,621 females,—total, 1,949,750, residing in 6530 villages or towns, and 327,845 houses. Classified according to religion, there are 1,729,890 Hindus, 219,332 Mahometans, 203 Christians, and 316 "others." Amongst the higher castes there is an unusually large proportion of Bráhmans, a circumstance due to the number of sacred places which the district contains. The Gayáwáls, or priests in charge of the holy places, are held in high esteem by the pilgrims; but they are not pure Bráhmans, and are looked down upon by those who are. They live an idle and dissolute life, but are very wealthy, from contributions extorted from the pilgrims. The ruined city of Buddh Gayá, about 6 miles south of Gayá town, marks the residence of Sakya Sinha, the founder of the Buddhist religion, who flourished in the 6th century B.C., and an ancient tree is pointed out as the identical fig tree under which the sage sat in abstraction for five years, until he attained to the state of Buddha. Another place of religious interest is a temple of great antiquity, which crowns the highest peak of the Barabar hills, and at which a religious fair is held each September, attended by from 10,000 to 20,000 pilgrims. At the foot of the hill are numerous rock caves excavated about 200 B. C.

Seven towns in Gayá district contain upwards of 5000 inhabitants, viz., Gayá, 66,843; Jahánábád, 21,022, Dáudnagar, 10,058; Tikárí, 8178; Sherghátí, 7033; Hasúá, 6119; and Rajauli, 5012. About four-fifths of the surface is cultivated. Rice forms the great agricultural staple, the area under cultivation being estimated at about 900,000 acres, yielding an outturn of over 400,000 tons. Wheat occupies about 170,000 acres, producing a crop of 60,000 tons, of which one-half is exported. Oil seeds are grown on about 35,000 acres, and opium on between 60,000 and 70,000 acres. Cotton, sugar-cane, chilies, and vegetables are also grown. Droughts are common, and in the famine of 1866 Gayá suffered severely. The scarcity of 1873–74 did not affect the district to any great extent. Manufactures consist of common brass utensils, black stone ornaments, pottery, *tasar* silk cloth. Formerly cloth-weaving and paper-making were important manufactures in the district, but these industries have now almost entirely died out. The chief exports are food grains, oil seeds, indigo, crude opium (sent to Patná for manufacture), saltpetre, sugar, blankets, brass utensils, etc. The imports are salt, piece goods, cotton, timber, bamboos, tobacco, lac, iron, spices, and fruits. The principal trade route is along the Patná branch road. The total net revenue of the district in 1876–77 was £188,426, of which £136,692 was derived from the land; the net civil expenditure, £23,878. The district and municipal police of all ranks numbered 923, besides a rural force of 6790 men paid by the landholders and villagers. The number of schools in 1873–74 was 446, attended by 8139 pupils. The climate of Gayá is dry and healthy,—the average annual temperature being about 80° F., and average annual rainfall 35·59 inches.

GAYÁ, the chief town and administrative headquarters of the above district, situated on the bank of the Phálgú river, lat. 24° 47′ 15″ N., long. 85° 3′ 10″ E. The population in 1872 numbered 66,843:—Hindus, 52,265; Mahometans, 14,444; Christians, 134. The municipal income in 1871 was £2716, and the expenditure £2351. The town consists of two distinct parts, adjoining each other; the part containing the residences of the priests is Gayá proper; and the other, which is the business quarter, is called Sáhibganj. The civil offices and residences of the European inhabitants are situated here. Gayá derives its sanctity from incidents in the life of Buddha connected with the adjoining district. But a local legend also exists concerning a pagan monster of great sanctity named Gayá, who wickedly tried to save sinners from deserved perdition. Brahma, in order to get rid of Gayá, induced him to lie down in order that a feast might be held on his body; and once down, he placed a large stone on him to keep him there. The tricked demon struggled violently, and, in order to pacify him, Brahma promised that the gods should take up their permanent residence in him, and that any one who made a pilgrimage to the spot where he lay should be delivered from the terrors of the Hindu place of torment. This may possibly be a Brahmanic rendering of Buddha's life and work. There are forty-five sacred spots in and around town, which are visited by from 100,000 to 200,000 pilgrims annually.

GAY-LUSSAC, JOSEPH LOUIS (1778–1850), one of the most distinguished of modern physicists and chemists, was born at St. Léonard, in the department of Haute Vienne, on the 6th of December, 1778. His father, Antoine Gay, who was procureur du roi and judge at Pont-de-Noblac, had added to the common family name the distinctive title Lussac, from a small property he had in the neighborhood of St. Léonard. The family consisted of two sons, of whom Joseph Louis was the elder, and three daughters. Intended for the bar, young Gay-Lussac prosecuted his early studies in Latin and other elementary subjects at home, under the superintendence of the Abbé Bourdeix and other masters, until 1794, when he was sent to Paris, where he worked very hard for three years preparing for admission to the École Polytechnique. After a brilliant examination he was received into this institution on December 27, 1797, whence on the 22d of November, 1800, he was transferred to the school Des Ponts et Chaussées. Shortly afterwards he was assigned to Berthollet, who had returned from Napoleon's Egyptian expedition, and who was desirous of having an able student from the École Polytechnique to aid him in his researches. The results expected by the author of the *Statique Chimique* were not verified by his assistant's experiments, which seem to have been recorded without any consideration of the theorizer's feelings. It was on this occasion, according to Arago, that Berthollet, at first nettled to find that his ideas were not confirmed, delivered himself as follows: "Young man, it is your destiny to make discoveries. You shall be henceforth my companion. I wish —it is a title of which I am sure I shall have cause some day to be proud—I wish to be your father in science."

Gay-Lussac accordingly entered on a long series of researches upon certain physical phenomena, which though of constant recurrence in experimental inquiries, had up to this time been very imperfectly examined. In his first memoir (*Ann. de Chimie*, t. xliii., 1802) he shows that different gases are dilated in the same proportion when heated from 0° to 80° (Réaumur). He does not seem to have been aware of Dalton's experiments on this subject, which were indeed very far from being accurate; but he states in a footnote that "le cit. Charles[1] avait remarqué depuis 15 ans la même propriété dans ces gaz; mais, n'ayant jamais publié ses résultats, c'est par le plus grand hasard que je les ai connus." In return for his having thus rescued from oblivion the remark which his fellow-citizen, probably wisely, did not think worth recording, some recent authors have changed the title of the law from that of Gay-Lussac to that of Charles. The investigations recorded in this memoir were followed by experiments on the improvements of thermometers and barometers, on the tension of vapors, their mixture with gases, and the determination of their density, evaporation, hygrometry, and capillarity. In course of these researches, which engaged him for a couple of years, he acquired not only dexterity in manipulation and the contrivance of experiments, but a great deal of valuable knowledge of physics. During the interval, in the year 1802, he had been nominated Fourcroy's demonstrator at the École Polytechnique, and as he had in this capacity to lecture frequently for the professor, he was beginning to acquire reputation as a teacher and expounder of chemistry and physics, by the clearness, precision, and care which his lectures evinced. In 1803–4 certain results respecting terrestrial magnetism had been obtained during two balloon ascents, which appeared of so much interest that the French Academy was desirous of having them repeated. Through Berthollet and Chaptal the balloon which had been used in Egypt was obtained, and fitted up with various instruments; the observations were entrusted to Gay-Lussac and Biot, who made their first ascent from the garden of the Conservatoire des Arts et Metiers, on August 24, 1804. In this ascent an altitude of 4000 metres was attained, but unexpected difficulties were encountered, and the results were not decisive. Not satisfied with the expedition, Gay-Lussac got a larger balloon provided with every requisite, and made an ascent by himself on September 16 of the same year. On this occasion the balloon rose to a height of 7016 metres, an altitude greater than any which had been formerly reached, and surpassed only by a few later ascents. At this great elevation of nearly 23,000 feet, and with the thermometer at 9½° C. below freezing, Gay-Lussac remained for a considerable time making observations on temperature, on the moisture of the air, on magnetism, and other points. He observed particularly that he had considerable difficulty in breathing, that his pulse was quickened, and that by the absence of moisture in the air his mouth and throat became so parched that it was painful to swallow even a piece of bread. The experiments on magnetism for which the ascent was primarily made were imperfect, but they led him to the conclusion that the magnetic effect at all attainable elevations above the earth's surface remains constant.[2] Having collected samples of air at different elevations he, on his return to Paris, proceeded to analyze them; and in conjunction with Alexander von Humboldt, whom he had associated with himself in this investigation, he published several papers on eudiometric analysis and related topics. The memoir, which was read to the Institute on October 1, 1804, contained the germ of what was afterwards Gay-Lussac's most important generalization. The authors observed that when oxygen and hydrogen combine together by volume, it is in the proportion of one volume of the former to two volumes of the latter. Prior to this the numerous experiments on the volume composition of water had always brought out various complicated ratios, though approaching the simple one more or less closely. It was not, however, till 1808, that Gay-Lussac announced the law of combination by volume in its general form. Shortly after these investigations were completed, Gay-Lussac got leave of absence to accompany Von Humboldt on a scientific journey to Switzerland, Italy, and Germany. Provided with physical and meteorological instruments, they left Paris March 12, 1805, and travelled by Lyons, Chambery, and Mont Cenis to Genoa, and thence to Rome, where they arrived on July 5. After a short stay at Rome in the residence of William von Humboldt, during which Gay-Lussac made a few chemical analyses, they departed for Naples in company with Leopold von Buch, afterwards so eminent as a geologist. During this visit Gay-Lussac had the opportunity of studying on the spot volcanic eruptions and earthquakes. Vesuvius, which was in violent action, he ascended six times. After this the party went back to Rome, and then started for Florence on September 17, 1805. A few days having been spent there, they went on to Bologna and thence to Milan, which they reached on October 1, and there they had the pleasure of meeting Volta. The party crossed the St. Gotthard on October 14–15, in the midst of a storm which prevented their seeing anything, and after some delay reached Göttingen, where they were received with much attention by Blumenbach, the famous naturalist. On November 16 they arrived at Berlin, where the winter and the following spring were spent. In this way Gay-Lussac became acquainted with the best society in Berlin, and was especially intimate with Klaproth and Erman. In spring he hurriedly returned to Paris. The death of an Academician had left a vacant place, and he was hopeful that he might be elected to fill it. Arago remarks that it is curious that Gay-Lussac should have found it necessary to be on the spot to ensure success. What he had already done for science might have been considered sufficient, apart from personal considerations, but there were prejudices which might have acted unfavorably, if he had not been present to meet them. These were, however, successfully overcome, and he entered the Academy in 1806. In the following year was inaugurated the Société d'Arcueil, a small group of scientific men who used to assemble at Berthollet's house. Gay-Lussac was an original member of this society, which is of interest chiefly on account of its having been the means of publishing some papers which have since proved of great historical interest. The results of his magnetic observations made along with Humboldt were published in vol. i. of its *Mémoires* (1807); and vol. ii. (1809) contains the important memoir on gaseous combination, in which he pointed out that, when gases combine with one another by volume or by measure, they do so in the very simplest proportions, 1 to 1, 1 to 2, 2 to 3, and so on, and that the volume of the product in the gaseous state bears a very simple ratio to that of the constituents. This law, which, along with Humboldt, he had shown to be true of water, he extended to several other gases, and he even deduced from the vapor density of compounds that of certain elements, more particularly, carbon, mercury, and iodine, which had not been ascertained by direct experiment.

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[1] The inventor of the "Charlière," or hydrogen balloon.

[2] The numerous observations made in both ascents are recorded in the *Journal de Physique* for 1804, vol. 59.

It would take too much space to give in detail the criticism which the enunciation of the principle evoked, more particularly from Dalton, who would not accept Gay-Lussac's position, and affirmed his belief that "gases do not unite in equal or exact measures in any one instance; when they appear to do so, it is owing to the inaccuracy of our experiments."[1] There was at that time the difficulty that the specific gravity of gases and vapors had been imperfectly determined, and the necessary consequence of Gay-Lussac's law, that the specific gravity and combining weight of elements should be expressed by the same number, could not be experimentally confirmed. Moreover, Dalton rested combination on atomic and not on combining weights, and the numbers he employed were in almost every instance very different from those which more accurate analysis has since determined. But the imperfect character of the then available data, and the amount of seemingly adverse experimental evidence, only throw a stronger light on the genius of Gay-Lussac in divining a law which, as science has progressed, has been duly confirmed, and which not only forms the most important control of the combining weight of chemical substances, but, when interpreted by the kinetic theory of gases, shows that the physical molecules (that is to say, the portions of the substance which are not broken up into smaller parts during the motion which we call heat) exist in equal numbers in equal volumes of different gases at the same temperature and pressure. This law, which has as high a claim as the other to bear the name of Gay-Lussac, is also sometimes deprived of that honor, and called the law of Avogadro, who, long afterwards, by his more extended researches, caused the importance of the law to be recognized by chemists.

The next events in Gay-Lussac's scientific career are connected with what may be called his rivalry with Davy, who in matter of age (b. December 17, 1778) was almost exactly his contemporary. In 1808 when Davy, having isolated potassium and sodium, was awarded Napoleon's prize for the most important discovery in voltaic electricity, the emperor is said to have asked how it was that these discoveries were made abroad and French prizes were carried away. Having been informed that there was no battery of power equal to that used by Davy, he caused a very large one to be made, and presented it to the École Polytechnique. While waiting for it, Gay-Lussac and Thénard succeeded in preparing potassium by a direct chemical action, in which fused potash was brought in contact with red-hot iron. This method enabled chemists to prepare the alkali metals in quantity, and Gay-Lussac and Thénard availed themselves of it to examine the properties of potassium very completely, and not only so, but also to use it as a means of decomposing other substances. It was in this way that they separated boron from boracic acid, an element which was also prepared by Davy with the same materials. It is worth notice that Davy admitted the advantage of the method of Gay-Lussac and Thénard, though he seems to have subsequently regarded their appropriation of the newly-discovered metal as not altogether warranted.[2] The researches with the great battery after it was made did not come up to their expectations; the power fell far short of what had been anticipated, and they confined themselves rather to an examination of the phenomena presented by the apparatus itself, than to using it as an engine for effecting important decompositions.

In 1809 was published the second investigation parallel to one by Davy, namely, upon hydrochloric (or, as it was then called, muriatic) acid, and chlorine, then called oxymuriatic acid. This memoir was read to the Institute, and was also published in the second volume of the *Mémoires d'Arcueil.* Gay-Lussac and Thénard describe a crowd of reactions they had tried for determining the characters of these bodies. They pointed out differences between the muriatic and other acids, and indicated that the anomalies which it presented were explicable either on the hypothesis of water being an essential constituent of the acid, or on that of the oxymuriatic acid being a simple gas. At the end of their memoir, however, they decided in favor of oxymuriatic acid being compound, although they had failed to get oxygen from it by heating it with carbon. The explanation of this decision seems to be that, while they themselves were influenced to some extent by Lavoisier's oxygen theory of acids, some of the other members of the Arcueil Society, such as Laplace and Berthollet, were keen Lavoisierians, and were prepared to oppose any criticism which might lead to a modification of the great Frenchman's opinion on so vital a point. To admit the existence of an acid without oxygen might have led to a loss of the whole scientific position which France had gained by Lavoisier's defeat of phlogiston. Davy, who was not under the same influence, declared, as the result of his inquiries, that oxymuriatic acid gas was simple, and that, therefore, there may be acids without oxygen. Some time after, Gay-Lussac and Thénard agreed with this view, which they could do with less hesitation, as they had themselves indicated it in their own memoir.

Among the investigations which Gay-Lussac undertook with Thénard in the years 1810–11, and which ultimately yielded most valuable results, must be mentioned those upon organic chemistry, and especially upon the analysis of fixed organic compounds. Before this time the only way of determining the composition of organic substances was to explode them with oxygen, and as this method was practicable only in the case of bodies which were gaseous, or could be readily volatilized, the great majority of fixed organic substances still remained unexamined. Gay-Lussac and Thénard introduced the plan of adding some oxidizing agent to the substance and burning it in a tube. They used chlorate of potassium, and the products of combustion were collected over mercury. The results obtained were in some cases very accurate, but the process was difficult of execution, and it is singular that the authors should have preferred it to combustion with oxide of copper, which they also tried. In 1815, however, Gay-Lussac employed the latter agent for the examination of cyanogen, and the other method was abandoned. The final improvements were made some years later by Liebig, when working in Gay-Lussac's laboratory. By their original method Gay-Lussac and Thénard determined the composition of fifteen organic substances, including sugar, starch, gum, wax, oil, various woods, resin; mucic, oxalic, tartaric, citric, and acetic acids; and albumen, fibrin, gelatin, and casein. Gay-Lussac succeeded also, in 1811, in obtaining pure hydrocyanic acid. He described its physical properties, but did not announce anything about its composition till 1815, when he published his celebrated memoir in which he described cyanogen as a compound radical, prussic acid as a compound of this radical with hydrogen alone, and the prussiates as compounds of the radical with metals. He also showed how to prepare free cyanogen, and explained Berthollet's oxyprussic acid to be really chloride of cyanogen. The proof that prussic acid contains hydrogen and no oxygen was a most important support to the hydrogen acid theory, while the isolation of the radical cyanogen was of equal importance for the subsequent epoch of compound radicals in organic chemistry.

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[1] *New System of Chemical Philosophy*, Manchester, 1810, part ii., p. 559.

[2] Gay-Lussac and Thénard made no claim, of course, to the discovery of potassium and sodium, though several important discoveries followed from their experiments. Thus, in addition to boron, they got also the fluoride of boron; and by the rapid combustion of the alkali metals in dry oxygen they got their peroxides, by means of which Thénard subsequently prepared the peroxide of hydrogen. At first, however they seem to have thought that the alkali metals contained hydrogen, and it was not for a couple of years that they accepted Davy's view of their simplicity. Indeed, about this time there appears to have been considerable uncertainty about the elemental character of the metals, it being thought that they contained hydrogen, an idea which, on account of its retrograde nature, was criticised by Davy as a kind of phlogistic revival.

In 1813–14 Gay-Lussac published his memoirs on iodine. This was the third investigation which involved a rivalry with Davy, and it was also that about which there was most feeling. Courtois had discovered the substance in 1811, and had given some of it for examination to Clément-Désormes. He had only published a brief notice of it when Davy arrived in Paris, having obtained express permission of Napoleon to pass through France on his way to Italy. Davy got a few fragments of this curious substance, and after a brief examination with a very limited portable laboratory, which he had with him, perceived its analogy to chlorine, and drew the conclusion that it must be a simple body of similar character. Gay-Lussac, it is said, having heard of Davy's making experiments with it, went off to Courtois, got a specimen, and proceeded to examine it. He also saw its likeness to chlorine, but his previous decision respecting that body hampered him, and it was with some hesitation that he ultimately acknowledged its elemental character. Whether or not Gay-Lussac was actuated by the motive ascribed to him by Arago—that it would be a reflection on French science were the settlement of the characters of this substance to be left to a foreigner visiting Paris—it is not necessary to inquire; but Davy seems to have felt that Gay-Lussac was competing, and not altogether fairly, with him. In a letter to Clément he gives a brief account of his work, and lays claim to the first revelation of the elemental character of iodine, and again in a subsequent letter to his brother, which contains a short review of the Parisian chemists and their reception of him, the only complaint he makes is that Gay-Lussac had played him a trick in trying to appropriate the discovery of the character of iodine and of hydriodic acid. Quite apart, however, from this claim on Gay-Lussac's part, the memoirs remain models of investigation and description. Davy quite freely admitted that full light might be expected on the subject from its having been taken in hand by so able and accurate a chemist as Gay-Lussac.

The year 1815 saw the completion of the research on cyanogen already referred to, and with it concludes the period of Gay-Lussac's most important discoveries. Having now attained a leading, if not the foremost place among the scientific men in the French capital, his advice was often required on important questions. His attention was thus turned in part from purely scientific subjects to points of practical interest. In these new fields, however, he displayed the same powers which he had exercised so sedulously in the pursuit of scientific truth; in fact he was now to introduce and establish scientific accuracy where there had been previously only practical approximations. The most important of these later discoveries were the method of estimating the amount of real alkali in potash and soda by the volume of standard acid required for neutralization; the method of estimating the amount of available chlorine in bleaching powder by a solution of arsenious acid; directions for the use of the centesimal alcoholometer, published in 1824, and specially commended by the commission of the Institute appointed to report on it, as displaying all the accuracy and exhaustive treatment of the author; and lastly, the perfecting of the method of assaying silver by a standard solution of common salt, a volume on which was published in 1833. This last has superseded the old method of assaying silver by cupellation, as being more rapid, more accurate, and easier of execution; and indeed all these processes are so complete and satisfactory, and are besides so identified with their author's name, that his reputation is secured by them, quite independently of his earlier work. In what has been said above, only the more important of Gay-Lussac's discoveries have been alluded to. To enter into an account, however brief, of all his labors, would occupy more space than can be allowed here. Indeed the list of his papers in the Royal Society's catalogue amounts to 148, besides those of which he was joint-author with Von Humboldt, Thénard, Welter, and Liebig; and they embrace every department of the science as cultivated fifty years ago. Among his later researches may be mentioned those on fermentation, and those executed by Liebig in conjunction with him, after the young German chemist had gained the coveted admission to Gay-Lussac's private laboratory during the years 1823–24. The latter include improvements on organic analysis, and the examination of fulminic acid. Gay-Lussac continued his work, and published the results in the *Annales de Chimie*, of which he had been joint-editor for some thirty years, up till almost his death, which took place at Paris on May 9, 1850.

Some of the appointments he held have been already referred to. After having acted as Fourcroy's demonstrator, he was made professor of chemistry at the École Polytechnique. From 1808 to 1832 he was professor of physics at the Sorbonne, and he only resigned that office when he was made professor of chemistry at the Jardin des Plantes. Besides being on the commission of arts and manufactures, and the "administration" of gunpowder and nitre, he was appointed assayer for the mint in 1829. In 1831 he was elected to the chamber of deputies as member for Haute Vienne, and finally, in 1839, entered the chamber of peers.

Gay-Lussac's scientific work is remarkable not only for its range but for its intrinsic worth, its accuracy of detail, its experimental ingenuity, its descriptive clearness, and the soundness of its inferences. He did not hesitate to criticise his own results, and replace them by others more accurate either of his own, or of another's discovery; he improved and invented physical and chemical apparatus; the barometer, thermometer, cathetometer, alcoholometer, and the burette, which still bears his name, all bear witness to his ingenuity and practical skill. He devised new analytical methods; he discovered new substances, such as fluoride of boron, and iodic, hydrosulphocyanic, dithionic, and hyposulphurous acids; he enlarged and corrected the knowledge of those already discovered; he examined the physical conditions of chemical action; he searched into the causes of chemical combination and chemical change. That he had the power of grasping the law underlying a few facts is nowhere more evident than in the memoir on gaseous combination, his most important contribution to science. That he missed the opportunity of assigning the chief limit to Lavoisier's hypothesis, must be ascribed partly at least to the influence of others. Authority decided it, perhaps against his secret convictions.

From Arago's and other notices one gathers that Gay-Lussac was reticent, patient, persevering, accurate to punctiliousness, perhaps a little cold and reserved, and not unaware of his great ability. But he was also bold and energetic, not only in his work, but equally so in defence and support of his friends. His earliest childish adventures, as told by Arago, herald the fearless aeronaut and undaunted investigator of volcanic eruptions. The endurance he exhibited under the laboratory accidents which befell him shows the power of will with which he could face the prospect of becoming blind and useless for the prosecution of the science which was his very life, and of which he is one of the most distinguished ornaments. It was only at the very end, when the disease from which he suffered left him no hope, that he complained with some bitterness of the hardship of leaving this world when so many discoveries were making, and when so many more were likely to be made.

The more important of Gay-Lussac's papers are scattered through journals difficult of access. The most complete list of them is contained in the Royal Society's catalogue of scientific papers; lists are also given at the end of Hoefer's article in the

Biographie Générale, and in Poggendorff's *Biographisch-literarisches Handwörterbuch*, Leipsic, 1863. Accounts of various portions of Gay-Lussac's discoveries and views will be found in such works as Thomson's *History of Chemistry*, vol. ii., London, 1830; Kopp's *Geschichte der Chemie*, Brunswick, 1843–47; Kopp's *Entwickelung der Chemie*, Munich, 1871; Dumas, *Leçons sur la Philosophie Chimique*, Paris, 1837, and reprinted Paris, 1878; Ladenburg, *Vorträge über die Entwickelungsgeschichte der Chemie*, Brunswick, 1869; Forbes, *A Review of the Progress of Mathematical and Physical Science in more recent times*, Edinburgh, 1858. The chief authorities for the life of Gay-Lussac are Arago (*Œuvres*, Paris, 1855, t. iii.); Biot (*Abstracts, Royal Society*, vol. v., 1843–50, p. 1013); P. A. Cap (*Le Muséum d'Histoire Naturelle*, Paris, 1854, pt. 1, p. 137). (J. F.)

GAZA, an ancient city of Philistia, close to the sea and to the south boundary of the Holy Land. The Hebrew is more correctly rendered in English as Azzah (Deut. ii. 23), and means "strong." The modern Arabic form of the name is Ghazzeh. The town stands on an isolated hill about 100 feet high, and has now a population of 1800 souls. It is divided into four quarters, the eastern suburb consisting entirely of mud houses. A magnificent grove of very ancient olives forms an avenue 4 miles long north of the city. On the south-east are a few palms. There are many lofty minarets in various parts of the town, and a fine mosque built of ancient materials. A 12th century church towards the south side of the hill has also been converted into a mosque. On the east is shown the tomb of Samson (an erroneous tradition dating back to the Middle Ages). The ancient walls are now covered up beneath green mounds of rubbish. The water supply is from wells sunk through the sandy soil to the rock; of these there are more than twenty—an unusual number for a Syrian town. The land for the 3 miles between Gaza and the sea consists principally of sand dunes. There is no natural harbor, but traces of ruins near the shore mark the site of the old Majuma Gazæ or Port of Gaza, now called el Mineh, which in the 5th century was a separate town and episcopal see, under the title Constantia or Limena Gaza. In the 7th century there were numerous families of Samaritans in Gaza, but they became extinct at the commencement of the present century. Hâshem, the father of Mahomet, lies buried in the town. On the east are remains of a racecourse, the corners marked by granite shafts with Greek inscriptions on them. To the south is a remarkable hill, quite isolated and bare, with a small mosque and a graveyard. It is called el Muntâr, "the watch tower," and is supposed to be the mountain "before (or facing) Hebron," to which Samson carried the gates of Gaza (Judg. xvi. 3). The bazaars of Gaza are considered good. An extensive pottery exists in the town, and black earthenware peculiar to the place is manufactured there. The climate is dry and comparatively healthy, but the summer temperature often exceeds 110° Fahr. The surrounding country is partly cornland, partly waste, and is inhabited by wandering Arabs. From the 5th to the 12th century Gaza was an episcopal see of the Latin Church, but even as late as the 4th century an idol named Marnas was worshipped in the town.

GAZA, THEODORUS (*c.* 1400–1478), one of the leaders of the revival of learning in the 15th century, was born at Thessalonica about the year 1400. On the capture of his native city by the Turks in 1430 he removed to Mantua, where he rapidly acquired a competent knowledge of Latin under the teaching of Victorino de Feltre, supporting himself meanwhile by giving lessons in Greek, and by copying manuscripts of the ancient classics. About 1440 he became professor of Greek in the newly founded university of Ferrara, to which students in great numbers from all parts of Italy were soon attracted by his fame as a teacher. He had taken some part in the councils which were held in Ferrara (1438), Florence (1439), and Siena (1440), with the object of bringing about a reconciliation between the Greek and Latin Churches; and in 1450, responding to the invitation of Pope Nicholas V., he went to Rome, where he was for some years employed by his patron in making Latin translations from Aristotle and other Greek authors. From 1456 to 1458 he lived at Naples under the patronage of Alphonso the Magnanimous; and shortly after the latter date he was appointed by Cardinal Bessarion to a benefice in the south of Italy, where the later years of his life were spent, and where he died at an advanced age in 1478. Gaza stood high in the opinion of most of his learned contemporaries, but still higher in that of the scholars of the succeeding generation. His Greek grammar, in Greek (*γραμματικῆς εἰσαγωγῆς βίβλια δ*), first printed at Venice in 1495, and afterwards partially translated by Erasmus in 1521, although in many respects defective, especially in its syntax, has done good service in the cause of sound learning. His translations were very numerous, including the *Problemata*, *De Historia Animalium*, *De Partibus Animalium*, and *De Generatione Animalium* of Aristotle, the *Historia Plantarum* and *De Causis Plantarum* of Theophrastus, the *Problemata* of Alexander Aphrodisias, the *De Instruendis Aciebus* of Ælian, and some of the *Homilies* of Chrysostom. He also turned into Greek Cicero's *De Senectute* and *Somnium Scipionis*—with much success, in the opinion of Erasmus; with more elegance than exactitude, according to the colder judgment of modern scholars. He was the author also of two small treatises entitled *De Mensibus* and *De Origine Turcarum.*

GAZELLE. See ANTELOPE.

GAZETTE, THE LONDON, is the official newspaper of the Government, and is published every Tuesday and Friday. It contains proclamations, orders, regulations, and other acts of state, and is received as evidence thereof in legal proceedings. It also contains notices of proceedings in bankruptcy, dissolutions of partnership, etc. The Bankruptcy Act, 1869, requires the order of adjudication to be published in the *Gazette*, and makes the *Gazette* conclusive evidence of adjudication. Other statutes, dealing with special subjects, have similar provisions. Unless by virtue of such statutes, the *Gazette* is not evidence of anything but acts of state. The Scotch law of evidence would appear not to be so stringent. Gazettes are also published in Edinburgh and Dublin.

GEBER. After all the research and criticism that have been expended on this the first and most interesting personage in the modern history of chemistry, little is definitely known about him, and about the origin of the works which pass under his name. It has been a very general tradition to regard Geber as an Arabian, but until the publication in recent years by European scholars of the works of Arabian historians and bibliographers, the probable source of the tradition has not been known. It seems to be pretty generally believed that the Geber of Western Europe is the same as the person who is called in full Abu Musa Dschabir (or Jabir) Ben Haijan Ben Abdallah el-Sufi el-Tarsusi el-Kufi, who was reckoned the most illustrious of the alchemists by the Arabs, and who is mentioned in the *Kitab-al-Fihrist* (10th cent.), by Ibn Khallikan (13th cent.), by Haji Khalfa (17th cent.), and other writers. If this be correct, Geber must have flourished in the 8th century, for, according to Haji Khalfa, Dschabir Ben Haijan died in the 160th year of the Hegira, which corresponds with the year beginning October 19, 776 A. D. This date is incidentally confirmed by other writers, though there are difficulties arising from the date of his teacher Kalid Ben Jezid, and his patron Dschaafar ess-Sadik. His birthplace was Tarsus, or, as others say, Kufa; and he is said to have resided at Damascus and at Kufa. This account, though apparently the most trustworthy, does not agree with the statements of D'Herbelot, quoted seemingly from native sources, that Geber was born at Harran in Mesopotamia, was a Sabæan by religion, and lived in the 3d century of the Hegira. Nor does it agree with that of Leo Africanus, who in 1526 gave a description of the Alchemical Society of Fez, in Africa, and told how the chief authority of that society was a certain Geber, a Greek, that had apostatized to Mahometanism, and lived a century after Mahomet. Leo's story has circulated very widely, but its accuracy has been impugned by Reiske and Asseman, and the works of both Leo and D'Herbelot have been rejected as authorities by Wüstenfeld. Other writers have tried to show that Geber was a native of Spain, or at least lived at Seville, but this has probably arisen from confusing Geber the chemist with other persons of the same or similar name. From the doubt encircling the personality of Geber, some have gone the length of questioning whether such a person ever existed but in name, and this view has been again expressed by Steinschneider, who mentions "Abu Musa Dschabir Ben Haiyan, commonly called Geber, an almost mythical person of the earliest period of Islam, renowned as an alchemist." While Steinschneider here exhibits notable scepticism with respect to Dschabir's very existence, he exhibits equal credulity in his belief that this mythical Dschabir is identical with Geber. In the present state of the question there is no alternative but to accept the account given in the Fihrist, and admit the possibility of Dschabir and Geber being one and the same. Confirmation of this view is to be sought in a comparison of the works ascribed to Geber with those bearing the name of Dschabir. The latter are divisible into two classes, those mentioned in Arabic bibliographies, and those existing in manuscript in European libraries. To Dschabir is assigned the authorship of an immense number of works on chemistry and many other topics besides. Titles of 500 of these are given in the Fihrist, and have been reproduced by Hammer-Purgstall, but nothing else is known about them. Haji Khalfa also enumerates the titles of several alchemical works by Dschabir, and other works are mentioned by other writers. Again Arabic MSS. on alchemy bearing the name of Dschabir Ben Haijan exist at Leyden, at Paris, in the British Museum, and elsewhere; but these have not been critically examined as to their date, age, authenticity, contents, etc. It is not known if they correspond with the lists already mentioned, or with the Latin MSS. or the printed versions. The Latin MSS. are contained in the Vatican, at Leyden, Oxford and other places. Of these the Vatican MS. is the alleged basis of some of the printed editions; and the Bodleian MSS. have been described by W. H. Black, but no collation of the text of these writings for critical purposes has as yet been made. The oldest of the MSS. dates from the 14th century; but if the works ascribed to Roger Bacon, Albertus Magnus, and others be genuine, Geber's name and writings must have been known and esteemed at a still earlier period. The works which purport to have been written by Geber, and which have been printed, bear the following names: *Summa perfectionis; Liber investigationis*, or *De investigatione perfectionis; De inventione veritatis; Liber Fornacum; Testamentum.* None of the editions appear to contain the whole of these tractates; there are usually found only two or three of them, but the English translation contains them all except the *Testament*, which is considered spurious by some writers. The printed editions of these works are very numerous, but they are all uncommon, and some of them are exceedingly rare. No approximately complete list is contained in any bibliography, and very few writers have seen more than half a dozen at most. The most complete catalogue from personal inspection is given by Beckmann. It contains twelve editions, but that does not comprise nearly all those which are known. While some of the editions correspond exactly, being merely reprints, there are important differences among others. What light these variations may throw upon the origin of the text has never been investigated. A critical edition of the works with the various readings would be necessary before deciding that what is found in them is really Geber's, and dates back eleven centuries. It may be that some of the knowledge of chemistry credited to Geber was really interpolated at a later date. It is quite possible that the account given of the various acids, salts, and metals, and of the apparatus and operations, may have been modified or extended. But, on the other hand, the general theory that runs through the whole of the writings is in all probability original. The theory is that the metals are composed of the same elements, and that by proper treatment the less perfect can be gradually developed into the more perfect metals. This theory is very clearly, and one may even say logically, worked out, and it was the leading idea in chemistry down to the 16th century at least. In carrying out this theory practically, certain materials were employed and were subjected to operations, and the knowledge acquired about them took shape by degrees. Though subsequent workers added to what was known, Geber's reputed works are so clear, so precise, so complete, that they differ in a most striking manner from the works of even the best writers in the later alchemical period, and make it difficult to account for their existence at all. Older writings there are none; subsequent writings as clear as Geber's do not appear until far more was known; the unsolved problem therefore remains, Who was Geber, and how does it happen that his works stand quite alone in chemical literature?

The following are a few of the authorities which may be consulted:—Abulfeda, *Annales Moslemici*, Copenhagen, 1790, with Reiske's note; Beckmann, *Geschichte der Erfindungen*, 1803, v. 272; Black, *Catalogue of MSS. bequeathed to the University of Oxford by Elias Ashmole*, 1845; D'Herbelot, *Bibliotheque Orientale*, Paris, 1697; Haji Khalfa, *Lexicon*, ed. Fluegel, London, 1835–58; Hammer-Purgstall, *Literaturgeschichte der Araber*, Vienna, 1850; Ibn-Khallikan, *Biographical Dictionary*, by De Slane, Paris, 1843, vol. i. pp. 300–1; *Kitab-al-Fihrist*, ed. Fluegel, 1871–72; Kopp, *Beiträge zur Geschichte der Chemie*, Brunswick, 1875, part iii.; *Laboratory*, 1867, vol. i. pp. 71–76; Leo Africanus, *Africæ Descriptio*, Leyden, 1632; Steinschneider, "Die toxicologischen Schriften der Araber," in Virchow's *Archiv*, Berlin, 1871, Bd. 52; Wüstenfeld, *Geschichte der Arabischen Aerzte*, Göttingen, 1840. See also article ALCHEMY. (J. F.)

GEBWEILER, in French *Guebwiller*, a town of the German imperial province of Alsace-Lorraine, in the district of Upper Alsace, situated about 13 miles south of Colmar, at the mouth of the Blumenthal or "Vale of Flowers." It communicates by a branch line with the railway between Strasburg and Basel. Among the principal buildings are the Roman Catholic church of St. Leodgar, dating from the 12th century, the Evangelical church, the synagogue, the town-house, and the old Dominican convent, now used as a market and concert-hall. The spinning, weaving, bleaching, and dyeing of cotton is the chief industry, but woollen goods and silk ribbons, as well as machinery, are also manufactured. Gebweiler is mentioned as early as 774. It belonged to the religious foundation of Murbach, and in 1759 the abbots chose it for their residence. At the French Revolution of 1789, however, the chapter house was laid in ruins, and though the archives were rescued and removed to Colmar, the library perished in the devastation. Population in 1871, 11,104; in 1875, 11,622.

GECKO, the common name applied to all the species of *Geckotidæ*, an extensive family of lizards belonging to the Pachyglossæ, or "thick-skinned" sub-order of Gray. The geckoes are small creatures, seldom exceeding 8 inches in length including the tail. With the head considerably flattened, the body short and thick, the legs not high enough to prevent the body dragging somewhat on the ground, the eyes large and almost destitute of eyelids, and the tail short and in some cases nearly as thick as the body, the geckoes altogether lack the litheness and grace characteristic of most lizards. Their colors also are dull, and to the weird and forbidding aspect thus produced the general prejudice against those creatures in the countries where they occur, which has led to their being classed with toads and snakes, is no doubt to be attributed. Their bite was supposed to be venomous, and their saliva to produce painful cutaneous eruptions; even their touch was thought sufficient to convey a dangerous taint. It is needless to say that in this instance the popular mind was misled by appearances. The geckoes are not only harmless, but are exceedingly useful creatures, feeding on insects and worms, which, owing to the great width of their œsophagus, they are enabled to swallow whole, and in pursuit of which they do not hesitate to enter human dwellings, where they are often killed on suspicion. The structure of the toes in those lizards forms their most characteristic anatomical feature. These organs are flattened out into broad discs, and are furnished with transverse lamellar plates, by means of which the geckoes are enabled to run with ease on the smoothest surface, and to imitate the fly in remaining suspended on ceilings or on the under surfaces of leaves. Most of the species have nails to their toes, and these in their sharpness and retrac-

Leaf-tailed Gecko (*Phyllurus platurus*).

tility bear considerable resemblance to the claws of feline animals. They are nocturnal in their habits; but when not exposed to the hot sunshine they are able to pursue their prey by day. They hibernate; and two fatty masses in front of the pubis are supposed to furnish the means of nourishment during this period. Many of the species possess to a limited extent the chameleon faculty of changing color, while their coloring generally may be regarded as protective; a few Indian forms are said to become luminous in the dark. The geckoes form an extensive family, including 60 genera and 200 species, found throughout the warmer regions of the earth, two only being inhabitants of Europe, and even these occur also in the north of Africa. Unlike most lizards, they are found in the remotest oceanic islands, a fact which leads Mr. Wallace (*Geographical Distribution of Animals*) to suppose that they possess exceptional means of distribution.

GED, WILLIAM (?–1749), the inventor of the art of stereotyping, was born at Edinburgh about the beginning of the 18th century. In 1725 he first put in practice the art which he had discovered; and some years later he entered into a partnership with a London capitalist, with a view to employing it on a great scale. The partnership, however, turned out very ill; and Ged, broken-hearted at his want of success, died at London, October 19, 1749. The only books which he produced by means of stereotyping were two prayer-books for the university of Cambridge, and an edition of Sallust. See Life by Nichols, 1781.

GEDDES, ALEXANDER (1737–1802), a learned theologian, biblical critic, and miscellaneous writer, was born at the farm of Arradoul, in the parish of Rathven, Banffshire, Scotland, on the 14th of September, 1737. At the age of fourteen he entered the small Roman Catholic seminary at Scalan in a remote glen of the Banffshire highlands, where he remained till October, 1758, when he was sent to the Scottish College in Paris for the further prosecution of his studies. Here to considerable acquirements in biblical philology and school divinity he succeeded in adding a good knowledge of most of the literary languages of Europe. Returning to Scotland after an absence of six years, he for a short time officiated as a priest in Dundee, but in May, 1765, received and accepted an invitation to become resident in the family of the earl of Traquair, where, with abundance of leisure and the free use of an adequate library, he made further progress in his favorite biblical studies. After a second visit to Paris which extended over some months, and which was employed by him in reading and making extracts from rare books and manuscripts in the public libraries, he in 1769 was appointed to the charge of the Catholic congregation of Auchinhalrig in his native county. During the period of a ten years' incumbency there he displayed a liberality of spirit which caused considerable scandal to his stricter brethren; and the freedom with which he fraternized with his Protestant neighbors once and again called forth the rebuke of his bishop (Hay). Ultimately, on account of his occasional attendance at the parish church of Cullen, where his friend Buchanan was minister, he was deprived of his charge and forbidden the exercise of ecclesiastical functions within the diocese. This happened in 1779; and in 1780 he went with his friend Lord Traquair to London, where he spent the rest of his life, with the exception of a few weeks devoted to travel on the Continent. Before leaving Scotland he had received the honorary degree of LL.D. from the university of Aberdeen, a compliment seldom before paid to any Catholic, and had been made an honorary member of the Society of Antiquaries, in the institution of which he had taken a very active part. Shortly after his arrival in London Geddes received an appointment in connection with the chapel of the imperial ambassador, which he held until the chaplaincy was suppressed some years afterwards. Having been introduced to Lord Petre, to whom he broached his long-cherished scheme for the publication of a new Catholic version of the Scriptures on the basis of the Vulgate, he met with every encouragement from that nobleman, who assigned to him an annual salary of £200, and, moreover, undertook to provide the needful books. Supported also by such scholars as Kennicott and Lowth, Geddes in 1786 published a *Prospectus of a new Translation of the Holy Bible, from corrected Texts of the Originals, compared with the ancient Versions, with various Readings, explanatory Notes, and critical Observations*, a considerable quarto volume, in which the defects of previous translations were fully pointed out, and the means were indicated by which these might be removed. It attracted considerable notice of a favorable kind, and led to the publication in 1788 of *Proposals for Printing*, with a specimen, and in 1790 of a *General Answer to Queries, Counsels, and Criticisms*. The first volume of the translation itself, which was entitled *The Holy Bible; or the Books accounted sacred by Jews and Christians; otherwise called the Books of the Old and New Covenants; faithfully translated from corrected Texts of the Originals, with various Readings, explanatory Notes, and critical Remarks*, appeared in 1792, and was the signal for a storm of hostility on the part of both Catholics and Protestants. It was obvious enough—no small offence in the eyes of some—that as a critic Geddes had identified himself with Houbigant, Kennicott, and Michaelis; but others did not hesitate to stigmatize him as the would-be "corrector of the Holy Ghost." Three of the vicars-apostolic almost immediately warned all the faithful against the "use and reception" of his translation, on the ostensible ground that it had not been examined and approved by due ecclesiastical authority; and by his own bishop (Douglas) he was in 1793 suspended from the exercise of his orders in the London district. The second volume of the translation, completing the historical books, published in 1797, found no more friendly reception; but this circumstance did not discourage him from giving forth in 1800 the volume of *Critical Remarks on the Hebrew Scriptures, corresponding with a New Translation of the Bible, containing the Pentateuch*, of which it is enough to say that, while fully saturated with all the best learning of its time, it presented in a somewhat brusque and injudicious manner the then novel and startling views of Eichhorn and his school on the primitive history and early records of mankind. Dr. Geddes was engaged on a critical translation of the Psalms, which he had completed down to the 118th, when he was seized with a lingering and painful illness which ultimately proved fatal on the 26th of February, 1802. Although for many years he had been under ecclesiastical censures, he had never for a moment swerved from a consistent profession of faith as a Catholic; and on his death-bed he duly received the last rites of his communion. It would appear, however, that the report which gained currency that before his death he had made recantation of his "errors" was entirely destitute of foundation in fact. In his lifetime he enjoyed the friendship of several eminent Continental scholars, and his death was noticed as being a loss to science in the *Gelehrte Zeitung* of Gotha and in other foreign journals.

Besides pamphlets on the Catholic and slavery questions, as well as several fugitive *jeux d'esprit*, and a number of unsigned articles in the *Analytical Review*, Geddes also published a metrical translation and adaptation of *Select Satires of Horace* (1779), and a verbal rendering of the *First Book of the Iliad of Homer* (1792). The *Memoirs* of his life and writings by his friend Dr. Mason Good, appeared in 1803, and his unfinished work on the Psalms in 1807.

GEELONG, one of the leading towns in Victoria, coeval with Melbourne in the history of Australian settlement, is pleasantly situated on Corio Bay, an extensive western arm of Port Phillip, 45 miles S. W. of Melbourne, in 39° 8′ S. lat. and 144° 21′ E. long. The town slopes to the bay on the north side and to the Barwon river on the south, and its position in this respect, as well as the shelter it obtains from the Bellarine range of hills, renders it the healthiest town in the colony. Its streets are wide and laid out at right angles, and there are many handsome public and private buildings. It has a botanical garden, and two parks maintained by the municipality. The public buildings comprise a mechanics' institute (with a library containing nearly 12,000 volumes), a public library, a town hall, a fire-brigade establishment, a handsome and commodious hospital, a supreme court, and orphan and benevolent asylums. The town is supplied with water from large state-constructed reservoirs in the Brisbane ranges, some 25 miles distant. As a manufacturing centre Geelong is of considerable importance. It contains extensive woollen mills and tanneries on the Barwon river, and paper of good quality is largely made in the neighborhood. Geelong harbor has area and depth enough to hold all the navies of the world. The bar at the entrance has been cut (at an expense of £6000) to admit vessels of heavy draught, and some of the largest wool ships are able to load at the wharves, which are connected by railway with all parts of the colony. The population of the city proper is a little over 12,000, but with the adjacent boroughs of Geelong West, Chilwell, and Newtown the total is increased to 24,000.

GEESTEMÜNDE, a seaport in the Prussian province of Hanover, in the district or *Landdrostei* of Stade, situated, as the name indicates, at the mouth of the Geeste, a right hand affluent of the estuary of the Weser. It lies about 32 miles N. of Bremen, and is the terminus of a railway from that city. The interest of the place is purely naval and commercial, its origin dating no further back than 1857, when the construction of the harbor was commenced. The great basin opened in 1863 has a length of 1785 English feet, a breadth of 4 0, and a depth of nearly 23, and can accommodate 24 or 25 of the largest ships of the line; and the petroleum basin opened in 1874 has a length of 820 feet and a breadth of 147. To the left of the great basin lies a canal, which has a length of 13,380 feet and a breadth of 155; and from this canal there strikes off another of similar proportions. The whole port is protected by powerful fortifications, and it lies outside of the limit of the German customs. Since 1864 the trade has been almost trebled, the number of vessels being 617 sea-going ships entering in 1875 and upwards of 2000 river craft. Among the industrial establishments of the town are ship-building yards, foundries, engineering works, and steam mills. The population, exclusive of the garrison, was 3218 in 1871, and 3436 in 1875; and if the neighboring commune of Geestendorf be included, the total for 1871 was 9148, and for 1875 10,425.

GEFLE, Latinized as *Gevalia*, a seaport town of Sweden, at the head of the Gefleborglån, about a mile from the shore of the Gulf of Bothnia, near the mouth of the Gefle-Å, 50 miles E. of Fahlun, and about the same distance N. of Upsala. With the former city it has been connected by railway since 1859, and with the latter and Stockholm since 1874. As the river at that place is divided into three channels, the town consists of four portions, communicating with each other by wooden bridges. In 1869 it was almost destroyed by fire, but it has been rebuilt, and may still be reckoned one of the prettiest, as it is certainly one of the busiest, of Swedish towns. The principal buildings are the castle, originally founded in the 16th century by King John III., but rebuilt since its destruction by fire in 1727; a beautiful council-house erected by Gustavus III., who held a diet in the town in 1792; a hospital, an exchange, and a freemason's lodge in the Gothic style. An orphan asylum, a gymnasium, removed to Gefle from Stockholm in 1668, and a public library may also be mentioned. Possessing an excellent harbor, and recently restored wharves to which large vessels have easy access, Gefle is the great port for the Dalecarlian district, and thus ranks in Sweden next to Stockholm and Gottenburg. It has about 100 ships of its own, and carries on a good trade in the export of timber, tar, flax, and linen, and in the import of grain, salt, coal, etc. The manufactures of the town include sailcloth and linen, tobacco, leather, iron wares, and machinery. In 1873 the population was 16,265.

GEIGER, ABRAHAM (1810–1874), one of the ablest leaders of the modern Jewish school of theology and criticism, was born at Frankfort-on-the-Main, May 24, 1810. After receiving from his father and uncle the elements of an ordinary rabbinical education, he was in his eleventh year sent to the gymnasium, whence in 1829 he passed to the university of Heidelberg, which he soon afterwards exchanged for that of Bonn. As a student he greatly distinguished himself both in philosophy and in philology, and at the close of his course wrote on the relations of Judaism and Mahometanism a prize-essay which was afterwards published, in 1833, under the title *Was hat Mohammed aus dem Judenthum aufgenommen?* In November, 1832, he went to Wiesbaden as rabbi of the synagogue there, and, still pursuing the line of scientific study upon which he had entered during his undergraduate course, became in 1835 one of the most active promoters of the *Zeitschrift für Jüdische Theologie*, which appeared from 1835 to 1839, and again from 1842 to 1847. In 1838 he removed to Breslau, where he continued to reside for the next twenty-five years, and where he wrote some of his most important works, including his *Lehr- und Lesebuch zur Sprache der Mischna* (1845), his *Studien* from Maimonides (1850), his translation into German of the poems of Juda ha-Levi (Abu'l Hassan) in 1851, and the *Urschrift und Uebersetzungen der Bibel in ihrer Abhängigkeit von der innern Entwickelung des Judenthums* (1857). The last-named work especially attracted much attention at the time of its appearance, and may be said to have marked a new departure in the methods of studying the records of Judaism. In 1863 Geiger became head of the synagogue of his native town, whence he removed in 1870 to Berlin, where, in addition to his duties as chief rabbi, he took the principal charge of the newly established seminary for Jewish science. The *Urschrift* was followed by a more exhaustive handling of one of its topics in *Die Sadducäer und Pharisäer* (1863), and by a more thoroughgoing application of its leading principles in an elaborate history of Judaism (*Das Judenthum u. seine Geschichte*) in 1865–71. Geiger also contributed frequently on Hebrew, Samaritan, and Syriac subjects to the *Zeitschrift der deutschen morgenländischen Gesellschaft*, and from 1862 until his death (which occurred on the 23d of October, 1874) he was editor of a periodical entitled *Jüdische Zeitschrift für Wissenschaft und Leben.* He also published a Jewish prayerbook (*Israelitisches Gebetbuch*), which is well known in Germany, besides a variety of minor monographs on historical and literary subjects connected with the fortunes of his people. An *Allgemeine Einleitung* and five volumes of *Nachgelassene Schriften* were edited by his son L. Geiger in 1875.

GEIJER, ERIK GUSTAF (1783–1847), Sweden's greatest historian, was born at Ransäter in Värmland, January 12, 1783, of a family that had immigrated from Austria in the time of Gustavus Adolphus. At sixteen he left Carlstad gymnasium for the university of Upsala, where in 1803 he carried off the Swedish Academy's great prize for an *Äreminne öfver Riksföreståndaren Sten Sture.* He graduated in 1806, and in 1810 returned from a year's residence in England to become "docent" in his university. Soon afterwards he accepted a post in the public record office at Stockholm, where, with eleven friends, he founded the "Gothic Society," to whose organ *Iduna* he contributed a number of prose essays and the songs *Manhem*, *Vikingen*, *Den siste kampen*, *Den siste skalden*, *Odalbonden*, *Kolargossen*, and others, whose simplicity and earnestness, warm feeling, and strong patriotic spirit are dearer to his nation for the fine melodies to which he set them. About the same time he issued a volume of hymns (1812), of which several are inserted in the Swedish Psalter. Geijer's lyric muse was soon after silenced by his call to be assistant to Fant, professor of history of Upsala (1815), whom he succeeded in that chair in 1817. In 1824 he was elected to the Swedish Academy. A single volume of a great projected work, *Svea Rikes Häfder*, itself a masterly critical examination of the sources of Sweden's legendary history, appeared in 1825. Geijer's researches in its preparation had severely strained his health, and he went the same year on a tour through Denmark and part of Germany, his impressions from which are recorded in his *Minnen* (1834). In 1832–36 he published three volumes of his *Svenska folkets historia*, a clear view of the political and social development of Sweden down to the close of Queen Christina's reign. The acute critical insight, just thought, and finished historical art of these two incomplete works of Geijer entitle him to the first place among Swedish historians. His chief other historical and political writings are his *Kort teckning af Sveriges tillstånd och af de fornämste handlande personer under tiden från Karl XII.'s död till Gustaf III.'s anträde af regjeringen* (Stockh. 1838), and *Feodalism och republikanism, ett bidrag till Samhällsförfattningens historia* (1844), which led to a controversy with the historian Fryxell regarding the part played in history by the Swedish aristocracy. Geijer also edited, with the aid of Schröder, a continuation of Fant's *Scriptores svecicarum medii ævi* (1818–25), and, by himself, Thorild's *Samlade skrifter* (1819–25), and *Konung Gustaf III.'s efterlemnade Papper* (3 vols. 1843–45). Geijer's academic lectures, of which the last three, published in 1845, under the title *Om vår tids inre samhällsforhållanden, i synnerhet med afseende på Fäderneslandet*, involved him in another controversy with Fryxell, exercised a great influence over his students, who especially testified to their attachment after the failure of the prosecution for alleged anti-Trinitarian heresies in his *Thorild, tillika en philosophisk eller ophilosophisk bekännelse* (1820). A number of his extempore lectures, recovered from notes, were published by Ribbing in 1856. Failing health forced Geijer to resign his chair in 1846, after which he removed to Stockholm for the purpose of completing his *Svenska folkets historia*, and died there 23d April, 1847. His *Samlade skrifter* (13 vols., 1849–55; new ed. 1873–75) include a large number of philosophical and political essays contributed to reviews, particularly to *Literaturbladet* (1838–39), a periodical edited by himself, which attracted great attention in its day by its pronounced liberal views on public questions, a striking contrast to those he had defended in 1828-30, when, as again in 1840-41, he represented Upsala university in the Swedish diet.

Geijer's style is strong and manly. His genius bursts out in sudden flashes that light up the dark corners of history. A few strokes, and a personality stands before us instinct with life. His language is at once the scholar's and the poet's; with his profoundest thought there beats in unison the warmest, the noblest, the most patriotic heart. Geijer came to the writing of history fresh from researches in the whole field of Scandinavian antiquity, researches whose first-fruits are garnered in numerous articles in *Iduna*, and his masterly treatise *Om den gamla nordiska folkvisan*, prefixed to the collection of *Svenska folkvisor* which he edited with A. A. Afzelius (3 vols., 1814–16). The development of freedom is the idea that gives unity to all his historical writings. This idea is not subjective; he traces it in the darkest annals of his country. Sweden, he repeats, is the only European land that has not been trod by foreign armies, that has never accepted the yoke of serfdom. There, on the whole, the king has ever been the people's faithfullest ally, and all his great designs for the country's external and internal gain have been carried out "by the help of God and Sweden." Throughout life Geijer was what he professed to be, a seeker; and to no philosophic system did he yield absolute allegiance. Yet his writings mark a new era in Swedish history, the rise of a "critical school" whose aim is to draw the truth without distortion, and present reality without a foil.

For Geijer's biography, see his own *Minnen* (1834). which contains copious extracts from his letters and diaries; Malmström, *Minnestal öfver E. G. Geijer*, addressed to the Upsala students, June 6, 1848, and printed among his *Tal och esthetiska af handlingar* (1868), and *Grunddragen af Svenska vitterhetens häfdar* (1866–68); and S. A. Hollander, *Minne af E. G. Geijer* (1869).

GEIKIE, WALTER (1795-1837), a Scotch subject-painter, was born at Edinburgh, November 9, 1795. In his second year he was attacked by a nervous fever by which he permanently lost the faculty of hearing, but through the careful attention of his father he was enabled to obtain a good education. His artistic talent was first manifested, while he was still very young, by attempts to cut out representations of objects in paper, and to draw figures with chalk on floors and walls. Before he had the advantage of the instruction of a master, he had attained considerable proficiency in sketching both figures and landscapes from nature, and in 1812 he was admitted into the drawing academy of the board of Scotch manufactures, where he made very rapid progress in the use of the pencil. He first exhibited in 1815, and was elected an associate of the Royal Scottish Academy in 1831, and a fellow in 1834. He died on the 1st August, 1837, and was interred in the Greyfriars Churchyard, Edinburgh. Owing to his want of feeling for color Geikie was not a successful painter in oils, but he sketched in India ink with great truth and humor the scenes and characters of Scottish lower-class life in his native city. The characteristics he depicts are somewhat obvious and superficial, but his humor is never coarse, and he is surpassed by few in the power of representing the broadly ludicrous and the plain and homely aspects of humble life. A series of etchings which exhibit very high excellence were published by him in 1829–31, and a collection of eighty-one of these was republished posthumously in 1841, with a biographical introduction by Sir Thomas Dick Lauder, Bart.

GEILER, or GEYLER, VON KAISERSBERG, JOHANN (1445–1510), one of the greatest of the popular preachers of the 15th century, was born at Schaffhausen, March 16, 1445, but from 1448 passed his childhood and youth at Kaisersberg in Upper Alsace, from which place his current designation is derived. In 1460 he entered the university of Freiburg in Baden, where, after graduation, he lectured for some time on the Sentences of Petrus Lombardus, the Commentaries of Alexander Halensis, and several of the works of Aristotle. A living interest in theological subjects, which had been awakened within him by the study of Gerson, led in 1471 to his removal to the university of Basel, at that period a centre of attraction to some of the most earnest spirits of the time. Made a doctor of theology in 1475, he received a professorship at Freiburg in the following year; but his tastes began to incline him more strongly to the vocation of a preacher, while his fervor and eloquence soon led to his receiving numerous invitations to the larger towns. Ultimately he accepted in 1478 a call to the cathedral of Strasburg, where he continued to work with few interruptions until within a short time of his death, which occurred on the 10th of March, 1510. The beautiful pulpit erected for him in 1481 in the nave of the cathedral, when the chapel of St. Lawrence had proved too small, still bears witness to the popularity he enjoyed as a preacher in the immediate sphere of his labors, and the testimonies of Sebastian Brandt, Beatus Renanus, Reuchlin, Melanchthon, and others who survived him, abundantly show how powerful, how healthy, and how widespread had been the influence of his personal character. His sermons—bold, incisive, abounding in quaint illustrations, nor altogether wanting in instances of what would now be called bad taste—taken down as he spoke them, and circulated (sometimes without his knowledge or consent) by his friends, told perceptibly on the German thought as well as on the German speech of his time.

Among the many volumes published under his name only two appear to have had the benefit of his revision, namely, *Der Seelen Paradies von waren und volkomnen Tugenden*, and that entitled *Das irrig Schaf*. Of the rest, probably the best known is a series of lectures on his friend Seb. Brandt's well-known work the *Navicula* or *Speculum Fatuorum*, of which an edition was published at Strasburg in 1511 under the following title:—*Navicula sive speculum fatuorum præstantissimi sacrarum literarum doctoris Joannis Geiler Keysersbergii concionatoris Argentinensis in sermones juxta turmarum seriem divisa; suis figuris jam signita; atque a Jacobo Othero diligenter collecta. Compendiosa vitæ ejusdem descriptio per Beatum Rhenanum Selestatinum.*

See Von Ammon, *Geyler's Leben, Lehren, und Predigten* (1826); Stöber, *Essai Historique et Littéraire sur la Vie et les Sermons de Geiler* (1834); and C. Schmidt in Herzog's *Real-Encycl.*, iv. 714 (1855).

GEISSLER, HEINRICH (1814–79), a distinguished practical physicist, was born at the village of Igelshieb in Saxe-Meiningen, Germany, where he was educated as a glass-blower. After many years spent in travelling from city to city in the exercise of his craft, he settled at Bonn, where he speedily gained a high reputation, not only for his surpassing skill and ingenuity of conception in the fabrication of physical apparatus, but for his comprehensive knowledge, acquired chiefly in later life, of the natural sciences. With Plücker, in 1852, by means of an ingeniously contrived instrument, in which mercury was made to compensate for the expansion of the glass, he ascertained the maximum density of water to be at 3·8° C. He also determined the coefficient of expansion for ice between $-24°$ and $-7°$ and for water freezing at 0°. In 1869, in conjunction with Vogelsang, he proved the existence of liquid carbon dioxide in cavities in quartz and topaz, and later he obtained amorphous from ordinary phosphorus by means of the electric current. He is best known as the inventor of the sealed glass tubes which bear his name, by means of which are exhibited the phenomena accompanying the discharge of electricity through highly rarefied vapors and gases (see ELECTRICITY, vol. viii., p. 60). Among other apparatus contrived by him are his vaporimeter, mercury air-pump, balances, normal thermometer, and areometer. From the university of Bonn, on the occasion of its jubilee, he received the honorary degree of doctor of philosophy. He died on the 24th of January, 1879, in the sixty-fifth year of his age. See A. W. Hofmann, *Ber. d. deut. chem. Ges.*, 1879, p. 148.

GELA, an ancient city on the south coast of Sicily, on a river of the same name, near the site of the modern Terranuova between Girgenti and Camerina. Founded by a joint colony of Cretans and Rhodians (the latter mainly from the city of Lindus), it soon rose to wealth and power, and by 582 B. C. it was able to become the mother-city of Agrigentum, by which it was however destined before long to be surpassed. The most important among its rulers were the following:—Cleander, who subverted the oligarchy and made himself despot (505–498 B. C.); Hippocrates, his brother, who raised Gela to its highest pitch of eminence (498–491 B. C.); Gelon, who immediately succeeded Hippocrates, and rapidly pursued the same career of aggrandizement till in 485 B. C. he got possession of Syracuse, and gave the first blow to his native city by removing the seat of government to his new conquest; and finally, Hiero, the brother of Gelon, who succeeded to the sovereignty in 478 B. C. The decadent Gela was laid waste by Phalaris of Agrigentum, and in the time of Strabo it was nothing more than a heap of ruins. Æschylus died at Gela in 456 B. C.; and it was the birthplace of Apollodorus, a comic poet of note.

GELASIUS, the name of two popes.

Gelasius I. succeeded Felix III. in 492, and confirmed the estrangement between the Eastern and Western Churches by insisting on the removal of the name of Acacius, bishop of Constantinople, from the diptychs. He was also the first decidedly to assert the supremacy of the papal over the imperial power, and the superiority of the pope to the general councils. He is the author of *De duabus in Christo naturis adversus Eutychen et Nestorium*. Five of his letters have also come down to us, and he is most probably the author of *Liber Sacrementorum*, published at Rome in 1680; but the so-called *Decretum Gelasii de libris recipiendis et non recipiendis* is evidently a forgery. Gelasius died in 496, and was canonized, his day being the 18th November.

Gelasius II. (Giovanni da Gaeta) was of noble descent, and was born at Gaeta about 1050. He received his theological education in the abbey of Monte Casino, and afterwards held the office of chancellor under Urban II., and of cardinal-deacon under Pascal II. On the death of Pascal II. he was elected pope by the cardinals, 18th January, 1118, and when his person was seized by Cencius Frangipani, a partisan of the emperor Henry V., he was almost immediately set at liberty through the general uprising of the people in his behalf. The sudden appearance of the emperor, however, compelled him to leave Rome for Gaeta, and the imperial party chose an anti-pope, Burdinus, archbishop of Braga, under the name of Gregory VIII. Gelasius, at a council held at Capua, fulminated bulls of excommunication against his ecclesiastical rival and the emperor; and under the protection of the Norman princes he was able to return to Rome, where he stayed for a time in partial concealment, but having barely escaped capture by the Frangipani while celebrating mass in the church of St. Praxede, he left the city, and after wandering through various parts of Italy and France, died in the abbey of Clugny, January 19, 1119.

GELATIN. When intercellular connective tissue, as met with in skin, tendons, ligaments, and the fasciæ of the muscles, of which it forms the basis, is treated with water, preferably hot, or in presence of dilute acids, for some time, a solution is obtained which in cooling solidifies to a jelly. The dissolved substance bears the name of *Gelatin* or *Glutin*.

The same substance is obtained when the matrix of bones is submitted to similar treatment, after previous removal of the lime salts by means of mineral acids. Again, when unossified cartilage, as for instance the bone-cartilages of the vertebrate fœtus, is treated with water or dilute acids, a solution is obtained which also gelatinizes on cooling. The coagulation in this case, however, is due, not to gelatin, but to a closely allied substance called chondrin. At one time it was supposed that in each of these three cases the gelatinizing materials obtained were formed by the hydration or by a physical metamorphosis of a different substance pre-existing in the respective tissues, to which the names *collagen*, *ossein*, and *chondrogen* were given respectively—the two former yielding gelatin, and the last chondrin.

Further experiments have made it more probable that gelatin and chondrin do not differ essentially from their parent tissues, analyses of tendons and of gelatin or isinglass (a very fine form of gelatin obtainable from the sturgeon) agreeing within the range of experimental error. At the same time, as Foster observes in the case of chondrin, the fact that its extraction from cartilage requires an amount of boiling with water, much more than would be necessary to dissolve the same amount of dried product, points rather the other way. Most probably the change which occurs is of a purely physical character.

True gelatigenous tissue occurs in all mature vertebrates, with the single exception, according to Hoppe-Seyler, of that in other respects anomalous vertebrate, *Amphioxus lanceolatus*. In the embryo it does not appear till late in fœtal life, chondrin being found instead; and the change which brings gelatin into the place of chondrin is effected, not by a metamorphosis of the latter, but by its removal, and the independent formation of gelatin. The tissue in question was believed to be peculiar to *Vertebrata* until Hoppe-Seyler discovered it in the bodies of *Octopus* and *Sepiola*. By boiling these cephalopods with water he obtained large quantities of gelatin free from chondrin, but in an extension of his experiments to other invertebrates, as cockchafers and *Anodon* and *Unio*, no such tissue could be detected. Gelatin, as such, is not met with in any of the normal fluids of the body, but occurs in the blood in cases of *leukhæmia*.

Various qualities of impure gelatin are prepared on the large scale by boiling up the hides of oxen, skins of calves, and spongy parts of horns; from any of the crude gelatins the pure substance may be obtained by bleaching with sulphurous acid and steeping repeatedly in warm water, when in the state of soft jelly.

Pure gelatine is an amorphous, brittle, nearly transparent substance, faintly yellow, tasteless, and inodorous, neutral to vegetable colors, and unaltered by exposure to dry air. Submitted to analysis it exhibits an elementary composition agreeing closely with that of chondrin, containing in round numbers C 50, H 7, N 18, O + S 24 per cent.; whilst chondrin contains about 3 per cent. less nitrogen and more oxygen.

Nothing is known with any certainty as to its chemical constitution, or of the mode in which it is formed from albuminoids. Besides a similarity in elementary constituents, it exhibits in a general way a connection with that large and important class of animal substances called *proteids*, being, like them, amorphous, soluble in acids and alkalies, and giving in solution a left-handed rotation of the plane of polarization. Nevertheless, the ordinary well-recognized reactions for proteids are but faintly observed in the case of gelatin, and the only substances which at once and freely precipitate it from solution are corrosive sublimate, strong alcohol, and tannic acid.

According to Wanklyn, gelatin is distinctly differentiated from such substances as *casein* and *albumin* by a marked difference in behavior when treated successively with boiling potash and alkaline permanganate. All nitrogenous organic substances yield large quantities of ammonia when decomposed by boiling with these solutions; but whereas albuminoids give up their ammonia at two successive stages, one of which is achieved by the action of potash alone, the other on the subsequent addition of permanganate, gelatin yields the same amount after the action of permanganate alone, as the total obtainable by the successive actions of the two reagents. Now, as there appear to be good grounds for believing the molecule of albuminoids to contain one or more urea-residues, and as urea, and presumably therefore a urea-residue, would yield its ammonia to potash alone, Wanklyn concludes that gelatin differs in constitution from albuminoids by containing no urea. On the other hand, as Foster observes, the behavior of gelatin as a food (see below), in diminishing the amount of fat used by an animal fed partly on it, as well as the quantity of nitrogen abstracted from other sources, is readily intelligible on the hypothesis that it splits into a urea and a fat moiety.

Although gelatin in a dry state is unalterable by exposure to air, its solution exhibits, like all the proteids, a remarkable tendency to putrefaction; but a characteristic feature of this process in the case of gelatin is that the solution assumes a transient acid reaction. The ultimate products of this decomposition are the same as are produced by prolonged boiling with acid (see below). It has been found that oxalic acid, over and above the action common to all dilute acids of preventing the solidification of gelatin solutions, has the further property of preventing in a large measure this tendency to putrefy when the gelatin is treated with hot solutions of this acid, and then freed from adhering acid by means of carbonate of lime. Gelatin so treated has been called *metagelatin*.

Strange to say, in spite of the marked tendency of gelatin solutions to develop ferment-organisms, and undergo putrefaction, the stability of the substance in the dry state is such that it has even been used, and with some success, as a means of preserving perishable foods. The process, invented by Dr. Campbell Morfit, consists in impregnating the foods with gelatin, and then drying them till about 10 per cent. or less of water is present. Milk gelatinized in this way is superior in several respects to the products of the ordinary condensation process, more especially in the retention of a much larger proportion of albuminoids.

Gelatin has a marked affinity for water, abstracting it from admixture with alcohol, for example. Solid gelatin steeped for some hours in water absorbs a certain amount and swells up, in which condition a gentle heat, as that of the water-bath, serves to convert it into a liquid; or this may be readily produced by the addition of a trace of alkali or mineral acid, or by strong acetic acid. In the last case, however, or if we use the mineral acids in a more concentrated form, the solution obtained has lost its power of solidifying, though not that of acting as a glue. By prolonged boiling of strong aqueous solutions at a high, or of weak solutions at a lower temperature, the characteristic properties of gelatin are impaired and ultimately destroyed. After this treatment it acts less powerfully as a glue, loses its tendency to solidify, and becomes increasingly soluble in cold water; nevertheless the solutions yield on precipitation with alcohol a substance identical in composition with gelatin.

By prolonged boiling in contact with hydrolytic agents, such as sulphuric acid or caustic alkali, it yields quantities of *leucin* and *glycocoll* (so-called "sugar of gelatin," this being the method by which glycocoll was first prepared), but no *tyrosin*. In this last respect it agrees with its near allies, chondrin and elastin, and differs from the great body of proteids, the characteristic solid products of the decomposition of which are leucin and tyrosin. At the same time the formation of glycocoll differentiates it from chondrin, from which, moreover, it can be readily distinguished by its non-precipitability by acetate of lead.

When it is mixed with copper sulphate a bright green liquid is formed, from which the copper cannot be thrown down free of organic matter. Addition of potash to the liquid merely changes the color from green to violet, which by boiling is further transformed into a pale red, but without any precipitation of hydrate. Hence the inapplicability of Trommer's sugar test in presence of gelatin, the cuprous oxide being soluble in gelatin solutions.

Treated with strong oxidizing agents, such as a mixture of sulphuric acid and bichromate of potash, or binoxide of manganese, it exhibits a close resemblance in behavior to casein, formic and valerianic acids being the principal products, along with a small quantity of benzoic aldehyde. When solution of gelatin is mixed with chromate of potash alone, it forms a medium very sensitive to light, which converts it into an insoluble yellow mass.

As bones are capable of yielding one third of their weight of solid gelatin, it follows that, if gelatin had a value equivalent to albuminoids, the bones of an animal would contain one-fifth of the total nutritive material in its body. Accordingly, at a time when gelatin was in high esteem for its food-value, recourse was had largely to this source, more especially in France, for a cheap nutritive soup for soldiers, pauper establishments, and hospitals. To prepare such a soup the bones may be either simply boiled in water under pressure, as in a Papin's digester, or without pressure, or they may be previously freed from salts of calcium by treatment with dilute hydrochloric acid. On the large scale the crushed bones are submitted to the combined action of steam at high pressure and a current of water percolating through the fragments. The bones, preferably in a fresh condition, or preserved by thorough drying or by antiseptic agents such as brine, are crushed by passing them between solid iron cylinders grooved longitudinally and kept revolving. They are then packed into a cylindrical cage, which can be lowered into a cylindrical jacket of rather larger diameter than itself, the whole closing with a well-fitting lid. A pipe for the entrance of water, regulated by a stopcock, projects from the top of the outer cylinder, and is connected before the lid is put on with an adjustable nozzle, through which the water trickles down among the caged bones. Another pipe is connected with the bottom of the apparatus for the passage of high-pressure steam. The gelatin solution may be removed at intervals by means of a stopcock at the bottom. The quantity of water percolating through the bones is carefully regulated in accordance with the varying pressure of the steam, so as to produce a soup of nearly uniform consistence.

As to the nutritive value of such a soup very different opinions have been entertained at different times. It was at the time of the first French Revolution, when the question of the improvement of the diet of soldiers and people was much discussed, that attention began to be directed to gelatin as a cheap and useful food; and at that time such men as Proust and D'Arcet were trying improved methods of extracting it from bone. The discovery of nitrogen as a constituent of foods generally led to its being regarded as the special criterion of food-value, and, as this element was found to exist in large proportion in gelatin, the percentage of gelatin extractable from any substance was held as determining its worth as food.

In 1802 a commission appointed by the Academy to investigate the question reported that, though it might to a certain extent replace flesh in soups, yet it could not be taken as the measure of food-value. Meanwhile experiments on men and dogs, especially by Donné, Gannal, Edwards, and Balzac, along with the results of hospital rations at St. Antoine and St. Louis, showed the impossibility of feeding upon gelatin alone, and in general its unsatisfactory character as a food. Accordingly, a second commission was appointed by the Academy in 1841, who reported very strongly against the use of gelatin at all as an article of diet, alleging that, besides being valueless itself, it actually diminishes the value of otherwise nutritious food; but this latter part of the indictment was overturned by the Netherlands' commission (*Compt. Rend.*, 1844). It ended by the Academy in 1850 declaring that gelatin was positively injurious to the digestive organs; and the natural result of this extreme reaction was of course a complete cessation of its use as food.

In Germany, Liebig had declared, in his *Thierchemie* (1843), that gelatin, being a product of the decomposition of albumen, could not take the place of albumen as food, though it might be conceived to be useful for the growth of gelatinous tissue. Boussingault's experiments on ducks (*Ann. Chem. Phys.*, 1846) showed that, contrary to what should happen if the report of the French Academy were true, gelatin did not pass unaltered into their fæces, but that a large increase of uric acid was found in their urine, a result which was confirmed by Frerichs and Bischoff, who found in the urine of dogs fed on gelatin large amounts of urea—uric acid in birds and urea in mammals being the characteristic forms in which nitrogen is eliminated from the system of these animals. The conclusion they arrived at was that the use of gelatin as a food was limited to its power of undergoing decomposition in the body, like the carbohydrates, to yield heat, but that it cannot replace the other nitrogenous constituents of the body. In 1853 Dr. Donders of Utrecht published a treatise on foods, in which he dealt with gelatin, and expressed opinions that have pretty much held their ground since, and only been confirmed in detail by subsequent investigators. Large quantities of gelatin, he says, are detrimental to digestion. In moderate quantity it gets decomposed in the body, and acts as a food probably by diminishing the otherwise necessary amount of albumen, the sole use of which, he remarks, is not merely to form tissues. In 1860 Bischoff and Voit published the result of their experiments on the subject, which completely established the fact that gelatin can take the place of albumen to a limited extent, in a way that fat cannot, so that the body-weight maintains itself on a smaller supply of albumen, and that gelatin has a function therefore of a higher character than a mere heat-producer like starch and sugar. In a more recent memoir by Voit, from which the previous historical sketch is mostly borrowed (*Zeitschrift für Biologie*, viii., 1872), the results of an extensive series of careful experiments are given in which the same conclusion comes out. He finds, moreover, that the saving of albumen is even more marked when a moderate amount of fat accompanies the gelatin, but that no combination of fat and gelatin can replace albumen or prevent the animal from losing flesh; but, on the contrary, when a dog was fed on equal parts of gelatin and fat it lost more flesh than when fed on gelatin alone. Fed on gelatin alone, it after a time evinced such a repugnance to the food that it would rather starve than feed; and, if it was induced to eat, vomiting and diarrhœa were the results. The time which gelatin takes for its complete metamorphosis in the body is far less than in the case of albumen, never exceeding 24 hours, in the course of which time all its nitrogen may be found in the urine and fæces.

A parallel series of experiments to determine how far gelatin could replace fats or carbohydrates in food showed that, though it could not be substituted for them to any large extent, it does somewhat diminish the amount of fat used up. As Voit puts it at the end of his paper, gelatin cannot, any more than fats or carbohydrates, take the place of that moiety of albumen which he calls the organic albumen,—the part which goes to build the organs and tissues; it cannot produce new blood-corpuscles to replace those that are worn out, or form muscles or any tissues, not even the gelatigenous. What it is capable of doing is to act as a substitute to some extent for that other and far larger part of the albumen of food which, never at any time forming part of any organ, circulates in the blood, and is carried to all the tissues, undergoing continual metamorphoses.

A later series of experiments by Etzinger, a pupil of Voit, was undertaken in order to elucidate the action of the digestive fluids on gelatin or gelatigenous tissue. Direct experiments showed that these substances are scarcely altered by prolonged contact with a dilute (0·3 per cent.) solution of hydrochloric acid at the ordinary temperature of the body. But when gelatin or tissues yielding it, such as *ligamentum nuchæ*, tendons, and bones were treated at the same temperature with an artificial gastric juice made by acidifying with acid of the above strength glycerin extract of pigs' stomach, a large quantity of these substances speedily disappeared to form a solution which did not gelatinize. The solution thus obtained exhibits physical and chemical characters so analogous to those of the peptones formed by a similar process from albuminoids that it has been called by some authors *gelatin-peptone*.

In a quite recent research by Hofmeister (*Zeitschrift für Physiol. Chem.*, ii. [5] 299, 1878) an attempt has been made to study the product formed in this digestion transformation. Taking the soluble gelatin obtained by prolonged boiling of gelatin in water to be the same material as is produced by the action of gastric juice, the author found that from the solutions so obtained two distinct substances could be separated, one precipitable by perchloride of platinum, which he calls *semiglutin*, and the other not so precipitable, and also more soluble in alcohol, which he calls *hemicollin*. Semiglutin forms definite salts with platinum and copper, analyses of which agree pretty well with the formula $C_{55}H_{85}N_{17}O_{22}$ as the simplest expression for the substance. Similarly the copper-salt of hemicollin gave results indicating for hemicollin a formula $C_{47}H_{70}N_{14}O_{19}$. Both of these substances yield leucin and glycocoll when treated by boiling with hydrochloric acid and stannous chloride. Further, this author states that, according to his analyses, collagen differs from gelatin by one molecule of water, and from the sum of the molecules of semiglutin and hemicollin by three molecules of water, so that a probable empirical formula for gelatin would be $C_{102}H_{151}N_{31}O_{39}$, agreeing pretty fairly with the percentage numbers given in an earlier part of this article.

See Hoppe-Seyler, *Medicinisch-Chemische Untersuchungen*, 1866 and 1871, and his *Physiologische Chemie*, just being published; Gmelin's *Handbook*, vol. xviii., 1871; Watt's *Dictionary of Chemistry*, vol. ii. For the digestion of gelatin, see Carl Voit, *Zeitschrift für Biologie*, viii., 297, 1872; Etzinger, same work, x. 84, 1874; and for constitution of collagen, Hofmeister, *Zeitsch. für Physiol. Chemie*, ii. [5] 299, 1878.

(D. C. R.)

Industrial Relations of Gelatin.

Glue.—Glue is a form of gelatin, which, on account of its impure condition, is employed only as an adhesive medium for wood, leather, paper, and like substances. There is, however, no absolute distinction between glue and gelatin, as they merge into each other by imperceptible degrees; and although the dark-colored varieties of gelatin which are known as ordinary glue are in no case treated as food, yet for several purposes the fine transparent kinds, prepared chiefly for culinary use, are employed also as adhesive agents. Neither again, except in respect of its source, is there any chemical or physical distinction between these two substances and isinglass or fish glue, and therefore the preparation and industrial applications of these three varieties of commercial gelatin—glue, gelatin, and isinglass—will be here noticed.

The gelatin-yielding substances in the animal kingdom are very numerous, comprising the skins of all animals, tendons, intestines, bladders, and fish sounds, bones, horns, and hoofs. Chondrin, the substance yielded by cartilaginous tissue, which is simply an impure variety of gelatin (see above), has greatly inferior power of adhesion. In the preparation of ordinary glue the materials used are the parings and cuttings of hides from tan-yards, the ears of oxen and sheep, the skins of rabbits, hares, cats, dogs, and other animals, the parings of tawed leather, parchment, and old gloves, and many other miscellaneous scraps of animal matter. Taking tan-yard refuse to be the principal material, it is first steeped for some weeks in a pit with lime water, and afterwards carefully dried and stored. The object of the lime steeping is to remove any blood and flesh which may be attached to the skin, and to form a lime soap with the fatty matter it contains. So prepared the "scrows" or glue pieces, as they are termed, may be kept a long time without undergoing change. Before being boiled, the glue pieces are thoroughly washed. They are then placed in hemp nets and introduced into an open boiler, which has a false bottom, and a tap by which liquid may be run off. The boiler is heated by direct firing, a series of boilers being arranged in the manner best fitted to obtain the greatest possible heating effect from one fire. As the boiling proceeds test quantities of liquid are from time to time examined and when a sample is found on cooling to form a stiff jelly, it is ready to draw off. Usually the first boiling occupies about eight hours, and when the liquid has been drawn off, more water is added and the boiling process repeated. In this way the gelatinous matter is only exhausted after six separate boilings, occupying about two days, the last boiling yielding a darker-colored glue than the first. It is essential that the boiling out of a charge should not be continued longer than is necessary for yielding a sufficiently stiff gelatinous solution, as it is found that, when the liquid is long exposed to a heat at or above boiling point, the gelatin loses its power of congealing. From the boiler the sufficiently concentrated solution is run to a tank or "setting back," in which a temperature sufficient to keep it fluid is maintained, and in this way any impurity is permitted to subside. The glue solution is then run into wooden troughs or coolers about 6 feet long by 2 feet broad and 1 foot deep, in which it sets to a firm jelly. When set, a little water is run over its surface, and with knives of suitable form it is detached from the sides and bottom, cut into uniform slices about an inch thick, and squares of these are placed on nets stretched between upright wooden frames or hurdles for drying. The drying operation, which requires very special care, is best done in the open air; the plastic masses must, however, be protected from rain. Frost and strong dry heat are equally injurious, and the best results are obtained in spring and autumn weather, when the glue dries in from twelve to eighteen days. When the pieces have become quite hard and sonorous, they are washed to remove dust from their surface, and to give them a glazed or polished appearance. A good quality of glue should be free from all specks and grit, and ought to have a uniform, light brownish-yellow, transparent appearance, and it should break with a glassy fracture. Steeped for some time in cold water it softens and swells up without dissolving, and when again dried it ought to resume its original properties. Under the influence of heat it entirely dissolves in water, forming a thin syrupy fluid with a not disagreeable smell. The adhesiveness of different qualities of glue, on which quality its value depends, differs considerably; and there are several methods of measuring the comparative value of commercial samples, the most reliable of which are based on actual experiment. Glue is also made from bones by first boiling them to remove the fatty matter they contain, and then treating them with strong hydrochloric acid till they become quite soft and translucent. In this condition, after they are washed and the acid neutralized, they are enclosed in a covered vessel and submitted to the action of steam, by which a concentrated gelatinous solution is first obtained. At a subsequent stage the whole mass is boiled by direct heat, and a further quantity of glue is so procured. The glue yielded by bones has a milky hue, owing to the phosphate of lime it carries with it.

Commercial Gelatin.—Gelatin, as a commercial product, is prepared in a manner similar to that followed in the manufacture of glue; but the materials used are selected with great attention to purity, and the various operations are carried out with the most scrupulous care and cleanliness. In the manufacture of the well-known sparkling gelatin of Messrs. Cox of Gorgie, near Edinburgh, the following is the process followed, according to their patent obtained in 1844. The shoulders and cheeks of ox-hides are preferred, but other parts may be used. The hide and skin pieces are cleansed in water, cut in small pieces by a machine, and reduced to pulp in a pulp mill. The pulp is pressed between rollers, mixed with water, and then subjected to heat varying from 150° to 212° F., whereby gelatin is produced. When a very pure quality is required, liquid gelatin is mixed with a small quantity of ox blood at a temperature not exceeding 160° or 170°, and further heated. The albumen of the blood becomes coagulated, and rises as a scum; the heat is then withdrawn, after which the scum is removed and the purer liquor allowed to settle, and afterwards it is run into coolers to congeal and dry. The gelatin is evaporated *in vacuo* to avoid the injury caused by long subjection to heat; but it may also be dried on a steam-heated surface. In Nelson's process the gelatin is extracted by steam heat from hide pieces which have been submitted to the bleaching action of sulphurous acid. The strained and purified product is spread in a thin layer on a marble slab till it partly solidifies, when it is cut up and washed to free it from all traces of acid. It is again redissolved at the lowest possible temperature, then resolidified and dried in thin sheets on nets.

Heuze of Berlin prepares a pure transparent gelatin, having a fine meaty flavor, from very impure materials, by intimately mixing with the hot solution of impure dark-colored gelatinous material a mixture of wood charcoal and animal charcoal, leaving the whole together for some hours, then redissolving and straining off the clarified gelatin.

Isinglass.—Isinglass or fish glue, in its raw state, is the swimming-bladder or sound of various species of fish. The sounds undergo no other preparation than careful drying, but in the drying they are variously treated and made up, so that the isinglass comes into commerce under the names of "leaf," "staple," "book," "pipe," "lump," "honeycomb," and other designations, according to its form. The finest isinglass, which comes from Russia, is prepared by cutting open the sounds, steeping them in water till the outer membrane separates from the inner, then washing the latter and exposing it to dry in the air. Russian isinglass is obtained from several species of sturgeon (*Acipenser*), found in the Volga and other tributaries of the Caspian Sea, in the Black Sea, and in the Arctic Ocean. Brazilian isinglass, obtained from Brazil and Guiana, is the produce of a large fish, *Silurus parkerii*, and probably some other species; and Manila and East Indian isinglass are yielded by species of fish not yet satisfactorily determined. The sounds of the common cod, the hake, and other *Gadidæ* are also used as a kind of isinglass. The principal uses to which isinglass is applied are for jellies and confections, and as a clarifying or filtering medium for wine, beer, and other liquids. When used for culinary and confectionery purposes, isinglass is rolled into thin sheets and cut into fine shreds to facilitate its solution. For clarifying liquids its fibrous structure is of great value, as it forms a fine network in the liquid in which it is disseminated, and thereby mechanically carries down all the minute particles which render the liquid thick and turbid. Isinglass dissolved in strong acetic acid forms a powerful cement, much used for repairing glass, pottery, and similar small objects.

Uses of Gelatin.—The gelatin derivable from bones enters very largely into human food, in the stock for soups, etc., and as prepared gelatin, "calves foot jelly," and isinglass. In addition to the uses already alluded to, gelatin has many other applications in the arts. It is employed as a sizing agent in paper-making, and by painters it is also used for sizing or priming, and for preparing tempera colors. Further, it is used in the preparation of elastic moulds of undercut work, and in the manufacture of inking rollers for printing. Gelatin treated with bichromate of potash, under the influence of light, undergoes a remarkable chemical and physical change, whereby it is rendered entirely inabsorbent of and insoluble by water. The change is due to the oxidizing effect of the bichromate; and the circumstance has given rise to the numerous so-called carbon-processes introduced into photography by Swan, Johnson, Woodbury, Albert, Edwards, and others, in all of which an image is produced in gelatin oxidized by chromium compounds. An insoluble glue may be prepared by adding to dissolved glue, just before using, a proportion of a solution of bichromate of potash, and such a preparation forms a useful waterproofing medium. Glue may be kept liquid at ordinary temperatures by the addition of concentrated acetic acid or of weak nitric acid. Dumoulin's liquid glue, which possesses powerful adhesive properties, is composed of glue in the proportion of 2 lb dissolved in 1 quart of water with 7 oz. of nitric acid (sp. gr. 1·335) added. Mouth or lip glue is prepared by adding ½ lb or thereby of sugar to each pound of dissolved glue. It forms solid but easily dissolved cakes, and as it can be sufficiently softened by the tongue, it is for many purposes extremely convenient. Transparent gelatin, brightly colored by dyeing substances, and cast in excessively thin sheets, is largely used for ornamental wrappings for bon-bons, etc.

Various adhesive but non-gelatinous substances are, on account of their properties, known commercially as glue, and are used as substitutes for ordinary glue. Thus marine glue, employed in shipbuilding and for other purposes, is a compound of india-rubber and shell-lac dissolved in coal-tar naphtha. Glue substitutes are also prepared from the albuminoids casein and gluten, but they are not likely to become substances of any considerable commercial importance. (J. PA.)

GELDERLAND, GELDERN. See **GUELDERLAND, GUELDERS.**

GELÉE, CLAUDE. See **CLAUDE OF LORRAINE.**

GELL, SIR WILLIAM (1777–1836), classical scholar and antiquarian, was born at Hopton in Derbyshire in 1777. After the usual preliminary education, he entered Emmanuel College, Cambridge, taking his B.A. degree in 1798, and afterwards becoming a fellow. About the beginning of the century he was sent on a diplomatic mission to Greece; and on his return in 1803 he was knighted. In the following year he published his *Topography of Troy and its Vicinity, illustrated and explained by drawings and descriptions.* His *Geography and Antiquities of Ithaca* was published in 1807. In 1810 appeared *The Itinerary of Greece, with a Commentary on Pausanias and Strabo, and an account of monuments of antiquity existing in that country.* This was followed in 1816 by the *Itinerary of the Morea, being a description of the routes of that peninsula*, a new edition of which was published in 1823, under the title of *Narrative of a Journey in the Morea.* His best known work is *Pompeiana, or Observations on the Topography, Edifices, and Ornaments of Pompeii*, in which he was assisted by Mr. J. P. Gandy. The first part of this was published in 1817–19, and was translated into French in 1828; the second part appeared in 1830–31. It was followed in 1834 by the *Topography of Rome and its Vicinity.* In Italy, whither he had retired on account of his health, he became acquainted with Queen Caroline, and his noble and disinterested behavior during her trial exhibits his moral character in a very favorable light. The queen showed her sense of his co-operation in her defence by appointing him one of her chamberlains in 1820. He died at Naples in 1836. His drawings, representing a very large series of views of classical ruins and localities, and executed, if not with much artistic skill, yet with great detail and exactness, are now in the print room of the British Museum.

GELLERT, CHRISTIAN FÜRCHTEGOTT (1715–1769), German fabulist, hymn-writer, and moral philosopher, was born 4th July, 1715, at Hainchen, in the Saxon Erzgebirge. He was educated at the university of Leipsic, where in 1751 he was appointed an extraordinary professor of philosophy, a position which he occupied till his death, 13th December, 1769. He wrote a romance, *Leben der schwed. Gräfin von G . . .* (2 vols., Leipsic, 1746), of little value, and several pastorals and comedies of, if possible, even less. His best works were his *Fabeln und Erzählungen* and *Geistliche Oden und Lieder.* Both are marked by a simple and easy directness of style. The latter express the maxims of a liberal piety, and were received by Catholics and Protestants with equal favor. They are still widely popular in Germany. The best known is the hymn entitled "Die Ehre Gottes aus der Natur." Not a little of Gellert's fame is due to the time when he lived and wrote. The German literature of the period was dominated by the pedant Gottsched and his school. A band of high-spirited youths, of whom Gellert was one, resolved to free themselves from the conventional trammels of such dictators, and began that revolution which was finally consummated by Schiller and Goethe. Gellert's share in the attempt was enhanced by the excellence of his personal character, his gentle piety, and his singular knack of gaining the reverence and love of young people. Part of his influence was also doubtless attributable to his position as a professor, and to his widely popular lectures.

See Gellert's *Sämmtliche Werke* (first edition, 10 vols. Leipsic, 1769–74, last edition, Berlin, 1867). His *Sämmtliche Fabeln und Erzählungen* and his *Geistliche Oden und Lieder* have often been published separately; the latest editions being those of Leipsic, 1874, and Berlin, 1873. See translation by J. A. Murke, Gellert's *Fables and other Poems* (London, 1851). Lives of Gellert have been written by J. A. Cramer (Leipsic, 1774) and by Döring (2 vols. Leipsic, 1833).

GELLIUS, AULUS, author of the *Noctes Atticæ*, was born in the first half of the 2d century of the Christian era, most probably in Rome, and died about 180. Nothing is known of his personal history except from incidental notices in his own book. He studied grammar and rhetoric at Rome and philosophy at Athens, after which he returned to Rome, and held there a judicial office. His only work, the *Noctes Atticæ*, takes its name from having been begun during the long nights of a winter which he spent in Attica. He afterwards continued it at Rome. It is compiled out of an "Adversaria," or common-place book, in which he had jotted down everything of unusual interest that he heard in conversation or read in books, and it comprises notes on grammar, geometry, philosophy, history, and almost every other branch of knowledge. The work, which is utterly devoid of sequence or arrangement, is divided into twenty books. All these have come down to us except the eighth, of which nothing remains but the index. The *Noctes Atticæ* is valuable for the insight it affords into the nature of the society and pursuits of those times, and for the numerous excerpts it contains from the works of lost ancient authors.

The *editio princeps* of Aulus Gellius appeared at Rome in 1469, and was speedily followed by many others in various cities of Italy, especially Venice. The best editions are those of Gronovius (Leyden, 1706), Lion (Göttingen, 1824–1825), and Hertz (Leipsic, 1853). Aulus Gellius has been translated into English by Belo (London, 1795); into French by the Abbé de Verteuil (Paris, 1776–89), and by Victor Verger (Paris, 1820–30); into German by Walterstern (Lemberg, 1785), and by Weiss, 2 vols. (Leipsic, 1875–76).

GELON, succeeded Hippocrates as tyrant of Gela in 491 B. C., and, by supporting the plebs of Syracuse in their quarrels against the aristocracy, became tyrant also of that city in 485 B.C. He used his power so discreetly that under him Syracuse attained an extraordinary degree of wealth and influence. The great event in Gelon's subsequent history was his defeat of the Carthaginians under Hamilcar at Himera, according to tradition on the same day that the Greeks defeated Xerxes at Salamis, 480 B. C., the result of his victory being that he obtained the lordship of the whole of Sicily. After Gelon had thus established his power, he made a show of resigning it; but his proposal was rejected by the multitude, and he reigned without opposition till his death 478 B. C. His memory was held in such respect that, 150 years after his death, when Timoleon was erasing from Sicily every vestige of the tyrants that had once reigned there, he spared the statues of Gelon. See SYRACUSE.

GELSEMIUM, a drug, consisting of the root of *Gelsemium* (or as sometimes less correctly called *Gelseminum*) *sempervirens*, a climbing shrub of the natural order *Loganiaceæ*, having a milky juice, opposite, lanceolate shining leaves, and axillary clusters of from one to five large, funnel-shaped, very fragrant yellow flowers, whose perfume has been compared to that of the wallflower. The fruit is composed of two separable jointed follicles, containing numerous flat-winged seeds. The stem often runs underground for a considerable distance, and indiscriminately with the root it is used in medicine. The plant is a native of the United States, growing on rich clay soil by the side of streams near the coast, from Virginia to the south of Florida. In the United States it is commonly known as the wild, yellow, or Carolina jessamine, although in no way related to the true jessamines, which belong to the *Oleaceæ*. It was first described in 1640 by John Parkinson, who grew it in his garden from seed sent by Tradescant from Virginia; at the present time it is but rarely seen, even in botanical gardens, in Great Britain.

The root, on analysis by Kollock in 1855, was found to contain an alkaloid (now called *Gelsemine* or *Gelsemia*), a dry acrid resin, $\frac{1}{2}$ per cent. of a volatile oil heavier than water, fatty resin, fixed oil, yellow coloring matter, gallic acid, starch, albumen, gum, pectic acid, extractive matter, lignin, and 3·17 per cent. of mineral matter, consisting chiefly of salts of potassium, calcium, magnesium, iron, and silica. The leaves and flowers were found to contain the same ingredients in less quantity. Eberle, who examined the root in 1869, states that the central woody portion of the root does not contain any alkaloid, and that therefore the bark is the physiologically active portion. In addition to the above, Wormley, in 1870, discovered in the root a crystalline substance named by him gelseminic acid, whose solution in alkalies exhibits a powerful blue fluorescence. It has, however, since been shown by Sonnenschein to be identical with æsculin, a crystalline glucoside found in the bark of the horse chestnut, *Æsculus Hippocastanum*. The active properties of gelsemium root have been proved by Wormley and Bartholow to depend upon the alkaloid *gelsemine* ($C_{11}H_{19}NO_2$), which in the pure state is a colorless, odorless solid, not yet obtained in a crystalline form, readily soluble in ether and chloroform, less so in alcohol, and very sparingly in water, except in the presence of hydrochloric acid, and having an intensely persistent bitter taste, perceptible in a solution containing only $\frac{1}{1000}$th part of it by weight.

The readiest and best test for gelsemine, detecting the smallest traces, appears to be the cherry-red color developed when ceroso-ceric oxide is added to its solution in concentrated sulphuric acid. The dose of the alkaloid is from $\frac{1}{60}$th to $\frac{1}{20}$th of a grain; larger quantities are poisonous, $\frac{1}{8}$th of a grain having proved fatal in an hour and a half to a strong cat.

The pharmaceutical preparation known as gelsemin consists chiefly of the resin, combined with uncertain proportions of the other constituents of the root, and is prepared by precipitation with water from the strong tincture.

The medicinal properties of the root were discovered by accident, the infusion having been administered instead of that of some other root, with the result of curing the fever for which it was taken. It was then experimented upon by the American eclectic practitioners. In 1852 Professor W. Proctor called the attention of the medical profession to its valuable properties; and in 1864 it was placed on approval in the secondary list, and in 1873, so rapidly had it risen in favor, in the primary list of remedies of acknowledged value in the United States pharmacopœia. It has latterly attracted considerable attention in England as a remedy for certain forms of facial neuralgia, especially those arising from decayed teeth, or involving branches of the fifth nerve. In the United States it is more particularly valued for controlling nervous irritability in fevers of a malarial type, in which it is said to excel every other known agent. The physiological action of the drug has been carefully examined by Bartholow, Ott, and Ringer and Murrell, from whose investigations it appears that it has a paralyzing action on the motor centres, affecting successively the third, fifth, and sixth nerves, its fatal action being due to its causing paralysis of the respiratory muscles, and thus producing death by asphyxia. In large doses it produces alarming symptoms, which occasionally terminate fatally. These appear to vary slightly in different cases, but the more prominent are pain in the forehead and in the eyeballs, giddiness, ptosis, a feeling of lightness in the tongue, slurred pronunciation, labored respiration, wide dilatation of the pupils, and impossibility of keeping an erect posture. The mind in most cases remains clear until shortly before death. The earliest and most prominent symptom of a fatal or dangerous dose is the drooping of the eyelids, which indicates the immediate administration of stimulants, for when the paralysis of the tongue which ensues extends to the epiglottis, deglutition becomes impossible, and the epiglottis is apt, unless the sufferer be placed in a forward position, to flap back and close the windpipe. The antidotes which have been found the most successful are carbonate of ammonia, brandy, aromatic spirits of ammonia, and morphia. It has been found that death may be averted by keeping up artificial respiration until the poison is eliminated by the kidneys.

See *Eclectic Dispensatory*, p. 186; *Pharm. Journ.*, 3d ser., vol. vi.; by Ringer and Murrell, etc., in *Lancet*, 1873, 1875–78; Hales, *New Remedies*, p. 390; Bartholow, *Materia Medica*, p. 380; *American Journ. Pharm.*, 1855, 1870; *Proc. Amer. Pharm. Assoc.*, 1873, p. 652; *Practitioner*, 1870, p. 202; Grover Coe, *Positive Medical Agents*, p. 114; Hughes, *Pharmacodynamy*, vol. i. p. 372; Sonnenschein, *Berichte der deutsch. chem. Ges.*, xi. p. 1182; Bentley and Trimen, *Med. Plants*, pt. xix. No. 181.

GEMINIANI, FRANCESCO (*c.* 1680–1762), a celebrated violinist, born at Lucca about 1680. He received lessons in music from Alessandro Scarlatti, and studied the violin under Lunati, and afterwards under Corelli. In 1714 he arrived in London, where his performance and compositions attracted much attention. He was taken under the special protection of the earl of Essex. After visiting Paris and residing there for some time, he returned to England in 1755. In 1761 he went to Dublin, where a servant robbed him of a musical manuscript on which he had bestowed much time and labor. His vexation at this loss is said to have hastened his death, which took place at Dublin on 17th September, 1762. He appears to have been a first-rate violinist, but most of his compositions are dry and deficient in melody. His *Art of Playing the Violin* is a good work of its kind, but his *Guida Armonica* is a miserable production. He published a number of solos for the violin, three sets of violin concertos, twelve violin trios, *The Art of Accompaniment on the Harpsichord, Organ*, etc., *Lessons for the Harpsichord*, and some other works. His musical opinions had no foundation in truth or principle.

GEMISTUS, or PLETHO, GEORGIUS, held high office under the Byzantine emperors during the first half of the 15th century, and derived his name, which signifies the Replete, from the extraordinary amount of his erudition. He is, however, chiefly memorable for having been the first person who introduced Plato to the Western world. This took place upon his visit to Florence in 1438, as one of the deputies from Constantinople on occasion of the general council. Cardinal Bessarion became his disciple; he produced a great impression upon Cosmo de' Medici; and though not himself making any very important contribution to the study of Plato, he effectually shook the exclusive domination which Aristotle had exercised over European thought for eight centuries. He promoted the union of the Greek and Latin Churches as far as possible, but his efforts in this direction bore no permanent fruit. He probably died before the capture of Constantinople. The most important of his published works are a treatise on the distinction between Plato and Aristotle as philosophers, and one on the religion of Zoroaster. In addition to these he compiled several volumes of excerpts from ancient authors, and wrote a number of works on geography, music, and other subjects, many of which still exist in MS. in various European libraries.

Plate I.

GEMS (ψῆφοι, gemmæ), engraved with designs, whether adapted for sealing (σφραγίς, sigillum, intaglio), or mainly for artistic effect (imagines ectypæ, cameo), exist in a very large number of undoubtedly genuine examples, extending from the mists of Babylonian antiquity to the decline of Roman civilization, and again starting with a new but unnatural impulse on the revival of art. Apart from workmanship they possess the charms of color deep, rich and varied, of material unequalled for its endurance, and of scarcity which in many instances has been enhanced by the strangeness of the lands whence they came, or the fortuity of their occurrence. These qualities united within the small compass of a gem were precisely such as were required in a seal as a thing of constant use, so inalienable in its possession as to become naturally a personal ornament and an attractive medium of artistic skill, no less than the centre of traditions or of religious and legendary associations. As regards the nations of classical antiquity all seals are classed as gems, though in many cases the material is not such as would strictly come under that heading. On the other hand, gems properly so called were not always seals. Many of the Babylonian cylinders could not have been so employed without great difficulty, and when Herodotus (i. 195) speaks of every Babylonian wearing a seal (σφρηγίς), it may have been in most cases no other than a talisman having an inherent power derived from the subject of its design, consisting perhaps mostly of figures of protecting deities. He adds that every Babylonian carried also a staff on which it was unlawful for him not to have the figure of an apple, a rose, a lily, an eagle, or something else, as his badge or ἐπίσημον, from which it may perhaps be inferred that having selected some such badge for his staff he would necessarily have the same for the seal with which he attested his name. But if that had been the case, then the great mass of existing cylinders could not have been seals in the ordinary sense. In Greece and Rome within historic times, gems were worn engraved with designs to show that the bearer was an adherent of a particular worship, the follower of a certain philosopher, or the attached subject of an emperor. It cannot be said that these gems may not have been used systematically as seals, but it is clear that they primarily served a different purpose. Again, when the sense of personal ornament naturally attaching to a seal increased, and the resources both of material and skill were enlarged, the process of engraving gems in cameo, that is, with the design in relief mostly in such stones as by their differently colored layers could be made to present a variety of surfaces, came largely into fashion (see article CAMEO, and figs. 18, 19 in Plate I.). As a rule these cameos are of a date subsequent to that of Alexander the Great; but there are exceptions in an Egyptian cameo in the Louvre, said to belong to the 12th dynasty, about 3000 B.C., and in some few Etruscan scarabs, which having designs in intaglio on the face have also reliefs engraved on the back, apparently in the same archaic manner of art as the intaglios. Such a scarab in carnelian was found at Orvieto in 1874 in a tomb along with vases dating from the beginning of the 5th century B.C., and it will be seen from the engraving of this gem (*Archäol. Zeit.*, 1877, pl. xi., fig. 3, compare figure of Siren on back of scarab engraved in Wieseler, *Denkmäler der alten Kunst*, No. 752) that, while the design on the face presents evidently the same subject which occurs on a scaraboid found in the treasury of Curium in Cyprus by General Cesnola (see his *Cyprus*, pl. xxxix., fig. 5, p. 381), the half-length figure of a Gorgon on the back seems to be the same in subject and treatment as a carnelian fragment, apparently cut from the back of a scaraboid, now in the British Museum. As further examples of the same rare form of cameo, the following scaraboids in the British Museum may be mentioned:—(1) a carnelian cut from back of a scaraboid, with head of Gorgon surrounded by wings; (2) carnelian scaraboid: Gorgon running to left, on face of gem an intaglio of Thetis giving armor to Achilles; (3) carnelian scaraboid: head of negro in profile, on face an intaglio of a harp; (4) steatite scaraboid: head of Achelous, full face, with intaglio of citharist (Plate I., No. 13); (5) scaraboid in burnt carnelian: head of Achelous, full face, with intaglio of Ajax carrying body of Patroclus; and four porcelain scaraboids from Camirus, each with a negro's head in relief on the back.

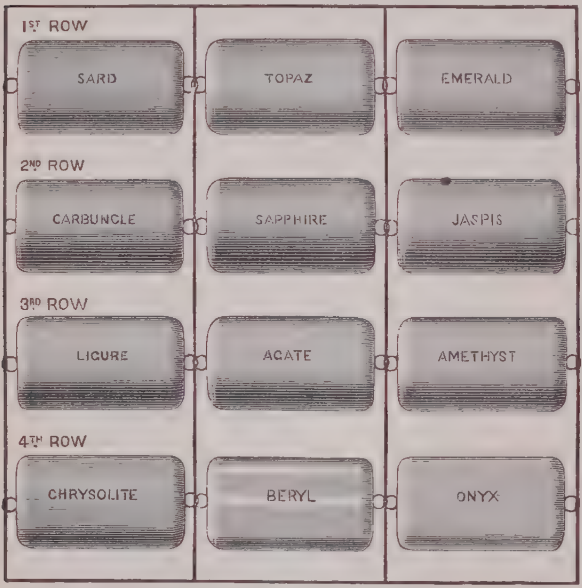
In gem engraving the principal modern implement is a wheel or minute copper disc, driven in the manner of a lathe, and moistened with olive oil mixed with emery or diamond dust. There is no proof of its use among the ancients, but M. Soldi, a practical authority on the subject, believes (*Revue Arch.*, 1874, xxviii. p. 147) that it was known before the time of Pliny, whose expression *fervor terebrarum*, as applied to the cutting of very hard stones, would fittingly characterize the rapid movement of the wheel. At the same time these words, apparently the only ancient statement on the question, may equally refer to the motion of the drill, an instrument of constant use in antiquity, which in this case was employed to drive an iron tool fitted with a diamond point or splinter. In intaglios, when the larger spaces had been sunk with the drill, the design was worked out in detail by a tool with a diamond point, and finally polished, but not, it would appear, to the extent to which polishing is carried in modern work, for this reason, no doubt, that their finer tools left less of roughness to be smoothed away. Still a gem highly polished in the interior of the design need not be taken to be modern on that account, since it is known that many genuine ancient gems have been repolished in modern times, and since it is not known whether ancient engravers may not sometimes have resorted to excess of this process; while on the other hand an intaglio dim in the surface of its design is not necessarily antique, since modern engravers have observed this peculiarity, and have imitated it with a success which, were there no other suspicions, might escape detection. Except in the hardest stones, much of the ancient gem engraving seems to have been done by a simple copper tool duly moistened and supplied with emery (σμίρις or σμύρις, naxium). The Ethiopians in the time of Xerxes employed a flint instrument, if that is what Herodotus means (vii. 69) when he says that their arrows were tipped "not with iron but with a sharp stone, with which they also engrave their seals." With such a tool steatite could be easily engraved, and it should be remembered that among very early gems this material is of frequent occurrence, while in the later art of Greece and Rome it can scarcely be said to exist; and the inference is that, when processes had been invented to cut harder stones, the softer substances were discarded. Still it would not be correct to found more than a general argument as to the comparative ages of gems on the different degrees of resistance in the stones themselves, even when dealing with the works of one nationality, much less so in a review of ancient gems as a whole, for this reason, among others, that the decline of art is in technical matters often very like its infancy. It would be easy to show from published criticisms how certain classes of rude intaglios have been regarded now as the very earliest efforts of the art, now as debased; and at times it is difficult to choose between these judgments. In the present state of knowledge it may seem idle to inquire where the infancy of the art was passed. One thinks in Egypt, which otherwise is known for its intimate skill in working hard stones. Another says Assyria, which doubtless had a civilization as remote as that of Egypt, but has left no similar evidence of the mastery of obdurate substances. The architectural and the artistic remains of the two nations present this broad distinction, that they are of much harder material in the one case than in the other, whence it would be reasonable to expect that at least the invention of the pointed tools had proceeded from Egypt, though of course if the idea of engraving gems originated with soft stones and simple implements such as flints, that origin may well have been in

Assyria. Possibly the marked difference in the shape of the gems peculiar to these two nations bespeaks little contact between them in this matter. The favorite shapes in Assyria were the cylinder pierced lengthways, and sometimes fitted with a swivel so as to be used as a seal, and the cone also pierced but not requiring a swivel, since the design was cut on its base. When inscribed, a cylinder generally states three things,—the name of the owner, his father's name, and the name of his protecting deity. But there are exceptions, as for example, a cylinder in the Bibliothèque at Paris inscribed, "Alchaloum, servant of Jehastukur," which from the Semitic form of name "Alchaloum" has been thought to have belonged to a Jewish captive in Babylon. A cylinder supposed to be the seal of Sennacherib, in the British Museum, is not inscribed. Another, purporting to be the seal of Igli, son of Uruck, the oldest king of Assyria, is rejected by M. Oppert as not having any such antiquity. An agate seal from Khorsabad reads, "Nipishi, of King Tiglath Pileser, king of Assyria, son of Haou Liklikhus, king of Assyria." But, as has already been said, many of the cylinders could not have been employed as seals without difficulty, and it appears to result from the most recent study of the designs on them that frequently their main function was to act as talismans in the system of magic generated among the Chaldæans. In what seems to be the oldest examples the design is sunk by a pointed tool pushed backward and forward in long straight lines. In the next stage round cavities are sunk here and there in the design by means of a drill, when greater depth is required, while the shallow parts are worked out with the pointed instrument. By practice in utilizing both methods the Assyrians reached whatever skill they could boast in this branch of art. The materials are hæmatite, jasper, calcedony, sard, basalt, agate, lapis lazuli, rock crystal, alabaster, porcelain, quartz, glazed clay. Mr. King classes them under four periods, beginning as early as 2234 B. C.

In Egypt the favorite form of gem was a scarab (beetle), having a flat surface underneath, on which was engraved a hieroglyphic design. The common materials are green jasper and porcelain. From the soft nature of the porcelain, and from the strict adherence to the scarab shape, it may be inferred that they were used much less as seals than as a sort of badges or ornaments, and this is confirmed by the finding of large numbers of them in foreign countries, as at Camirus in Rhodes and in Etruria, where the hieroglyphics could not have been understood. No doubt it may be true that these specimens had been manufactured by Phœnicians for export to these countries merely as articles of ornament, but had the originals been strictly held by the Egyptians to be seals, it would have been the height of dishonesty in the Phœnicians to reproduce them in this way. In Egypt, however, the art of gem engraving was not confined altogether to scarabs, as may be seen among other interesting exceptions in the oblong intaglio of green jasper in the Louvre (*Gazette Archéol.*, 1878, p. 41) with a design on both sides, representing on the obverse, as known from the cartouche, Thothmes II. (1800 B. C.) slaying a lion, and on the reverse the same king drawing his bow against his enemies from a war chariot. In the Louvre also is an Egyptian gem, said to belong to the 12th dynasty, 3000 B. C. But uninteresting in themselves as are the scarabs of Egypt, they have this accidental importance in the history of gem engraving that they furnished the Phœnicians with a model which they first improved as regards the intaglio by a freer spirit of design, gathered partly from Egypt and partly from Assyria (see the Phœnician scarabs from Tharras in Sardinia and from Cyprus). The scarab thus improved they communicated to the Etruscans, under whose skilful hands it received often a degree of delicacy in the workmanship which has not been equalled in the gems of any other country. The best specimens are due to the influence of Greek art in the 6th century B. C. or somewhat later. The subjects engraved are Greek in origin, and the habit of inscribing the names of the subjects is an early Greek habit, but with this difference, that the Greeks would be correct in the naming, while the Etruscan artists are perhaps as often wrong as right. The name of Tydeus, for instance (TYTE), is assigned in one case to a figure scraping himself with a strigil, and in another to a fallen warrior, who otherwise would be identified as Capaneus. Again a figure washing his hair is called Peleus, and Achilles sulking becomes Theseus, to the exercise of much ingenuity in times past. With these and other examples it should no longer be necessary to cast about for an unusual form of the legend of the Seven against Thebes, when five only of their names are found beside five figures on what is the most celebrated of existing scarabs—a carnelian in the Berlin Museum (Winckelmann, *Alte Denkmäler*, No. 105). Another scarab of first importance is a banded onyx in Florence representing the Salii carrying their shields, inscribed *Angils* and *Alce.* For Etruscan scarabs see ETRURIA, vol. viii. p. 562.

While the Phœnicans have left actual specimens to show with what skill they could adopt the systems of gem engraving prevailing at their time in Egypt and Assyria, the Israelites, on the other hand, have left records to prove, if not their skill, at least the estimation in which they held engraved gems. "The sin of Judah is written with a pen of iron and with the point of a diamond" (Jerem. xvii. 1). To pledge his word Judah gave Tamar his signet, bracelets, and staff (Gen. xxviii. 18); whence if this passage be compared with the frequent use of "seal" in a metaphorical sense in the Bible, and with the usage of the Babylonians already cited from Herodotus, it may be concluded that among the Israelites also every man of mark at least wore a signet. Their acquaintance with the use of seals in Egypt and Assyria is seen in the statement that Pharaoh gave Joseph his seal as a badge of investiture (Gen. xli. 42), and that the stone which closed the den of lions was sealed by Darius with his own signet and with the signet of his lords (Daniel vi. 17). Then as to the stones which were most prized, Ezekiel (xxviii. 13), speaking of the prince of Tyre, mentions the sardius, topaz, and diamond, the beryl, oynx, and jasper, the sapphire, emerald, and carbuncle, stones which again occur in that most memorable of records, the description of the breastplate of the high priest (Exodus xxviii. 16-21, and xxxix. 8). Twelve stones grouped in four rows, each with three specimens, may be arranged on a square, measuring a palm, not a span, so as to have the rows placed either vertically or horizontally. If they are to cover the whole square, then they must be cut in an oblong form, and if the names engraved on them are to run lengthwise, as is the manner of Assyrian cylinders, then the stones, to be legible, must be grouped in four horizontal rows of three each. There is in fact no reason to suppose that the gems of the breastplate were in any other form than that of cylinders such as abounded to the knowledge of the Israelites, with this possibility, however, that they may have been cut lengthways into half-cylinders like a fragmentary one of sard in the British Museum, which has been mounted in bronze, and, as a remarkable exception, has been set with three small precious stones now missing. It could not have been a seal, because of this setting, and because the inscription is not reversed. It reads: "Nabu . . . . [son of] Iddina-Nergal (?) . . . . son of Nabu-zira-iddin . . . . Khi (?)-su-ba . . . ," according to Mr. Pinches. The names of the twelve tribes, not their standards, as has been thought, may have been engraved in this fashion, just as on the two onyx stones in the preceding verses (Exodus xxviii. 9–11), where there can be no question but that actual names were incised. On these two stones the order of the names was according to primogeniture, and this, it is likely, would apply to the breastplate also. The accompanying diagram will show how the stones, supposing them to have been cylinders or half-cylinders, may have been arranged consistently with the descriptions of the Septuagint. In the arrangement of Josephus the jasper is made to change places with the sapphire, and the amethyst with the agate, while our version differs partly in the order and partly in the names of the stones, but probably in all these accounts the names had in some cases other meanings than those which they now carry. From the fact that to each tribe was assigned a stone of different color, it may be taken that in each case the color was one which belonged prescriptively to the tribe and was symbolic, as in Assyria where the seven planets appropriated each a special color (see Brandis in the Berlin *Hermes*, 1867, p. 259 *sq.*, and De Sacy, *Revue Archéologique*, 1869, and compare Revelation xxi. 13, where the twelve gates are grouped in four threes, and 19, 20, where the twelve precious stones of the walls are given). The precious stones which occur among the cylinders of the British Museum are sard, emerald, lapis lazuli (sapphire of the ancients), agate, onyx, jasper, and rock crystal. Both Ælian (*Var. Hist.*, iv. 34) and Diodorus (i. 75) speak of an object known as an image of truth worn round the neck of the judge, who of course was a priest, in ancient Egypt; but how far this may have suggested or corresponded with the Jewish breastplate is not to be made out.

The records of gem engravers in Greece begin in the island of Samos, where Mnesarchus, the father of the philosopher Pythagoras, earned by his art more of praise than of wealth. Thence also came Theodorus, who made for Polycrates the seal of emerald (Herodotus, iii. 41), which according to the curious story, was cast in vain into the deep sea on purpose to be lost. That the design on it was a lyre, as is stated in one authority, is unlikely, now that Benndorf's ingenious reading of Pliny (*Nat. Hist.*, xxxiv. 83) has shown that the portrait statue of Theodorus made by himself was in all probability a figure holding in one hand a graving tool, and in the other, not, as previously supposed, a quadriga so diminutive that a fly could cover it with its wings, but a scarab with the engraving of a quadriga on its face (*Zeitschrift für die Oesterreich. Gymnasien*, 1873, pp. 401–411), whence it is not unreasonable to conclude that this scarab in fact represented the famous seal of Polycrates. Shortly after 600 B. C. there was a law of Solon's forbidding engravers to retain impressions of the seals they made, and this date would fall in roundly with that of Theodorus and Mnesarchus, as if there had in fact been just about then a special activity and unusual skill. That the art had been practised perhaps for several centuries before in Greece is probable from the general usage of sealing implied in Solon's law, from the extraordinary degree to which it obtained soon after his time, and from the influence which was exercised on the Greeks in such matters by the Phœnicians, Egyptians, and Assyrians. Yet it is singular to find, as Pliny points out (xxxiii. 4), no direct mention of seals in Homer, not even in the passage (*Iliad*, vi. 168) where Bellerophon himself carries the tablets on which were written the orders against his life. Then as regards the rings or seals of Prometheus, of Midas, of Minos (which like that of Polycrates was thrown into the sea in vain), of Phocus, and of Orestes, the legends may not all have come down from a very early period, but that of Phocus can at least be traced back to the time of Polygnotus, while that of Prometheus may be taken to have inspired the seal (engraved *Rev. Arch.*, 1878, pl. xx.) on which the Titan is seen bound and submitting to the vulture. Or, conversely, such a gem may have suggested the legend of the ring which he bore as proof of his former punishment. There is no need to put it much later than 600 B. C., and it is a specimen of a class of lentoid gems which of late years have been found in small numbers chiefly in the Greek islands. Two more of them from the British Museum collection are engraved in Pl. I., figs. 2 and 3. As a rule the materials are comparatively soft, most frequently steatite and hæmatite, while the designs consist mainly of animals so turned and twisted as to cover almost the entire surface of the gem. Certain exceptional cases, where the design is taken from legend or mythology, may be seen in the *Revue Archéologique*, 1878, pl. xx., Nos. 1–3; for the ordinary subjects see *Revue Arch.*, 1874, pl. xii.; Schliemann, *Mycenæ*, pp. 112, 202, 362; Cesnola, *Cyprus*, pl. xxxvii. 9, and pl. xxxviii. 21, 23; and for gold signets with designs in this stage of art see Schliemann, *Mycenæ*, p. 223; Cesnola, *Cyprus*, pl. xxxiv. 2; and *Revue Arch.*, 1874, pl. iv., No. 44, in which volume is an interesting article on early engraved gems by Count Gobineau. In most cases the designs though heraldic rather than natural, with a prevalence of animal forms perhaps due to notions of heraldry, are yet so singularly free from Egyptian or Assyrian influence that they must be assigned as essentially Greek productions, possibly from a period when Oriental examples had lost sway. "Not to carry the image of a god on your seal" was a saying of Pythagoras; and, whatever his reason for it may have been, it is interesting to observe him founding a maxim on his father's profession of gem engraving (Diogenes Laert., viii. 1, 17).



Jewish High Priest's Breastplate.

From the time of Theodorus to that of Pyrgoteles in the 4th century B. C. is a long blank as to names, but not altogether as to gems, the production of which may be judged to have been carried on assiduously from the constant necessity of seals for every variety of purpose. The references to them in Aristophanes, for example, the lists of them in the ancient inventories of treasures in Athens, and the number of them found by General Cesnola in the treasure chambers of Curium in Cyprus confirm this frequent usage during the period in question. To it belong in particular the inscribed gems mentioned in ARCHÆOLOGY (vol. ii. p. 308), including the Woodhouse intaglio there figured (p. 313), which may be referred to as perhaps the very finest example of Greek gem engraving that has come down to us. It would stand early in the 5th century B. C., a date which would also suit the head of Eos from Ithome in Messenia (Pl. I., fig. 14), the head (fig. 5), the citharist (fig. 9), while the scarabs (figs. 6, 7), though apparently of Etruscan origin, obviously reflect the character of archaic Greek art, as far as concerns the shallow cutting and the delicate execution of minute details. The touch which isolates a design and literally arrests the eye they do not possess, but by comparison they render it more distinct as it exists in the Woodhouse gem already mentioned, and in figs. 8, 10–13, and 15 in Plate I., all of which may be assigned to the end of the 5th century B. C. Singularly beautiful in this class are the two Cesnola gems (*Cyprus*, pl. xxxix. figs. 1, 2), the latter, simple and even awkward in parts, yet on the whole conceived by a Greek mind imbued with the poetry of art, while the former is rather a triumph of faultlessness, delicate as the color of the stone on which it is engraved.

By the beginning of the 4th century B. C. every element of archaism had vanished; but gems of this period are scarce, except in the collection of St. Petersburg, which has obtained them exclusively from tombs in the Crimea. Foremost among them are the two by Dexamenus of Chios, the one, a calcedony with the figure of a stork flying, and inscribed in two lines, the letters carefully disposed above each other, ΔΕΞΑΜΕΝΟΣ ΕΠΟΙΕ ΧΙΟΣ (*Compte-rendu de la Commiss. Arch. St. Petersburg*, 1861, pl. vi. fig. 10), and the other, an agate with a stork standing on one leg, inscribed ΔΕΞΑΜΕΝΟΣ simply (*Compte-rendu*, 1865, pl. iii. fig. 40). A third gem, apparently by the same Dexamenus, is a carnelian belonging to Admiral Soteriades in Athens, and has a portrait head, bearded and inscribed ΔΕΞΑΜΕΝΟΣ ΕΠΟΙΕ (*Compte-rendu*, 1868, pl. i. fig. 12). Apart from the splendor of their workmanship, those three gems are interesting for the variety of their inscriptions. Thus a name standing alone in the nominative case, when it does not describe the subject of the design, will indicate the artist. Again, when the nationality of the artist is added, it should follow the verb as a rule, which, however, is not without exceptions. ΕΠΟΙΕ for ΕΠΟΙΕΙ is an archaism. The design of a stork flying occurs on an agate scarab in the British Museum from the old Cracherode collection, and therefore beyond all suspicion of having been copied from the more recently discovered Kertch gem. The condition of the surface and the skill of execution are both interesting. Reckoned among the best of the Crimea gems, and that is equivalent to saying among the best of all gems, are the following: (1) a burnt scaraboid with an eagle carrying off a hare; (2) a gem with a scarab border and the figure of a youth seated playing on the trigonon, very much resembling the Woodhouse intaglio (both engraved, *Compte-rendu*, 1871, pl. vi. figs 16, 17); (3) a scaraboid with border and the design of a horse running at speed, with which may be compared a carnelian scaraboid in the British Museum from the old Hamilton collection, and again on this account above suspicion, if the great beauty of the work were not alone convincing; the horse is here stung by a gadfly; (4) an ovoid calcedony, mounted on a chain to be worn as a collar, with an intaglio of a Gorgon (3 and 4 engraved, *Compte-rendu*, 1860, pl. iv. figs. 6 and 10). In these, and in almost all Greek gems belonging to this period of excellence, the material is of indifferent quality, consisting of agate, calcedony, or carnelian, just as in the older specimens. Brilliant color and translucency are as yet not a necessary element, and accordingly the design is worked out solely with a view to its own artistic merit.

At this stage appears the name of Pyrgoteles, of whom it is said that he alone was permitted to engrave the portrait head of Alexander the Great. The portrait head of Alexander given in Pl. I., fig, 16, is not likely to represent the art of this time, but more probably belongs to the age of Augustus who used this design as a seal. On the other hand the ancient pastes (figs. 20–22) will convey a notion of the gem engraving of the time of Alexander. Still it should be observed that one of the special difficulties of the subject is to account for the scarcity of gems from this period of wealth, luxury, and artistic activity in all directions. Possibly not a few belong to it which it is thought safer to class as Roman. This much at least is certain, that Roman art altogether was a prolongation, hardly a development, of the Macedonian art. Those Roman engravers may have been conscious of this who boldly placed on their productions the names of celebrated Greek artists, as for instance on a garnet in the British Museum, having a figure perhaps of Jason and inscribed with the name of Phidias (ΦΕΙΔΙΑΣ ΕΠΟΕΙ); others elsewhere profess to be the work of Polycletus or of Scopas. The same effrontery was seen in sculpture, and unfortunately has revived again in the gem engraving of comparatively recent times, as may be seen in a calcedony intaglio of the head of Alexander the Great in the British Museum, which, though clearly modern, claims to be the work of Pyrgoteles.

From literary sources are known the engravers Apollonides, Chronius, Tryphon, Satyreius, and Dioscurides, but the date of the last-mentioned only is certain. He lived in the time of Augustus, whose portrait he executed, and did not, it may be supposed, inscribe his own name on it in full. On the other hand, if, as Pliny states, it became a custom afterwards to seal with this portrait of Augustus, it would be natural enough to place on the copies of it made for that purpose the name of Dioscurides. With this view of the case may be reconciled two gems bearing his signature in the British Museum—the one a jacinth, the other a sard—and both obviously portraits which, though more resembling Julius Cæsar than Augustus, might yet be regarded as unsuccessful portraits of the latter. Of the two the jacinth, which is from the Blacas collection, is doubted by Brunn; the other is a higher class of work, and yet even it presents some difficulties that require the theory of an imitator, most probably a Roman one. The obtrusive display of the wreath and the fringe of drapery round the bust are details which, apart from the style of workmanship, are objectionable. That the name of this engraver has been often added to modern gems is true enough, and in some cases also it may have been in modern times inscribed on perfectly ancient gems. Even among those which appear to be in all respects antique there are differences in the spelling and form of the letters not to be accounted for if they had come from his hand, but intelligible if they had been made by ancient copyists. Abbreviations such as ΔΙΟΣΚ for Dioscurides, or ΕΠΙΤ for Epitynchanus, are always suspicious. ΕΠΙΤΥΓΧΑ, on a beautiful cameo of the young Marcellus, might seem to have been abbreviated by the accident which broke off the lower part of the gem, but the inscription does not bear examination except as the work of a modern hand. Not necessarily modern is the inscription ΔΙΟΣΚΟΥΡΙΔ, on a fragmentary amethyst, with a head which may perhaps have been meant for Alexander the Great, whose portrait, as has been said, was used as a seal by Augustus, and may have been executed for him by Dioscurides. It is possibly an ancient copy of this seal, with the addition of the name of the original artist to show that it is so. With regard to the question whether a name standing in the genitive case may indicate the engraver, the evidence is affirmative, if for no other reason than that the names are most frequently Greek, while the owners or collectors of gems in Italy were Romans. Collecting was a passion with wealthy Romans, but their names have not survived on gems. Names like Aulus or Gnæus, written in Greek letters, cannot indicate a Roman of position, but on the contrary show that it was to the naturalized Greeks that the Romans looked for their engravers. When, for instance, one gem reads ΣΟΛΩΝΟΣ and another ΣΟΛΩΝ ΕΠΟΙΕΙ, it is fair to conclude that we have to do in both with an engraver named Solon, if the inscriptions are genuine. The former occurs on a gem found with jewelry at Pompeii (*Bullet. d' Inst. Arch.*, 1863, p. 91), so that if the other examples of it, *e. g.*, on the Strozzi Medusa in the British Museum, and on the so-called head of Mæcenas, be inventions of the 16th or 17th centuries, they are at least correct in reproducing a name which is now seen on one undoubtedly ancient intaglio. Obviously one or more gems so inscribed must have existed in the 16th or 17th centuries, and this fact alone of the existence of several gems with the same name would suggest if not actually prove that it was the name of an engraver. The other inscription, ΣΟΛΩΝ ΕΠΟΙΕΙ, on an intaglio of Diomedes carrying off the Palladium, though known since the year 1660, has not always passed unchallenged. The Medusa just mentioned is a gem of extraordinary pretensions, but very unsatisfactory when compared with good Greek work. In the matter of names the evidence as to the Greek usage, though very slight, is not at variance with what may be gathered from the coins where the names of the die-sinkers appear either in the nominative or genitive case.

In the discussions as to what is or is not proper in the way of engravers' signatures, frequent reference is made to the inscription ΕΥΤΥΧΗΣ ΔΙΟΣΚΟΥΡΙΔΟΥ ΑΙΓΕΑΙΟΣ ΕΠ, which occurs twice—on a pale amethyst said last century to belong to the prince of Avella, and on an amethyst in the Marlborough collection. The design on the two is identical, consisting of a helmeted bust of Minerva in full face. Unless what was formerly the Avella gem is now the gem belonging to the Marchese Strozzi of Florence, then this again must be a third example. Professor Maskelyne in his *Catalogue* quotes Mr. King as agreeing with him that the Marlborough gem (No. 81) is not a copy as Brunn supposed, but may be regarded as an original work of Eutyches till the Avella gem be proved to exist elsewhere. But Stephani insists on the inscription being a modern production, especially on account of the contraction ΕΠ for ΕΠΟΙΕΙ, which he says had arisen through the last letters ΟΙΕΙ being hidden from the modern copyist, either owing to the setting, or from some other cause. The gem which Cyriacus of Ancona and a contemporary of his saw and described in the early part of the 15th century had the full inscription, and possibly it was from an inexact impression of it that the Marlborough gem was made (*Compte-rendu*, 1861, p. 157). Another celebrated Marlborough gem with the head of the dog-star Sirius, inscribed ΓΑΙΟΣ ΕΠΟΙΕΙ, is condemned by Professor Maskelyne in his *Catalogue* (No. 270), as it deserves to be. Apparently meant for the same engraver, though written differently, is the ΓΝΑΙΟΣ on the beryl in the British Museum with the head of Hercules, as to which Köhler's adverse judgment appears to be entirely just. ΣΚΥΛΑΞ, which is found on an amethyst head of Pan in the British Museum executed with wonderful exactness of detail, is not disputed, except as to whether it is the name of the engraver or the owner. Among the other names which have been more or less the subject of discussion are those of Hyllus, who also claims to be a son of Dioscurides, Epitynchanus, Agathopus, Euodus, Felix, Mycon, Allion, Admon, Onesas, Protarchus, and Alexas.

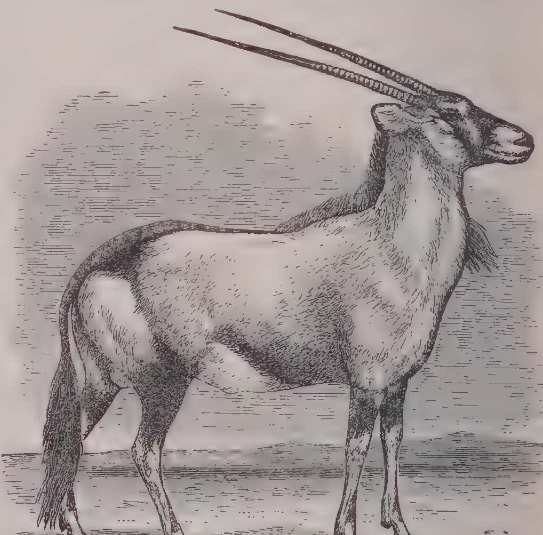
The habit of gem collecting is recorded first in the instance of Ismenias, a musician of Cyprus, who appears to have lived in the 4th century B.C. But though individual collectors are not again mentioned till the time of Mithradates, whose cabinet was carried off to Rome by Pompey, still it is to be inferred that they existed, if not pretty generally, yet in such places as Cyrene, where the passion for gems was so great that the poorest person owned one worth 10 minas, and where according to Ælian (*Var. Hist.*, xii. c. 30), the skill in engraving was astonishing. The first cabinet (dactyliotheca) in Rome was that of Scaurus, a step-son of Sulla. Cæsar is said to have formed six cabinets for public exhibition, and from the time of Augustus all men of refinement were supposed to be judges both of the art and the quality of the stones. To this pretension is doubtless due most of the existing gems engraved on large beautiful jacinths, garnets, sards, beryls, and amethysts, leaving, as regards purely technical skill, nothing to be desired. Except in portraiture, and in grylli or conceits, in which various things are combined into one, often with much skill, the subjects were as a rule only variations or adaptations of old types handed down from the Greeks. When new and distinctly Roman subjects occur, such as the finding of the head on the Capitol, or Faustulus, or the she-wolf with the twins, both the stones and the workmanship are poor. In such cases, where the design stirs a genuine national interest, it may happen that very little of artistic rendering will be acceptable rather than otherwise, and much more is this true when the design is a symbol of some article of faith, as in the early Christian gems. There both the art and the material are at what may be called the zero of engraving; that is to say, it has reached the point beyond which barbarousness or folly sets in. The usual subjects on the early Christian gems are the fish, anchor, ship, dove, the good shepherd, and, according to Clemens, the lyre. Under the Gnostics, however, with whom there was more of speculation than of faith, symbolism was developed to an extent which no art could realize without the aid of writing. A gem was to them a talisman more or less elaborate, and the difficulty is to make out how they carried them. Many specimens exist, but none show signs of mounting. The materials are usually hæmatite or jasper. As regards the designs, it is clear that Egyptian sources have been most drawn upon. But the symbolism is also largely associated with Mithraic worship. The name Abraxas or Abrasax, which, from its frequency on these gems, has led to their being called also "Abraxas gems," is, when the Greek letters of which it is composed are treated as Greek numerals, equal to 365, the number of days in a year, and the same is the case with ΜΕΙΘΡΑΣ.

More interesting, from the occasionally forcible portraiture and the splendor of some of the jacinths employed, are the Sassanian gems, which as a class may be said to represent the last stage of true gem engraving in ancient times. In the middle ages and onwards metal stamps were found more serviceable for the purpose of sealing, and though engraved gems still continued to be a luxury of the great, the old traditions were broken through, as may be seen, for example, in the large crystal in the British Museum representing Susanna and the Elders, made by order of the French king Lothair, 954–986. With the revival of classical tastes under the patronage of popes and princes in the Cinquecento period, it was natural that this branch of art should have a new career of activity, which, after a lapse during the 17th century, again during the last century revived under an even greater amount of encouragement from men of wealth and rank. In this last period the names of engravers who succeeded best in imitating classical designs were Pichler (Pl. I. fig. 28), Natter, and the Englishmen Marchant (fig. 29) and Burch. Compared with the Greek gems on the same plate, it will be seen that what at first sight is attractive as refined and delicate is after all mere pretence of refinement, and entirely devoid of the ancient spirit. The success with which modern engravers imposed on collectors is recorded in many instances, of which one may be taken as an instructive type. In the Bibliothèque in Paris (Chabouillet's catalogue, No. 2337) is a gem familiarly known as the signet of Michelangelo, the subject being a Bacchanalian scene. So much did he admire it, the story says, that he copied from it one of the groups in his paintings in the Sistine chapel. The gem, however, is evidently in this part of it a mere copy from Michelangelo's group, and altogether is a later production.

The gems engraved in Plate I. show a progressive development of the art from the earliest times down to last century. They are all in the British Museum, and are enlarged to about a half more than their real size. No. 1, Porcelain scarab, from Camirus in Rhodes; No. 2, Carnelian, lentoid gem, from Ialyssus, in Rhodes; No. 3, Crystal, lentoid, also from Ialyssus; No. 4, Paste scaraboid, from Tharras, in Sardinia; No. 5, Carnelian head of a king; No. 6, Crystal scarab, Gorgon; No. 7, Carnelian scarab, Citharist; No. 8, Sard, female figure with water jar; No. 9, Steatite scaraboid, Citharist; Nos. 10–13, Four sides of an amethyst, Mænads; No. 14, Agate, Eos; No. 15, Carnelian, unknown; No. 16, Carnelian, head of Alexander the Great, as Helios; No. 17, Sard, head of Zeus; No. 18, Sardonyx cameo, Actæon; No. 19, Sardonyx cameo, head of Athena; No. 20, Paste, Victory; No. 21, Paste, Mænad; No. 22, Paste, Victory sacrificing bull; No. 23, Agate scaraboid, Priest; No. 24, Amethyst, head of Brutus (?) from Rhodes, inscribed C. I. Q.; No. 25, Jacinth, Sassanian portrait; No. 26, Gnostic gem; No. 27, Christian gem, the Good Shepherd; No. 28, Modern gem, by Pichler; No. 29, Modern gem, by Marchant.

Literature.—See M. A. Levy, *Siegel und Gemmen*, with three plates of gems having Phœnician, Aramaic, and old Hebrew inscriptions, Breslau, 1869; and on the same subject, De Voguë, in the *Revue Archéologique*, 1868 (xvii.), p. 432, pl. 14–16; De Saulcy, in the *Rev. Arch.*, 1869 (xx.), p. 101, "Recherches sur le costume chez les Juifs;" Victor Ancessi, *L'Égypte et Moïse*, Paris, 1875, giving on plate 7 a fanciful restoration of an Egyptian breastplate; Soldi, in the *Rev. Arch.*, 1874 (xxviii.), p. 147, on Babylonian cylinders; Count Gobineau, in the *Rev. Arch.*, 1874 (xxvii.), p. 111 and p. 179, on early Oriental gem engraving. Fr. Lenormant, in the *Rev. Arch.*, 1874 (xxviii.), pl. 12, gives five examples of early lentoid gems, and seven more gems of the same class are given by A. S. Murray in the *Rev. Arch.*, 1878, pl. 20. On Greek and Roman gems the principal authorities are Köhler, *Gesammelte Schriften*, iii. and v., and Stephani, in his notes to these volumes, and in the *Compte-rendu de la Commission Imperiale de St. Petersbourg*, 1870–1, p. 215 and pp. 221–224. Opposed to them is Brunn, in his *Geschichte der Griechischen Künstler* (1859), ii. p. 443, where a full discussion of Greek and Roman gems will be found. See also Krause, *Pyrgoteles*, Halle, 1856, and *Bollettino dell' Inst. Rom.*, 1831, p. 105; 1834, p. 116; and 1839, p. 99. In England the authority is C. W. King, *Antique Gems*, 2d edit., London, 1866; *Handbook of Engraved Gems*, 1866; *Precious Stones*, 1865; *Gnostic Gems*, 1864; and appendix on ancient gems in Cesnola's *Cyprus*, which gives 11 plates of gems. Of special interest as regards the stones used by ancients, and valuable as a criticism of a single collection, is Prof. Maskelyne's *Catalogue of the Marlborough Collection*, privately printed in 1870. This collection is now the property of Mr. Bromielow. On Abraxas gems see Barzilai, *Gli Abraxi*, Trieste, 1873, and Matter, *Histoire du Gnosticisme*. An indispensable book of reference is Raspe's *Catalogue of Tassie's large series of Sulphur Casts*. Among catalogues of public collections are Tolken's *Verzeichniss d. preuss. Gemmen*, 1835; Chabouillet's *Catalogue des Camées et Pierres Gravées de la Bibliothèque Imperaile*, Paris, 1856; and Jansson's *Nederlandsch-Rom. Daktyliotheek*, Leyden, 1844. Older works are generally of small critical value, but the following may be mentioned:—Winckelmann, *Description des Pierres Gravées du Feu Baron de Stosch*, Florence, 1760; Visconti, *Opere Varie*, ii. pp. 115–386; Mariette, *Traité des Pierres Gravées*; Millin, *Pierres Gravées*, and *Introduction à l'Étude des Pierres Gravées*, Paris, 1796. (A. S. M.)

GEMSBOK (*Oryx gazella*, Gray), a species of antelope, abounding on the dry yet fertile plains of South Africa, where it feeds on the bulbs of water-root and other kinds of succulent vegetation, by means of which the antelopes of those regions are able to subsist without water for months together. It is a large and powerful animal, measuring about 5 feet in length and over 3 feet in height at the shoulders. Its horns, situated on the same plane with its forehead, exceed 2 feet in length, are al-



Gemsbok.

most straight, and are obscurely ringed throughout their lower half. The color of the upper part of the body is a rusty grey, and of the under part white, while these are separated from each other by a well-defined black band on each side. These bands unite on the breast, and are continued as a single black band until reaching the lower jaw, when they again divide and form two transverse bands on the head, terminating at the base of the horns. The head otherwise is white, as also are the limbs, with the exception of the thighs which are black. The striking appearance presented by this antelope is in great part due to the absence of any blending in the different colors of its body. The gemsbok avoids the woods, living on the open plains in pairs or in small groups of four or five. Possessing powerful weapons of attack in its long spear-like horns, and with ample courage to use them, this animal, especially when wounded, is a formidable antagonist both to man and to the numerous beasts of prey which are attracted to the karroos of the Cape by the presence of this and other ruminant species. It is said to defend itself not unfrequently with success against the lion. Its flesh is esteemed a delicacy, and its hide forms a valuable leather.

GENDARMERIE, a body of troops or police in France, composed of *gendarmes*, or men-at-arms. In the days of chivalry they were mounted and armed cap-a-pie, and attended each by five soldiers of inferior rank and more lightly armed. They were then furnished by the fiefs, and marched in the train of the knights and esquires. In 1439 this feudal gendarmerie was replaced by the *compagnies d'ordonnance* which Charles VII. formed when the English were driven out of France, and which were distributed throughout the whole extent of the kingdom for preserving order and maintaining the king's authority. These companies, fifteen in number, were composed of 100 lances or gendarmes fully equipped, each of whom was attended by at least three archers, one *coutillier* (soldier armed with a cutlass), and one *varlet* (soldier's servant). The states-general of Orleans (1439) had voted a yearly subsidy of 1,200,000 livres in perpetuity to keep up this national soldiery, which replaced the bands of mercenaries who for about a century had made France their prey. The number and composition of the *compagnies d'ordonnance* were changed more than once before the reign of Louis XIV. This sovereign on his accession to the throne found only eight companies of gendarmes; but after the victory of Fleurus (1690), which had been decided by their courage, he increased their number to sixteen. The four first companies were designated by the names of *Gendarmes écossais*, *Gendarmes anglais*, *Gendarmes bourguignons*, and *Gendarmes flamands*, from the nationality of the soldiers who had originally composed them; but at that time they consisted entirely of French soldiers and officers. These four companies had a captain-general, who was the king. The fifth company was that of the queen; and the others bore the name of the princes who respectively commanded them. This organization lasted till 1787, when Louis XVI. dissolved it, only retaining the *Gendarmes écossais* in his body-guard. The great Revolution swept away all these institutions of the monarchy, and, with the exception of a short revival of the *Gendarmes de la garde* at the Restoration, the word gendarmerie had thenceforth an altogether different meaning. It has been since that time employed to denote a military police, whose duties are to watch over the public safety, keep order, and enforce the execution of the laws. This police force superseded the old *maréchaussée.*

The law of the 28th Germinal, An VI. (17th April, 1797), and the royal ordinance of the 29th October, 1820, organized the gendarmerie, and laid down the general rules that are still in force, dividing it into legions and companies, and the latter into brigades. In time of war a colonel of gendarmerie, with the title of *grand-prévôt*, is attached to the army with a detachment of gendarmes, for maintaining discipline among the soldiers. Though placed under the control of the minister of war, the gendarmerie is also at the disposal of the minister of the interior as a police force, of the minister of justice as agents to secure the execution of judicial sentences and police regulations, and also of the minister of marine and colonies for enforcing his authority over marines and sailors in the colonies and sea-towns of France. The gendarmerie of Paris constitutes a special corps established first in 1802, and successively called *Gendarmerie de Paris*, *Garde royale*, and *Garde municipale.* Suppressed by the provisional Government in 1848, the Garde de Paris was soon reorganized. It is now composed of 6 squadrons of cavalry and 24 companies of infantry, and is officially styled *Garde républicaine de Paris.* Both in the *Garde républicaine* and in the *légions*, the gendarmes consist for the most part of deserving soldiers of the regular army, who have been drafted into this service, where, with other privileges, they have a much higher rate of pay than the soldiers of the line. Their total numbers are about 40,000, made up of the Garde de Paris as above, 31 provincial legions, 1 legion of gendarmerie mobile, and the *Gendarmerie coloniale.*

Russia also has a gendarmerie, a secret police appointed in all towns of the empire to watch over Russian subjects of all ranks and classes, and to report to the chancery office such information as they receive from their detectives and secret agents.

For the history of the old French gendarmerie before 1789 see Chéruel, *Dictionnaire historique des institutions de la France*, 2 vols., and Lacroix, *Vie militaire et religieuse au moyen âge et à l'époque de la Renaissance ;* and for the present gendarmerie, *Réorganisation de la Gendarmerie*, 1871, and *Annuaire militaire*, 1877.

GENEALOGY. *Biblical.* — The word "genealogy" (*γενεαλογία*), which occurs twice in the New Testament (1 Tim. i. 4; Tit. iii. 9; compare also Heb. vii. 3, 6) in the ordinary concrete sense of "pedigree" or "list of ancestors," is of somewhat frequent occurrence in the authorized version of the Old Testament scriptures, but only in Chronicles-Ezra-Nehemiah, where the words יַחַשׂ and הִתְיַחֵשׂ, which are peculiar to that work, are invariably rendered "genealogy" and "to reckon by genealogy." This translation, however, is of somewhat doubtful accuracy; for, whatever the original meaning of the root יָחַשׂ may have been,[1] there seems to be no room for doubt that the noun and the verb connected with it were used in later Hebrew simply to denote respectively the roll and the act of registration; and that the "book" alluded to in Neh. vii. 5 (in A. V. "register of the genealogy") was genealogical only in so far as the individuals registered in it were classified according to their "houses," "families," and "tribes." While a catalogue of this sort was admirably fitted to be a permanent record of tribal relations in Israel, as these subsisted at the time of its compilation, there is not any reason to suppose that it made any attempt to trace them through previous generations.[2] The scripture genealogies, properly so called, are rather to be sought for in these תּוֹלְדוֹת (A. V. "Generations;" Gen. ii. 4; v. 1; vi. 9; x. 1, etc.; Ex. vi. 16, 19, etc.; Num. iii. 1) so frequently met with in some other canonical books, and so specially characteristic of the first book of the Pentateuch as apparently to have suggested to the Alexandrian translators its distinctive name of *γένεσις*. These begin with the antediluvian period, and indeed with "the generations (or genealogy) of the heavens and of the earth." The descendants of Adam are traced through the lines of Cain and of Seth respectively to the seventh and to the ninth generation. In the two lists the frequent similarity of the names has not escaped observation; nor has the symmetry of the numbers (in one case, a series of seven, the seventh branching into three; in the other a series of ten, in which the seventh is peculiarly prominent, while the tenth branches into three). The very ancient tradition which they embody is not at present so works of J. L. L. Gebhardi, especially his continuation of Lohmeier and *Der Mohammedanischen und Heidnischen hohen Häuser historische und genealogische Erläuterung* (1731), and those of Gatterer (*Handbuch der Genealogie und Heraldik*, 1761, and *Abriss der Genealogie*, 1788), the latter being the first and still a useful manual upon the theory of genealogy. Of works belonging to the present century, one of the earliest was the *Atlas historique généalogique, chronologique et géographique* (1803–4) of Le Sage; and one of the greatest, bearing upon the general subject, was the famous Benedictine *L'Art de vérifier les dates* (1820–33). During recent years the stricter principles of criticism which have become characteristics of all modern historical investigation have made themselves felt in a very marked manner in the field of genealogical research. A wise scepticism has been increasingly shown with regard to all assertions which had not the support of adequate "diplomatic" evidence; and with the increased desire have come enlarged facilities for consulting ancient documents either directly or by means of authentic reprints. So far as England is concerned, the improved arrangements with regard to the public records, and the various publications of the record commissioners, have brought the materials for a successful prosecution of this and cognate branches of antiquarian science within the reach of every zealous student; and although in current *Peerages*, assertions which probably had no origin but in vanity, and certainly have no evidence except that of long unquestioned tradition, are still perpetuated, such statements can mislead none except the very unsophisticated. The principal and almost the only sources from which authentic family history can be drawn are such documents as the Domesday books; the chartularies, leiger books, registers, necrologies, calendars, and chronicles of the various monasteries, records which convey both directly and indirectly a vast amount of information as to the pedigrees of founders and patrons; also the tournament and crusade rolls sometimes found in these establishments; the various sorts of Chartæ Antiquæ, such as title deeds and enrolments in Chancery and other courts of justice; the books and rolls which record the returns to the successive inquisitions made into the state of the "Knights' Fees" which were granted at the time of the Norman Conquest; the placita, in which are recorded decisions of parliament and other courts; the Rotuli, including charter rolls, patent rolls, pipe rolls, and many others; the Inquisitiones post mortem, sometimes inaccurately termed escheats; the records of heralds' visitations; monumental inscriptions, coats of arms, seals, etc. These sources are indicated with considerable fulness and discrimination in Grimaldi's *Origines Genealogicæ, or the sources where English Genealogies may be traced from the Conquest to the Present Time* (1828), and, after him, by Sims in the *Manual for the Genealogist, Topographer, Antiquary, and Legal Professor*, 1856.[1]

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[1] According to Ewald (*Gesch. d. V. Isr.* i. 261, *cf. Alt.* 363), it meant properly "to count." In the LXX. the Hithpael is rendered differently in each passage where it occurs; *ἐγενεαλογήθη* is only once given. In Ezra ii. 62 the translation is *γραφὴν αὐτῶν οἱ μεθωσειμ* (Vulg., scripturam genealogiæ suæ); in Neh. vii. 64 it is *γραφὴν ἑαυτῶν τῆς συνοδίας* (scripturam suam in censu). It may be added that the habit of taking a written census of sections of the population, or even of the entire nation, was obviously not unfamiliar to the Jews. This appears from numerous indications in the earlier historical books, *e. g.*, Num. i. 18, where the word (used here only) is וַיִּתְיַלְדוּ, as well as in Chronicles-Ezra-Nehemiah. Compare also Ezek. xiii. 9 and Ps. lxxxvii. 6.

[2] When, for example, we read in 1 Chr. vii. 6, 7 that Benjamin had three sons (Bela, Becher, and Jediael); in viii. 1, 2 that he had five (Bela, Ashbel, Aharah, Nohah, and Rapha); in Numb. xxvi. 38 again that he had five, but that their names were Belah, Ashbel, Ahiram, Shupham, and Hupham; and finally, in Gen. xlvi. 21 that they numbered ten "souls" (Bela, Becher, Ashbel, Gera, Naaman, Ehi, Rosh, Muppim, Huppim, and Ard); or when the descendants of Bela are variously given, in 1 Chr. vii. 7 as Ezbon, Uzzi, Uzziel, Jerimoth, and Iri; in 1 Chr, viii. 3–5, as Addar, Gera, Abihud, Abishua, Naaman, Ahoah, Gera, Shephuphan, and Huram; and in Numb. xxvi. 40 as Ard and Naaman, the simple explanation (after all due allowance for corruptions in the text has been made) seems to be, that in the course of a long history the Benjamite tribe included a varying number of families or clans with varying names. Similar instances might be indefinitely multiplied. It ought to be added, however, that criticism has not yet by any means completed its task on the book of Chronicles in its genealogical bearings. See Wellhausen, *Geschichte Israels*, i. 230 *sq.*, 1878.

The earliest printed "British Peerage" was that of Milles, entitled *Catalogue of Honor*, published in folio in 1610; but Camden's *Britannia* (1586) also contained many genealogies. Among recent works the best known are those of J. and J. B. Burke (*A Genealogical and Heraldic Dictionary of the Peerage and Baronetage of the United Kingdom*, 1822; 40th ed., 1877), of Lodge (*The Genealogy of the Existing British Peerage*, 1832–33; 48th ed., 1879), of Dod, and of Debrett; but the number of publications (inclusive of those of the London Genealogical and Historical Society) which have been, and continue to be, issued on this attractive subject is very great. For a bibliography approaching to completeness reference may be made to the privately printed *Catalogue of Works on the Peerage and Baronetage of England, Scotland, and Ireland*, prepared by Sir C. G. Young (1827), to Moule's *Bibliotheca Heraldica* (1822), or to Sims's *Manual for Genealogists*. In any list, however brief, the names of Dugdale (*The Baronage of England*, 1675–76) and of Collins (*A Peerage of England*, 1709; *The English Baronage*, of which only the first volume was ever completed, 1727) deserve a special place. The works of Sir R. Douglas on *The Peerage of Scotland* and *The Baronage of Scotland* appeared respectively in 1764 and 1796; that of John Lodge, on *The Peerage of Ireland*, in 1754. On the knightage of Great Britain and Ireland the most accessible writers are again Burke and Dod; but the work of Sir N. H. Nicolas (*A History of the Orders of Knighthood of the British Empire*, 4 vols. fol., 1842) is of more importance. As being somewhat of an innovation in genealogical literature, Burke's work on the commoners of Great Britain and Ireland may be mentioned here (*A Genealogical and Heraldic History of the Commoners of Great Britain and Ireland enjoying territorial possessions or high special rank but uninvested with heritable honors*, 1833–38).

For the purposes of genealogical research in the United States of America one society at least has been formed, "The New England Historical and Genealogical Society," under the auspices of which an annual *Register* is published. Among numerous other publications bearing upon this subject may be mentioned J. F. Holgate's *American Genealogy* (1851), Whitmore's *American Genealogy* (1868), Webster's *Genealogy* (1877), and Thomas's *Genealogical Notes* (1878). (J. S. BL.)

GENELLI, GIOVANNI BUONAVENTURA (1798–1868), was born at Berlin, September 28, 1798, and died at Weimar, November 13, 1868. He was the son of Janus Genelli, a painter whose landscapes are still preserved in the Schloss at Berlin, and grandson to Joseph Genelli, a Roman embroiderer employed to found a school of gobelins by Frederick the Great. Buonaventura Genelli first took lessons from his father and then became a student of the Berlin Academy. After serving his time in the guards he went with a stipend to Rome, where he lived ten years a friend and assistant to Koch the landscape painter, a colleague of Hähnel, Reinhard, Overbeck, and Führich, all of whom made a name in art. In 1830 he was commissioned by Dr. Härtel to adorn a villa at Leipsic with frescoes, but quarrelling with this patron he withdrew to Munich, where he earned a scanty livelihood at first, though he succeeded at last in acquiring repute as an illustrative and figure draughtsman. In 1859 he was appointed a professor at Weimar, where he ended his days. Genelli painted few pictures, and it is very rare to find his canvases in public galleries, but there are six of his compositions in oil in the Schack collection at Munich. These and numerous water-colors, as well as designs for engravings and lithographs, reveal an artist of considerable power whose ideal was the antique, but who was also fascinated by the works of Michelangelo. Though a German by birth, his spirit was unlike that of Overbeck or Führich, whose art was reminiscent of the old masters of their own country. He seemed to hark back to the land of his fathers and endeavor to revive the traditions of the Italian Renaissance. Subtle in thought and powerfully conceived, his compositions are usually mythological, but full of matter, energetic and fiery in execution, and marked almost invariably by daring effects of foreshortening. Impeded by straitened means, the artist seems frequently to have drawn from imagination rather than from life, and much of his anatomy of muscle is in consequence conventional and false. But none the less Genelli merits his reputation as a bold and imaginative artist, and his name deserves to be remembered beyond the narrow limits of the early schools of Munich and Weimar.

GENERATION, a term in general biology or physiology. synonymous with the Greek *βιογένεσις* and the German *Zeugung*, may comprehend the whole history of the first origin and continued reproduction of living bodies, whether plants or animals; but it is frequently restricted to the sexual reproduction of animals. The subject, in its most comprehensive aspect, would naturally be divided into the following branches, viz.:—(1) the first origin of life and living beings, (2) non-sexual or agamic reproduction, and (3) gamic or sexual reproduction. The first two of these topics have already been shortly treated of in the articles ABIOGENESIS and BIOLOGY; the third and more extensive division, including (1) the formation and fecundation of the ovum, and (2) the development of the embryo in different animals, it has been deemed expedient to refer to the heading REPRODUCTION.

GENESIS. See PENTATEUCH.

GENET (*Genetta*) a genus of carnivorous mammals belonging to the *Viverridæ* or family of civets. It contains six species, all of which are found exclusively in Africa, with the exception of the common genet (*Genetta vulgaris*), which occurs also throughout the south of Europe and in Palestine, where Tristram notes it as occurring on Mount Carmel. The fur of this species is of a dark grey color, thickly spotted with black, and having a dark streak along the back, while the tail, which is nearly as long as the body, is prettily ringed with black and white. The genet is abundant in the south of France and in Spain, where it frequents the banks of streams, and feeds on the smaller mammals and on birds. In the vertically slit pupil of its eyes, and in the complete retractility of its claws, it approximates, along with the other species, to the cats, and correspondingly differs from the true civets, while the anal pouch which is so fully developed in the civet exists as a mere depression in the present genus, and contains only a faint trace of the highly characteristic odor of the former. In south-western Europe and in Africa it is sought after for its soft and beautifully spotted fur, while in Constantinople it has been tamed and kept like a cat for destroying mice and other vermin.

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[1] According to Grimaldi, in 1828 there were 294 peers, exclusive of the royal family. Of these thirty-five claimed to have traced their descent to beyond the Conquest, forty-nine to a date prior to the year 1100, twenty-nine to the 12th century, thirty-two to the 13th, twenty-six to the 14th, seventeen to the 15th, twenty-six to the 16th, and thirty to the 17th. In the case of forty-five noblemen no satisfactory conclusion could be drawn as to the commencement of their pedigree. The pedigree of the Percys is one of the most full and complete genealogies of the kingdom. In Scotland the house of Mar is probably that which can at once carry its nobility to the remotest period (1093), and authenticate it by the best evidence.

Genet.

GENEVA (in French *Genève*, in German *Genf*, in classical Latin *Geneva*, and in Low Latin, by metathesis, *Gebenna* or *Gevenna*), a city and canton of Switzerland,—the canton being, with one exception, the smallest, and the city, without exception, the largest within the limits of the confederation.

Canton.

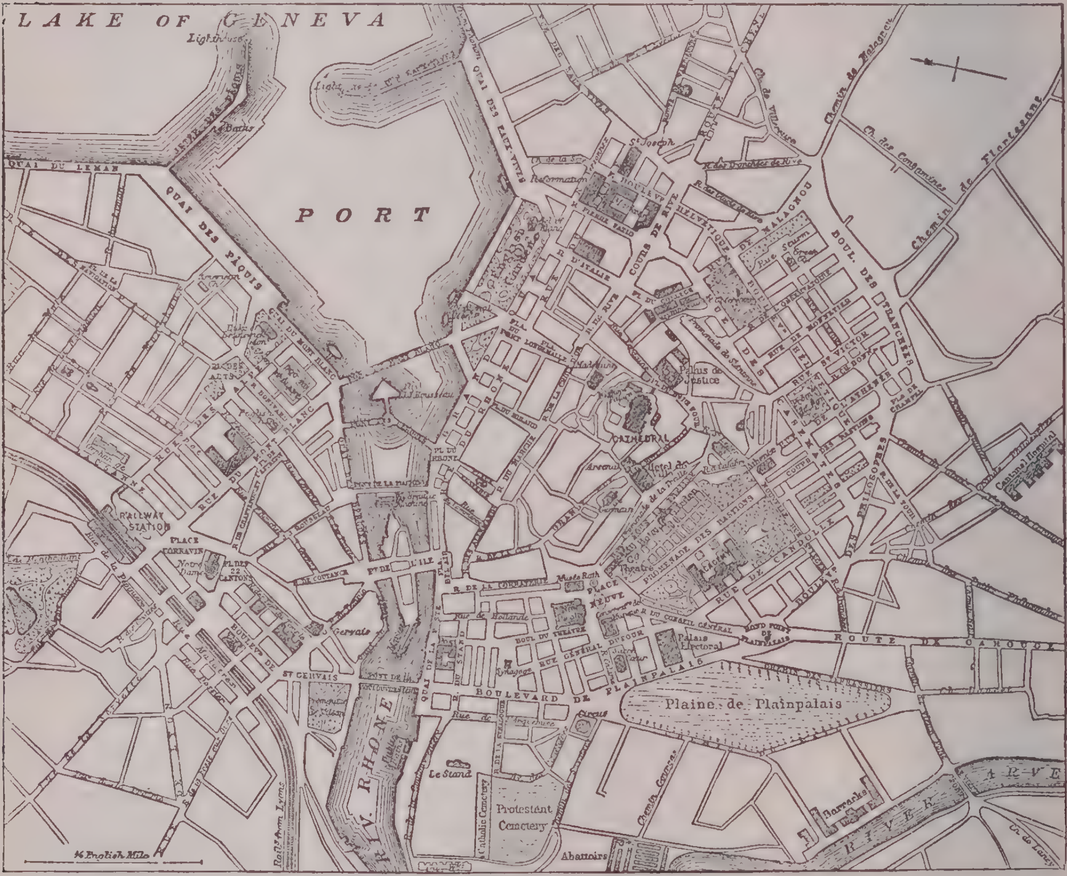
The canton of Geneva has an area of 279·4 square kilometres, or 107·8 square miles, considerably less than that of Rutland, the smallest of the English counties, and this includes 11½ square miles of water-surface belonging to the lake. The greater part of its frontier is conterminous with France, the department of Haute-Savoie lying to the south, and that of Ain to the west and north; while it is connected with the Swiss canton of Vaud (Waadt) along a line of not more than 3½ miles. The area belongs to the basin of the Rhone, which flows for about 4 miles through the canton, and then for nearly 2 miles forms the boundary towards France. With the exception of the Arve, the Rhone tributaries are mere mountain streams, of which the largest is the London in the extreme west. Market gardens, orchards, and vineyards occupy a large proportion of the soil, whose apparent fertility, however, is due not so much to its natural qualities as to the noble industry of the cultivators. Besides building materials such as sandstone, slate, etc., the only mineral to be found within the canton is bituminous shale, the products of which can be used for petroleum and asphalte (see *Les Gisements bitumineux du canton de Genève*, Paris, 1877). While Geneva is, as has been stated, almost the smallest of the Swiss cantons, the size of the city makes the density of its population far greater than that of any other. In 1870 it had, inclusive of strangers, 93,239 inhabitants, or 871 to the square mile; and this had increased by 1876 to 99,352 inhabitants, or 921 to the square mile. At the earlier date, 43,639 were Protestants and 47,868 Roman Catholics,—the remaining fraction comprising 961 Jews, and 771 of various Christian sects. The prevailing language is French; but the German element, represented in 1870 by 978 households, is on the increase.

City.

The city of Geneva is situated at the south-western extremity of the beautiful lake of the same name, whence the noble current of the Rhone flows westward under the five bridges by which the two halves of the town communicate with each other. To the south lies the valley of the Arve, which unites with that of the Rhone a little distance further down; and behind the Arve the grey and barren rocks of the Lesser Salève rise like a wall, which in turn is overtopped by the distant and ethereal snows of Mont Blanc. To the north-west the eye takes in the long line of the Jura, with a pleasant stretch of country between it and the lake. The actual site of the town, apart from the river and the lake, is not so picturesque as that of many other places in Switzerland. Though the central plateau, crowned as it is by the cathedral, gives a certain relief to the general view from the water, a large proportion of the town is built on the alluvial flats along the river. But what Geneva lacks in picturesqueness it now makes up in an appearance of prosperity and comfort,—presenting fine quays, well-ordered pleasure grounds, good streets, and substantial houses, and, in the number and extent of its modern suburbs, giving evidence that its prosperity is not a thing of the past. Since the demolition of the fortifications in 1848, it has pushed eastward to Eaux Vives, and westward into Plainpalais, and an almost continuous succession of houses links it on the south with the village of Carouge beyond the Arve.

Buildings.

In the strict sense of the words, Geneva is not a city of great buildings. It possesses, indeed, a great many edifices, both public and private, which may fittingly be described as handsome, elegant, or even beautiful, but it has almost nothing to which the memory reverts as to a masterpiece of architectural art. Being a favorite resort for wealthy foreigners from many lands, it has been enriched with a countless variety of hotels and villas, many of which are palatial in their dimensions, their construction, and their environment, and its principal institutions have been installed in buildings not unworthy of a modern capital; but none of these things compensate for the absence of the grander and more characteristic legacies of the Middle Ages and the Renaissance. The artistic blight of that Calvinism which was too sternly enamored with the beauty of holiness to be mindful of any other beauty has left indelible effects on the central city of the creed; though it is probable that all the blame does not lie at the door of Calvinism, which certainly did not find in the Genevese a people whose æsthetic faculties had been too strongly developed in the previous periods of their history. The cathedral itself is a second-rate building; and though as Mr. Freeman remarks, "it is an excellent specimen of a small cathedral whose style and plan are peculiarly its own, and which has undergone only very few alterations," its main interest is moral and historical. According to a tradition, at least as likely to be true as false, it occupies the site of a temple of Apollo; and the present building is the third church of St. Peter which has been erected on the spot. As a foundation the cathedral is said to date from the middle of the 10th century; but (even apart from documents still extant which relate to the works) the transition from the Romanesque to the Gothic style is sufficient evidence that it belongs architecturally to the 12th and the 13th. The most glaring alteration to which it has been subjected is the substitution for the original façade (1749-1756) of a portico with Corinthian pillars, copied after the Pantheon at Rome, which, while effective and simple enough in itself, is altogether out of keeping with the rest of the design. In its general plan the church is a Latin Cross, having a width of about 65 feet and a length of 187. It is lighted by 86 windows,—those of the choir still preserving painted glass of the 15th century, and some of the others being filled with modern work in commemoration of the jubilee of 1835. Of the internal decorations, the little that has been left comprises portions of the carved stalls, and a few sepulchral monuments—most of them removed from their original sites—Agrippa d'Aubigné's, Michel Roset's, Theodore de Beza's, the duke and duchess of Rohan's, etc. Among the older secular buildings in Geneva are the Hôtel de Ville, the court-house, and the arsenal. The first, which is popularly called the Maison de Ville, or Town House, is situated to the west of St Peter's. It is first mentioned in 1448, but most of the structure dates from the 16th and 17th centuries. There is nothing remarkable, except their plainness about the several halls or chambers—the hall of the lost footsteps, the chamber of the great council, etc. The *Salle des Festins* is now known as the Alabama Chamber, in memory of the arbitration decided within its walls in 1872. To the historian the building is interesting, not only for its associations, but for the magnificent series of archives which it contains. It was in front of the house that the works of Rousseau were publicly burned in 1762. (See *Nouv. Descr. du Hôtel de Ville*, 1877.) The court-house was formerly a hospital, and has been appropriated to its present purpose only since 1858. As a building it dates from 1709, and is a good specimen of the Mansard style in vogue at the time. Among the structures of modern date the most noteworthy are the academic or university buildings, the Athénée, the Rath museum, the conservatorium, the electoral palace, the new theatre, the hall of the reformation, and the Russian church. The first stone of the academic buildings was laid in 1868. They consist of three blocks forming three sides of a square, and occupy an excellent position near the botanic gardens in the Promenade of the Bastions. The Athénée, a highly ornamental building, was founded for the accommodation of the old society of the arts by the wealthy Genevese, J. G. Eynard (1775–1863), well known for his generous devotion to the cause of Greek independence. It was in 1824 and 1826 that, in accordance with his wishes, the sisters of the deceased Simon Rath (1766–1819), a general in the Russian service, devoted a large part of their fortune to the erection of the museum which preserves the name of the family. The building is in the Greek style, with a Corinthian portico and a flight of steps, and it contains a collection of copies of the cardinal masterpieces of ancient art and valuable works of the modern Swiss school. The conservatorium, whose foundation was due to Bartholony, a Genevese financier, owes its reputation as a musical school to Bovy Lysberg (1821–1873). The Fol museum, famous for its Greek and Etruscan vases, occupies the old Academy buildings in the Grand' Rue.



Plan of Geneva.

Benevolent institutions. Among the larger benevolent institutions are the civic hospital, with an endowment of 3½ million francs, a lunatic asylum, a deaf and dumb institute, and an orphanage; and upwards of 200 distinct societies for philanthropic purposes are at work in the state.

Education. From a comparatively early date the Genevese have given considerable attention to education. In 1429 François Versonnex endowed and restored the "great school," which continued to flourish till the Reformation, and was attended by numerous foreign pupils. An academy and college were established by Calvin and Beza in 1558, and soon became famous. Since 1875 the academy has ranked as a university, having five faculties—a scientific, a literary, a legal, a theological, and a medical. Though medical teaching was long practised in Geneva by its more eminent physicians, according as circumstances suggested, there was no regular provision for this department till 1874, when a staff of 13 professors and 10 privatdocents was instituted. An anatomical theatre has been erected by the cantonal hospital, and a maternity hospital and a *policlinique* or dispensary are supported by the property of the suppressed religious corporations. In the winter session of 1876–7 the university had 142 regularly enrolled students and 182 unattached auditors; and in the summer session the students numbered 155 and the auditors 147. Of the 297 regular students, no fewer than 126 were foreigners, and only 106 were Genevese proper, while among the auditors the proportion of foreigners was still greater, or 187 as compared with 95. The canton of Geneva has no normal school, but there are two colleges (one in the town and one at Carouge), a gymnasium, and a high school for girls, and in those institutions the training of teachers is an object of attention. The Genevese college had 1134 pupils in 1876–7,—309 being foreigners, and of these 139 French. In all the primary schools, with the exception of those of Carouge, Plainpalais, and Eaux Vives, the mixed system is in vogue. Nearly all the communes, from Lancy in 1848 to Plainpalais in 1877, have been provided with educational libraries, the total number of the books in 1867 being upwards of 20,000. The "public library," formerly located in the Rue Ardaine and now in the university buildings, is an admirable institution, thoroughly deserving the title of public, as its books, without any needless formality, are at the service of even the casual reader. The first nucleus of the collection, which now numbers about 75,000 volumes, was Bonivard's bequest in 1568.

Industries. As early as the 14th century, Geneva was the seat of a flourishing silk trade, and its woollen fabrics were largely exported. Four times a year the streets of the town were filled with the traffic of its fairs, which were visited by the merchants of Venice, Florence, and Genoa, of France and German Switzerland. In the 16th century hats, ribbons, velvets, woollens, and gold and silver plate, were among the principal products of Genevese industry; the guild of armorers or *heaumiers* was a powerful corporation; and watchmaking was already carried to a high degree of perfection, under the influence of Charles Cusin, who had settled in the town in 1587. By 1685 there were 100 master watchmakers with 300 workmen, and 80 master jewellers with 200 workmen. In the 17th century the silk trade made great progress, and towards its close calico-printing was introduced by the Fazy family. During the 18th century the number of wealthy immigrants from Italy gave an impetus to the various architectural industries, but at the same time the political troubles tended to scatter the industrial population. Voltaire introduced a number of Genevese watchmakers to Ferney; the French sought to make Versoix a manufacturing centre; and the Government of Savoy established a royal watch factory at Carouge. Since the restoration of Genevese independence in 1813 the principal industries of the city and canton have steadily developed. According to the census of 1860, there were 515 master watchmakers and jewellers in the canton, and the number of workers in the trade was 4876, of whom 4004 were men and 872 women. As early as 1827, about 240 persons were employed in the manufacture of musical boxes, and this number had by 1873 increased to at least 1080 of both sexes, capable of turning out 13,000 boxes in a year. Among the minor industries are wood and ivory carving, the making of tools and scientific instruments, iron-smelting and engineering, and the manufacture of tobacco, soda water, and various chemical stuffs. Banking operations are conducted on a large scale, and printing and publishing have long been of prime importance to the city. Printing was introduced in 1478 by Steinschaben of Schweinfurth; and by 1563 there were 20 printing establishments in the city. Robert Stephen, having fled from Paris, was received a citizen of Geneva in 1556; but his son Henry found that the attentions of the consistory could be nearly as offensive and dangerous as those of the Sorbonne, and the great printing establishment over which he presided came to an untimely end. For details on the contributions made by Genevese inventors to the progress of the various arts, the reader may refer to Elie-François Wartmann's interesting brochure, *Notice historique sur les inventions faits à Genève*, Geneva, 1873.

Distinguished Genevese. It would be hard to find a city of the same size as Geneva which could claim the honor of being the birthplace of a greater number of eminent men; and still harder perhaps to find one that had extended its hospitality to so many foreigners of distinction. In the roll of its celebrities the first place is due to Jean Jacques Rousseau, who, in spite of its treatment of him, retained considerable affection for "ma république." The house in which he was born occupied the site of No. 69 of the present Rue Rousseau. Though M. Marc Monnier, himself a Genevese, has found materials for a volume on *Les poètes de Genève*, such names as Mulhauser (1806–71), author of the dramatic poems *Sempach* and *Philibert Berthelier*, or Petit Senn (1792–1870), whose *Bluettes et Boutades* (1846) has gone through a number of editions, have hardly more than local reputation. Rodolphe Toepffer, the humoristic novelist, has attained a wider popularity, which may almost be called European. But the really famous Genevese are mostly men who have devoted themselves to the sciences, or to the more utilitarian forms of literature. Among the theologians are Mestrezat, the opponent of the Jesuits; Diodati, the translator of the Bible; the Tronchins, the Turrettines (Fr. and J. A.), Ed. Diodati, Felix Neff, Cæsar Malan, and Gaussen. Among the historical writers may be mentioned Baulacre, Mallet (of Scandinavian celebrity), De Lolme, Grénus, Sismondi, Picot, Cherbuliez, Sayous, Blavignac, and Galiffe; and among the philologists, Cramer, Leclerc, Casaubon, and Spanheim. To the medical sciences belong the names of Jean de Carro, Espine, and Charles de la Rive; and to the physical sciences Bonnet, Huber, De Luc, De Saussure, De Candolle, and Pictet. Pradier, the sculptor of the statue of Rousseau on the island in the Rhone, Chapponnière, Hornung, and Calame are the best known of the modern artists.

Population. As far back as 1356 the town of Geneva is said to have contained 5800 inhabitants, and this by 1404 had increased to 6490, exclusive of the Bourg de Four and St. Gervais outside of the fortifications. In 1545 the number is given as 12,500, but the plague and other causes had reduced it to 11,000 by 1572. After the revocation of the edict of Nantes it rose to 16,934 in 1698, no fewer than 3000 refugees having sought shelter within its walls. The 18th century was marked by a steady increase: 18,500 in 1711, 24,712 in 1782, and 26,140 in 1789. In 1850 the total was 31,238, of whom 5717 were from other parts of Switzerland, and 6513 from other parts of the world. The census of 1870 gave 46,783, or including the suburbs of Eaux Vives and Plainpalais, 61,486. The noteworthy fact about this increase is that it is due solely to immigration, for the Genevese families are far from prolific, and indeed have an indubitable tendency to die out (Galiffe, *Genève historique*, 1869).

History. According to a well-known passage in Cæsar's *Commentaries*, he found Geneva the frontier town of the Allobroges, and when he crossed the bridge which even then spanned the river, he was no longer in the territory of the Allobroges but in that of the Helvetians. How long the little *oppidum* had been in existence before that time it is impossible even to conjecture: that the spot had in far earlier days been occupied by a cluster of crannogs may be accepted as rather more than a conjecture, though the extensive formation of new land within the historic period has completely buried whatever archæological evidence might otherwise have been available. There was a time clearly when the site of the present lower town was entirely submerged and the waters of the lake and river found their shores along the edge of the rocky plateau of the upper town. The Allobroges were, it would appear, a Celtic people, and the name Geneva, according to the favorite etymology of modern investigators, has its explanation in the words *gen* and *ev*, the "issue" of the "waters." For several centuries of the Christian era the history of Geneva remains a blank, but remains of substructions, aqueducts, canals, inscriptions, statues, pottery, bronzes, arms, coins, etc., show that during the Roman period the town must have been a large and flourishing place, extending, if M. Galiffe is right, over the plateau of the Tranchées. Christianity must have been early introduced, the traditional apostles being Dionysius and Paracodus. In 456 the Celtic town passed under the dominion of the German Burgundians, and in 534 it was incorporated with the kingdom of the Franks. To Charles the Fat it was indebted for the right, sanctioned by Pope John VIII., of electing its bishops from among its own clergy. Optandus, the bishop whose election led to the decision of this point, was a supporter of Rodolph I., founder of Transjuran Burgundy; and it was at Geneva that Conrad the Salic caused himself to be crowned king of Burgundy in 1033. This accession of Conrad proved in several ways of moment to the town; for to him was due the first aggrandizement of the house of Savoy, and from him was derived the temporal sovereignty of its bishops. The counts of Genevois—a district to the south of the Genevan territory, now included in the French department of Haute Savoie—were partly reconciled to the loss of the authority they had previously had over the city when in 1070 they saw Guy of Faucigny Genevois, a member of their own family, elected to the episcopal see. The next bishop, however, Hubert or Humbert of Grammont, laid claim to all the rights and possessions alienated by Guy; and at length, in 1124, by the "Accord of Seyssel," the count of Genevois recognized the bishop as his superior under the emperor. Bishop Ardutius (1135–1185) had again to oppose the encroachments of the counts; but the emperor Barbarossa, to whom he appealed at the diet of Spires (1153), not only upheld his claims, but made him prince of the empire. As the bishops could not always attend in person to the civil concerns of his jurisdiction, a vidom or vidomne (*vice dominus*) was appointed, who had to judge according to the customs and usages of the city, and in difficult matters was assisted by the advice of three or four citizens, two canons of Geneva, and two nobles of the church. During the bishopric of Robert of Genevois (1277–1288), the Genevese sought protection from the encroachments of his family at the hands of the count of Savoy, Amadeus V.; and on Robert's death a contest for possession of the city took place between the count and the new bishop, William of Conflans (1288–1294). In the resulting anarchy the citizens learned to act for themselves, and in 1289 and 1291 we find the bishop complaining of certain procurators, syndics, or agents of the city who had acted as chief magistrates in peace and war. In 1293, however, the syndicate was (for the time) abolished. Between the count of Genevois, who held the castle at Bourg de Four, at the corner of the city, and the count of Savoy, who by the peace of Asti in 1290 had secured the office of vidomne, and now held the castle of the Island, both citizens and bishop were hard bestead. In 1320 the castle of Bourg de Four was demolished by Edward and Aymon, sons of the count of Savoy. When the emperor Charles IV. visited Geneva on his way to Avignon (1365), Amadeus V., the "Green Count," obtained the rank of imperial vicar over the old kingdom of Burgundy and over the city of Geneva; but William of Marcossay, who was bishop from 1366 to 1377, persuaded the emperor to abolish the vicariate by a bull at Frankfort (1366), and by a second bull at Prague (1367) to cancel all rights granted to the counts of Savoy over Geneva and its territory; and in 1371 Pope Gregory XI. caused the count to withdraw from the city his castellan and judges. The year 1387 is a memorable one in Genevese history, as the date of the publication by Bishop Adhémar Fabri (1385–1388) of the franchises which served for centuries as the Magna Charta of the city.[1] By the purchase of the countship of Genevois, Amadeus VIII. became possessor of all the country round the city; and although he accepted investiture from the bishop and took the oath of fealty, his ambition was simply biding its time. On the visit of Sigismund in 1455, he was raised to be duke of Savoy; and when Pope Martin V. shortly afterwards passed through the district, he sought to obtain complete jurisdiction over the city. Jean de Pierrescise, however, appointed bishop at the suggestion of the duke, who hoped to find in him an easy tool, was no sooner occupant of the see than he appealed to the people, obtained their vote against the alienation of the temporal rights of his predecessors, and swore in return for their support to maintain their liberties. In 1420 a bull of the emperor Sigismund formally declared that the city held directly of the empire. But by a strange turn of events, the indefatigable Amadeus did ultimately become master of Geneva,—not, indeed, by way of conquest or through the degradation of its bishopric, but by himself succeeding to the bishop's see. During the greater part of his pontificate as Felix V. he resided in Geneva; and on his resignation the council allowed him the administration of the bishoprics of Geneva and Lausanne. In the latter part of the 15th century, amid the dissensions of the house of Savoy, two facts deserve special notice for their effect on Geneva. The duke Louis, irritated against the Genevese because they had admitted his rebellious son Philip of Bresse within their walls, caused the king of France, his son-in-law, to establish a fair at Lyons, which withdrew the greater part of its traffic from the city of Lake Leman; and Bishop John Louis forming an alliance with Charles the Bold, the Swiss (for Geneva was still the last town of the Allobroges) inflicted a ransom of 20,000 crowns.

The beginning of the 16th century brought the long contest between Savoy and Geneva to a climax and a close. Into the struggle, interesting as it is, between the Mamelukes (Mamelus) or ducal party and the Eidgnots (Eidgenossen) or patriots, it is impossible to enter. The great heroes of the city are Philibert Berthelier, Pierre Lévrier, François of Bonivard, the prior of St. Victor, and Besançon Hugues. To their patriotic devotion it owed its ultimate liberty, and the alliances with Freiburg and Bern, which, first formed in 1519 and 1526, were solemnly renewed in 1531. Meanwhile the Reformation was advancing in Switzerland. In 1532, Farel entered the city, and in 1535 the reformed doctrine was officially recognized as the religion of the state. In October, 1536, a new actor appeared on the scene—John Calvin, then about 25 years of age. By force of intellect and strength of will he soon made himself the leader of the Protestant party, and proceeded to work out his ideal of government and society. While it rendered homage to many of the noblest elements of human nature, to purity, to honesty, to industry, to benevolence, this ideal had grievous defects; it forgot especially that all healthy moral action must be spontaneous, and that in regard to deeds as well as men it is a dangerous thing to confound the innocent with the guilty. The moral dictates of the sternest conscience of the community were to be the binding laws of every citizen. Religious observances were no longer to be the outcome of individual piety, but part of the inevitable routine of daily life. The church became the state; breach of ecclesiastical discipline was crime; innovation in dogma was treason. The Genevese as a people appear to have been naturally religious; in the old pre-Reformation times they had been distinguished for their liberality and kindness to the clergy, their appreciation of a good preacher, the abundance of their contributions for masses and prayers. Under the guidance of Calvin, this religiosity took a new and sterner cast. But a certain part of the citizens were not so willing to relinquish their liberty, and under the name of Libertins or Liberty men, they contended earnestly against the establishment of the new régime. In 1538 they were so powerful that the four syndics were chosen from their ranks; and they had the satisfaction of seeing Calvin and Farel, on 23d April, expelled from the city by order of the little council, confirmed by the council of the two hundred and the council-general. But the Libertins did not know how to rule; anarchy and license got possession of the city; the Catholic party recovered ground. Calvin was recalled, and, returning on 3d September, 1541, at once re-established his system in all its vigor. The Libertin party again revolted; sixty of their number were condemned to death, and four who failed to make their escape were beheaded. In 1547 Jacques Gruet was executed as an utterer of threats against the dictator and a possessor of impious books; and in 1553 Michel Servetus was burned alive. To the historian of Geneva it is of comparatively little importance whether or not the main guilt of this too famous crime fell directly and solely on Calvin himself; it is condemnation enough that such a deed was possible within the walls of a city where his fiat and his veto were equally supreme. And on the other hand, it must never be forgotten that the very reason why the fagot fire in which Servetus perished has become such a beacon to after times, while the smouldering embers round a Dolet or a Vanini are only now and then stirred to a fitful glare, is that Calvin had made Geneva a city set upon a hill, and that the lurid smoke and flame showed doubly dark against the clear light of his wonderful intellect and his noble life. In some respects Geneva was never greater than under his dictatorship. It was at once the moral capital of the half of Christendom and the great frontier fortress against the invasions of Rome. Like every fortress city, it had to pay the penalty of its position, and the penalty was none the less because its garrison fought with spiritual weapons, and its martial law interfered with the liberties of the mind. In 1564, after twenty-three years of such labors as few men could rival, Calvin died, and his body was laid in the cemetery of Plainpalais; but his spirit continued to live in the constitution he had founded. The milder character of his successor, Theodore Beza, allowed free scope to the other members of the Government, and the democratic element obtained greater prominence. About 1564 Geneva appeared for a time in danger from its Catholic neighbors, and especially from the duke of Savoy; but though this prince recovered possession of the Chablais, the Genevois, and the country of Gex, and appointed Francis of Sales titular bishop of Geneva, no direct attempt was made against the independence of the city. The year 1568 is of note for a revision of the constitution, drawn up by Germain Colladon, which, while retaining in the main the Calvinistic framework, practically placed political power in the hands of a few principal families. The administration nominally consisted of the syndicate and four councils—the council of the twenty-five, the council of the sixty, the council of the two hundred, and the council-general; but the council of the twenty-five, usually called the "little" or "narrow council," managed in the long run to arrogate the direction of all public affairs. During the 16th century, both before and after the Colladon revision, the variety of affairs which were considered under its jurisdiction is sufficiently amusing. It was at once the foreign office of the republic and the high court and the police court combined; and it accordingly passed, as matter of course, from the consideration of matters of state, in which the potentates of Europe were parties, to the squabbles of market women, the use of bad eggs in cakes, or the length of a minister's sermon.[2] Its private deliberations were kept strictly secret: in 1491 the betrayer of any of its transactions was judged "infamous," and in 1530 it was added that his tongue should be pierced. Torture was still retained as a legal instrument of investigation, and the penal enactments against heresy and witchcraft remained unrepealed. In 1579 the city was taken under the protection of Bern and Soleure, and in 1584 it formed an alliance with Zurich; but these agreements proved of little advantage, and in the conflicts which were always being renewed with the duke of Savoy, Geneva was left to her own resources, and the accidental assistance of Elizabeth of England or Henry IV. of France.

At length, in 1602, Charles Emmanuel of Savoy determined to seize the city by a *coup de main*, and on the night of the 11th and 12th December (O. S.) an army of 8000 men were despatched against it. As no declaration of war had been made, the citizens were taken by surprise; and the enemy had fixed their scaling ladders and were already mounting the walls before the alarm was given. But once aroused, the Genevese were not long in turning this success into discomfiture and rout, and when morning broke the city was once more safe, and a joyous crowd heard the voice of the aged Beza in the cathedral read out the grand old Psalm, "Now may Israel say, If the Lord had not been with us." Such is the famous "Escalade," the Bannockburn of the Genevese, which has since been celebrated with all possible forms of celebration.[3] By the treaty of St. Julian in the following year the duke of Savoy granted the Genevese freedom of trade, restored the lands of St. Victor and St. Peter, and promised to build no fortress and assemble no troops within four leagues of the city; but the ambitious prince made one more attack before his death in 1620. During the rest of the 17th century the history of Geneva consists mainly of dissensions between different councils, and between the governing bodies and the people; but amid them all the city advanced in prosperity, especially after the accession to its population occasioned by the revocation of the edict of Nantes. The 18th century brought the political contest to a head. In 1707 Fatio, advocate and member of the two hundred, was appointed president of a commission charged to formulate the grievances of the people. In the document which he drew up he maintained the sovereignty of the people, the equality of all citizens, and the subordination of the magistracy as mere executive functionaries; and at the same time demanded that the council-general should meet at least once a year, and not only when the syndics chose. The councils appeared to yield, but shortly afterwards, supported by confederates from the oligarchical cities of Bern and Zurich, they crushed the popular party, and caused Fatio to be shot. How sternly they were disposed to resent interference was shown in 1731 by their sentence of perpetual imprisonment passed on Micheli Du Crest for merely giving expression to the popular opposition to the new system of fortifications carried out by the councils. The party of which he was so far a spokesman—known as the *representants*—at length, in 1734, gained a decided victory in the general council of 1734. By the edict of 1738, though the whole initiative in matters of legislation was left in the hands of the lesser councils, the actual passing of laws and fixing of taxes were entrusted to the general council, and thirty years later the people obtained the right of naming the half of the council of the two hundred. There was an important class of the inhabitants, however, who were still excluded from political rights—the so-called "natives" or descendants of the aliens who had settled in the city; and this class continued to make known its discontent. At length, in 1782, Bern, Sardinia, and France interfered in favor of the aristocratic party, and by the Act of Pacification the most important reforms in a liberal sense were again abolished. A few years later, and France was under a different régime. The Revolution at Paris was followed by a revolution at Geneva. A new constitution, accepted by the National Assembly in 1794, declared the political equality of all the Genevese; but, by a curious inconsistency, the national committee of finances divided them again into aristocrats, the *englués*, and the patriots, taxing the last class much less heavily than the others. In March, 1798, it was agreed that Geneva should become a part of the French republic, and on 13th June the French authorities entered the city. By the treaty of Paris its independence was restored, and it became one of the cantons of the Swiss confederation. A new constitution declared all the citizens equal, and placed the legislative power in the hands of a representative council. As no one, however, could be an elector who paid less than 20 Swiss livres, or about 23 shillings, of direct taxes, the democratic character of the system was considerably modified. It was not till 1841 that any great change was effected. In the early part of that year the "Third of March Society" was formed to watch over the interests of the citizens, and in October the Government was forced by a popular demonstration to summon a constituent assembly.

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[1] This document, consisting of 79 paragraphs, was translated into French, and published by Montyon, 8vo, 1507.

[2] See "Le Petit Conseil" in *Étrennes genevoises*, Geneva, 1877.

[3] See H. Hamman, *Les Représentations graphiques de l'Escalade*, Geneva, 1869; and the drama of Mulhauser, the national poet, 1865.

The legislative power for the canton was now placed in a grand council, consisting of representatives elected in the ratio of 1 to every 333 inhabitants; and the executive power in a council of state consisting of 13 members chosen by and from the grand council. At the same time the city received a communal council of 81 members, and an administrative council of at most 11 members. But the new constitution was not allowed to work long. The radical party had been gathering strength, especially in St. Gervais, and in 1846 the Government, finding that the attempt to suppress its opponents by force of arms was of doubtful result, gave in its resignation. A provisional Government, under the leadership of the democrat James Fazy, drew up a constitution, which was accepted by the people on 24th May, 1847. The franchise was bestowed even on the pauper class of prolétaires, and the election of the council of state was entrusted to the council-general or collective assembly of citizens. The old Protestant church of Geneva was abolished, and a new and almost creedless church established, the government of which was vested in a consistory elected by the universal suffrage of Protestants in the canton. For nearly fifteen years the radical party continued in power; and under its hands the physical condition of Geneva was rapidly transformed, and, for good or evil, the city was brought as much as possible into the general current of European progress. "On voudrait faire de Genève," sighed the conservative De le Rive, "la plus petite des grandes villes, et pour moi je prefère qu'elle reste la plus grande des petites villes." Unfortunately for its permanence the radical Government was lavish in its expenditure, and the finances of the canton and city got into a dangerous condition. In November, 1861, Fazy was not returned to the council of state; in 1862 the conservative party obtained a majority in the great council; and in 1863, though all the other radical candidates for the council of state were carried, Fazy himself was rejected. The attempt to invalidate the election of his opponent Chenevière led to a conflict between the parties, in which some blood was shed; and the city was consequently occupied by federal forces, and the matter submitted to the federal council. As the decree was in favor of Chenevière, Fazy retired from public life. The "independents," as the opponents of the radicals are called, came into power in 1865, and for a number of years they fully maintained their position, in spite of the difficulties thrown in their way by the Ultramontane party. Their principal antagonist was Mermillod, the vicar of the bishop of Freiburg, who was declared bishop of Geneva by the pope, and insisted on exercising his episcopal functions without regard to the Government. In February, 1873, Mermillod was banished by the federal council of Switzerland, and in the same year the grand council of Geneva deprived all Roman Catholic priests who refused to take the oath of allegiance to the state. Fazy's bill for the separation of church and state was rejected in June, 1876; religious corporations were abolished on 23d August, and, on the 26th of the same month all public ecclesiastical services outside of the churches were forbidden. The cathedral of Geneva was handed over to the Old Catholics. On the 6th of November, 1878, Fazy died, and two days after the "conservative-democrat" party gained a victory in the elections for the great council. The expelled curés were now allowed to return, and in December the council accepted the principle of the separation of church and state.

Besides the older works of Spon, Béranger, Picot, etc., and the *Mémoires et documents de la soc. genevoise d'hist. et d'archéol.*, see Senebier, *Hist. litt. de Genève* (1786); J. A. Galiffe, *Matériaux pour l'hist. de Genève* (1829–30), and *Notices généalogiques* (3 vols., 1819–36); Rigaud, *Renseignements rel. à la culture des beaux-arts à Genève* (1849, new ed. 1876); Archinard, *Genève ecclés. ou Livre des spectables pasteurs* (1861) and *Les édifices religieux de l'ancienne Genève* (1869); J. B. G. Galiffe, *Genève hist. et archéol.* (1869); Blavignac, *Armorial genevois* (1849), and *Études sur Genève* (1872–74); Thourel, *Hist. de Genève* (1833); Pictet de Sergy, *Genève, origine, etc.* (1843–47), and *Genève ressuscitée* (1869); Cherbuliez, *Genève, ses institutions, etc.* (1868); Roget, *Hist. du peuple de Genève* (1876); Thorens, *Abrégé de l'hist. de Genève* (1878); Albert de Montet, *Dict. biogr. des Genevois et des Vaudois* (1878). (H. A. W.)

GENEVA, THE LAKE OF (the Latin *Lacus Lemanus* or Lake Leman, also known in the Middle Ages as Lae Losannete or Lake of Lausanne, and as Mer du Rhône or Sea of the Rhone), is the largest of the Swiss lakes, having an area of 578 sq. kil. or 223 sq. miles. Its general form is that of a crescent, the northern shore being almost the arc of a circle, with a radius of 21½ miles. The eastern end of the crescent is broad and rounded, while the western tapers towards Geneva. Its maximum breadth, between Morges and Amphion, is 8½ miles. It is divided into two portions, the Great and Little Lake, by the strait of Promonthoux, which is not much more than 2 miles across. The Great Lake is 39 miles long, with a mean breadth of 6 miles, and the Little or Western Lake is 14 miles long, with a mean breadth of rather more than 2 miles. The bottom of the larger basin forms a wide valley, which gradually deepens from 200 to 325 feet at the foot of the slopes to a maximum of 1095 feet, which it attains between Ouchy and Évian. The mean level of the surface of the lake is 1230 feet above the level of the sea. According to the elaborate soundings made in 1873 by M. Gosset, engineer of the Federal Topographic Department, the bottom is remarkably free from inequalities, almost all traces of rocks, erratic blocks, or moraines having been covered over by a regular bed of extremely fine argillo-calcareous mud, which can be moulded and baked like potter's clay. Between the basin of the Great Lake and that of the Little Lake there runs a ridge or bar not very strongly marked, 200 feet from the surface. The maximum depth of the lesser basin is only 71 metres or 233 feet. The bottom is apparently level, but it presents numerous erratic blocks, and in one place rises to a considerable eminence, known to the Genevese fishers as th Hauts Monts.[1] The unusual blueness of the waters of th Leman has long been remarked. According to M. Forel,[2] the transparency is very much greater in winter than summer, the extreme limit of visibility of a white disk on an average for the seven winter months from October to April being 41 feet, and for the five summer months 21·6. This arises from the thermal stratification of the water keeping in suspension a greater quantity of dust and organic particles during summer. It is generally in August that the level of the lake reaches its highest limit, between 4 and 5 feet on an average above its lowest limit, which is usually reached in March. Besides this seasonal change, due to differences of influx and removal of water, several disturbances of level of a less obvious kind have attracted the attention of the Swiss physicists. Most remarkable are the *seiches*, or "movements of steady uninodal oscillation," in which the whole mass of water in the lake rhythmically swings from shore to shore. According to M. Forel,[1] there are both longitudinal and transverse *seiches.* Their effect is most distinctly seen at Geneva where they sometimes raise the level of the water from 4 to 5 feet. They are not improbably due to several distinct causes, but the most efficient would appear to be a difference of barometric pressure in different parts of the lake. In the eastern portion of the lake there is an irregular but violent current during spring and autumn, called Lardeyre or La Dière, which is supposed to be due to subterranean affluents. The principal winds are the Bise from the north-east, the stormy Bornand that rushes from the ravines of Savoy, and the dry south wind known as the Séchard. Less use is made of the lake as a means of communication since the opening of the railway along the Swiss shore, but the lateen sails of the minor craft still brighten the landscape, and an excellent steam service is maintained by a company formed in 1873. The first steamboat, the "William Tell," was introduced on the lake in 1823; and the first saloon steamboat, the "Mont Blanc," dates only from 1876.

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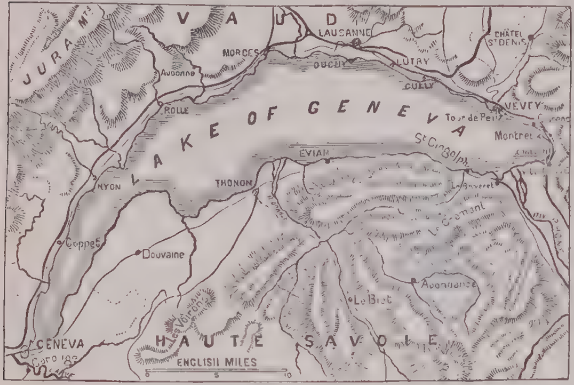
[1] Further details on the conformation of the lake will be found in De la Beche's letter to Professor Pictet, published in *Bibliothèque Universelle: Sciences et Arts*, t. xii., 1817; in M. Gosset's *Carte Hydrogr. du Lac Léman*, issued as part of the *Topog. Atlas der Schweiz*, and described in *Bibl. Un. (Sci. et Arts)*, t. lii., 1875, and in a *Note sur la Carte du Lac*, by Ed. Pictet, in the same number.

[2] "Études sur les variations de la transparence des eaux du lac Léman," in *Bibl. Un. (Sc. et Arts)*, 1877.



Lake of Geneva.

The Lake of Geneva is not so rich in fish as many of the smaller lakes of Switzerland.[2] Comparatively small success has attended the attempts of Professor Chavannes of Lausanne to introduce the salmon, which, like many other fishes, finds the Perte du Rhône a barrier between the sea and the lake. The "fera" (*Coregonus fera*) is economically the most important species. In the mud at the bottom of the lake there exists an interesting fauna of about 40 species, mainly belonging to the lower orders. Several of the species, as *Gammarus Cæcus*, are found 1000 feet below the surface, in the reign of perpetual darkness. Two species of Gastropods of the genus *Limnæus* are worthy of special note as possessing developed lungs, though they live at a depth of from 150 to 300 feet.[3]

See Rodolphe Rey, *Genève et les rives du Léman*, 3d ed. (Geneva, 1875); Egli, *Taschenbuch Schweizerischen statistiks* (Zurich, 1875); Herbst, *Der Genfer See und seine Umgebung* (Weimar, 1877).

GENEVA, a post village of Ontario county, New York, U. S., is beautifully situated at the north end of Seneca Lake, on the New York Central railway and at the terminus of the Ithaca branch railway, 52 miles E. S. E. of Rochester. One of its chief features is the terraced gardens, which extend from the principal street to the shore of the lake; and there are also two fine parks. Geneva is the seat of Hobart Free College, which is under Episcopalian management, and has 9 professors and about 50 students. It has also a graded union school, attended by upwards of 1000 pupils. The prosperity of the town depends chiefly on the nurseries in the neighborhood, which extend to nearly 10,000 acres, and from which plants to the value of more than 1,000,000 dollars are shipped annually. There are also marble-works, benching-works, and iron-works. A daily line of steamers plies between Geneva and Watkins at the head of the lake. The population in 1870 was 5521.

GENEVA CONVENTION, an agreement concluded at an international conference which was held at Geneva in 1864, under the presidency of General Dufour the Swiss plenipotentiary, for the purpose of ameliorating the condition of the sick and wounded in time of war. The credit of originating this conference must be given to two citizens of Geneva, Dunant, a physician, who published a startling account of what he had seen in two military hospitals on the field of Solferino, and his friend Moynier, chairman of the Geneva society of public utility, who took up the idea of "neutralizing the sick wagons," formed associations for its agitation, and at length pressed it upon the governments of Europe, most of which sent representatives to the conference. The convention was drawn up and signed by them on the 22d of August, and since then it has received the adherence of every European power, and one Asiatic (viz., Persia). The convention consists of ten articles, of which the last two are formal.

The others provide (1) for the neutrality of ambulances and military hospitals as long as they contain any sick; (2) for that of their staff; (3) that the neutrality of these persons shall continue after occupation of their hospitals by the enemy, so that they may stay or depart, as they choose; (4) that if they depart, they can take only their private property with them, except in case of ambulances, which they may remove entire; (5) that a sick soldier in a house shall be counted a protection to it, and entitle its occupant to exemption from the quartering of troops and from part of the war requisitions; (6) that wounded men shall, when cured, be sent back to their own country on condition of not bearing arms during the rest of the war; (7) that hospitals and ambulances shall carry, in addition to the flag of their nation, a distinctive and uniform flag bearing a red cross on a white ground, and that their staff shall wear an arm-badge of the same colors; (8) that the details shall be left to the commanders.

A second conference was held at Geneva on the same subject in 1868, and a supplementary convention drawn out, which, though not formally signed, has been acquiesced in by all the signatories of the original convention, except the pope, and which, while still unratified, was adopted provisionally by France and Germany in their war of 1870. It consists partly of interpretations of the former convention, and partly of an application of its principles to maritime wars. Its main provisions are these:—

That when a person engaged in an ambulance or hospital occupied by the enemy desires to depart, the commander-in-chief shall fix the time for his departure, and, when he desires to remain, that he be paid his full salary; that account shall be taken in exacting war requisitions not only of actual lodging of wounded men but of any display of charity towards them; that the rule which permits cured soldiers to return home on condition of not serving again shall not apply to officers, for their knowledge might be useful; that hospital ships, merchantmen with wounded on board, and boats picking up wounded and wrecked men, shall be neutral; that they shall carry the red-cross flag and their men the red-cross armlet; that hospital ships belonging to Government shall be painted white with a green strake, those of aid societies white with a red strake; that in naval wars any strong presumption that the convention is being abused by one of the belligerents shall give the other the right of suspending it towards that power till the contrary is proved, and, if the presumption becomes a certainty, of suspending it to the end of the war.

GENEVIÈVE, or GENOVEFA, ST., patroness of Paris, flourished during the latter half of the 5th century. She was born about 425 at Nanterre near Paris, or according to another tradition at Montriere; her parents were called Severus and Gerontia, but accounts differ widely as to their social position. According to the legend, she was only in her seventh year when she was induced by Bishop (afterwards Saint) Germain d'Auxerre to dedicate herself to the religious life. On the death of her parents she removed to Paris, where she distinguished herself by the activity of her benevolence, as well as by the austerity of her sanctity. She is said to have been the recipient of supernatural revelations, and to have predicted the invasion of the Huns;

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[1] M. Forel's numerous studies on the subject will be found in the *Bibliothèque Universelle*, and the *Bulletin de la soc. vaud.* (Lausanne).

[2] According to G. Lunel, whose *Histoire naturelle des poissons du bassin du Léman*, (Geneva, 1874) has superseded the valuable memoir of Professor Jurine in the *Memoires de la Sociétié de physique*, tome iii. (1825), there are 21 species:—*Perca fluviatilis*, L.; *Cottus gobio*, L.; *Lota vulgaris*, Cuv.; *Cyprinus carpio*, L.; *Cyprinopsis auratus*, L.; *Tinca vulgaris*, Cuv.; *Gobio fluviatilis*, Cuv.; *Alburnus lucidus*, Heckel; *Alb. bipunctatus*, L.; *Scardinius erythrophthalmus*, Bonap.; *Leuciscus rutilus*, L.; *Squalius cephalus*, Bonap.; *Phoxinus lævis*, Ag.; *Cobitis barbatula*, Lin.; *Coregonus fera*, Jurine; *Coregonus hiemalis*, Jurine; *Thymallus vulgaris*, Nilsson; *Salmo umbla*, L.; *Trutta variabilis*, G. L.; *Esox lucius*, L.; *Anguilla vulgaris*, Fleming.

[3] For details see Forel's contributions to the *Bulletin de la soc. vaudoise des sc. nat.*, t. xiii., etc

and when Attila with his army was threatening the city, she gave courage to the panic-stricken inhabitants by an assurance, justified by subsequent events, to the effect that the attack would come to nothing (451). In the year 460 she caused a church to be built over the tomb of St. Denis, where the abbey was afterwards raised by Dagobert I. Her death occurred in 500, or according to another account in 512, and her remains were ultimately laid in the chapel bearing her name, which has now become merged in the Pantheon or Église St. Geneviève. Charpentier published in 1687 a life of the saint based upon the statements of an anonymous author who is alleged to have written her biography only eighteen years after her death. The legends, miraculous and other, are also given in the Bollandist *Acta Sanctorum* and in the great work of Tillemont. Her festival is celebrated on the 3d of January.

The "Canonici of St. Geneviève," or "Canonici of the congregation of France," constitute a religious order dating from 1614, in which year they were organized by Charles Faure, a reforming monk belonging to the abbey of St. Vincent at Senlis. They rapidly came into considerable repute; and for a considerable period the chancellor of the Sorbonne was invariably chosen from their order. The "daughters of St. Geneviève" were constituted in 1636 at Paris, at the instance of a pious nun of the name of Blosset, but since their union, in 1665, with the order "of the Holy Family" whose lady-foundress was called Miramion, they have been best known as Miramiones. They find their chief employment in tending the sick, and in the education of girls.

GENGA, Girolamo (*c.* 1476–1551), a painter and architect, was born in Urbino towards 1476. At the age of ten he was apprenticed to the woollen trade, but showed so much inclination for drawing that he was sent to study under an obscure painter, and at thirteen under Luca Signorelli, with whom he remained a considerable while, frequently painting the accessories of his pictures. He was afterwards for three years with Pietro Perugino, in company with Raphael, and he developed a similar style of painting. He next worked in Florence and Siena, along with Timoteo della Vite; and in the latter city he painted various compositions for Pandolfo Petrucci, the leading local statesman of the time. Returning to Urbino, he was employed by Duke Guidobaldo in the decorations of his palace, and showed extraordinary aptitude for theatrical adornments. Thence he went to Rome; and in the church of S. Caterina da Siena, in that capital, is one of his most distinguished works, The Resurrection, remarkable both for design and for coloring. He studied the Roman antiquities with zeal, and measured a number of edifices; this practice, combining with his previous mastery of perspective, qualified him to shine as an architect. Francesco Maria, the reigning duke of Urbino, recalled Genga, and commissioned him to execute works in connection with his marriage-festivities. This prince being soon afterwards expelled by Pope Leo X., Genga followed him to Mantua, whence he went for a time to Pesaro. The duke of Urbino was eventually restored to his dominions; he took Genga with him, and appointed him the ducal architect. As he neared the close of his career, Genga retired to a house in the vicinity of the city, continuing still to produce designs in pencil; one, of the Conversion of St. Paul, was particularly admired. Here he died on the 11th of July, 1551. Genga was a sculptor and musician as well as painter and architect; and he wrote various essays, as yet unpublished, on the arts. He was jovial, an excellent talker, and kindly to his friends. His principal pupil was Francesco Menzocchi. His own son Bartolommeo (1518–1558), also a pupil, became an architect of celebrity. In Genga's paintings there is a great deal of freedom, and a certain peculiarity of character consonant with his versatile, lively, and social temperament. One of his leading works is in the church of St. Augustine in Cesena—a triptych in oil-colors, representing the Annunciation, God the Father in Glory, and the Madonna and Child. Among his architectural labors are the church of the Baptist in Pesaro, one of the finest edifices in that neighborhood; the bishop's palace at Sinigaglia; the façade of the cathedral of Mantua, ranking high among the productions of the 16th century; and a new palace for the duke of Urbino, built on the Monte Imperiale. He was also concerned in the fortifications of Pesaro.

GENGIS KHAN. See Jenghiz Khan.

GENLIS, Stéphanie-Félicité Ducrest de Saint-Aubin, Comtesse De (1746–1830), a voluminous French writer, was born of a noble but impoverished Burgundian family, at the Château de Champcery, near Autun, on the 25th of January, 1746. When six years of age, she was received as a canoness into the noble chapter of Alix, near Lyons, with the title of Madame la Comtesse de Lancy, taken from the town of Bourbon-Lancy, of which her father was at that time superior. Her entire education, however, was conducted at home under the eye of her mother by an accomplished governess. In 1758 she removed along with her mother to Paris, where her skill in music and her vivacious wit speedily attracted attention and admiration. Her marriage with the Comte de Genlis, a colonel of grenadiers, who afterwards became marquis of Sillery, took place in her sixteenth year, but was not suffered to interfere with a rapidly developing taste for acquiring and imparting knowledge. Some years later, through the influence of her aunt, Madame de Montesson, who had been clandestinely married to the duke of Orleans, she entered the Palais Royal as lady-in-waiting to the duchess of Chartres (1770); and, after having acted with great energy and zeal as governess to the daughters of the family, she was in 1781 appointed by the duke to the responsible office of "gouverneur" of his sons, a bold step which, though it led to the resignation of all the tutors as well as to much social scandal, can hardly in fairness be held to have seriously prejudiced the intellectual interests at least of those committed to her charge. The better to carry out her theory of education, she wrote several works for the use of her royal pupils, the best known of which are the *Théâtre d'Éducation* (1779–80), a collection of short comedies for young people, and *Les Annales de la Vertu* (1781). When the Revolution of 1789 occurred, Madame de Genlis showed herself not unfavorable to the movement, and is said to have had considerable influence on the conduct of the duke of Orleans; but the fall of the Girondins in 1793 compelled her to take refuge in Switzerland along with her pupil Mademoiselle d'Orleans. It was in this year that her husband, the marquis of Sillery, from whom she had been separated since 1782, perished on the scaffold. An "adopted" daughter, Pamela Berkley or Simms, had been married to Lord Edward Fitzgerald in the preceding December (see Sir Bernard Burke's *Rise of Great Families*, 1872). In 1794 Madame de Genlis fixed her residence at Berlin, but having been expelled by the orders of King Frederick William, she afterwards settled in Hamburg, where she supported herself for some years by writing and painting. After the revolution of 18th Brumaire (1799) she was permitted to return to France, and was received with favor by Napoleon, who gave her apartments at the arsenal, and afterwards assigned her a pension of 6000 francs. During this period she wrote largely, and produced what is generally considered to be her best romance, entitled *Mademoiselle de Clermont*. At the restoration she succeeded in adjusting herself once more to the new state of things, and continued to write with all her former diligence. Her later years were occupied largely with literary quarrels, notably with that which arose out of the publication of the *Diners du Baron d'Holbach*, a volume in which she set forth with a good deal of sarcastic cleverness the intolerance, the fanaticism, and the eccentricities of the "philosophes" of the 18th century. Madame de Genlis before her death, which occurred on the 31st of December, 1830, had the satisfaction of seeing her former pupil, Louis Philippe, seated on the throne of France.

The numerous works of Madame de Genlis (which considerably exceed eighty), comprising prose and poetical compositions on a vast variety of subjects and of various degrees of merit, owed much of their success to adventitious causes which have long ceased to operate, and they are now but little read. The swiftness with which they were written, their very multiplicity, and their diffuseness, all forbid us to look in them for thought of perennial value or literary art of any high order. They are useful, however (especially the voluminous *Mémoires*), as furnishing material for history; and she herself can hardly pass altogether unnoticed in the crowd which thronged the stage of public life in the confused and busy time of the French Revolution. Most of her writings were translated into English almost as soon as they were published.

GENNADIUS. Georgius Scholari or Scholarius, better known as Gennadius, a learned Greek and for some time patriarch of Constantinople, obtains a place in history through the important part played by him in the contest between Platonism and Aristotelianism which marks the transition from mediæval to modern thought. Extremely little is known of his life, and so contradictory are some of the accounts bearing on detached facts in it that it has often been supposed there were two writers of the same name living at the same period. The researches of Renaudot seem, however, to render it approximately certain that all the historical notices we possess relate to one Scholarius, and that the apparent inconsistency in the accounts is due largely to a real change in that writer's views. Scholarius first appears in history as assisting at the great council held in 1438 at Ferrara and Florence with the object of bringing about a union between the Greek and Latin Churches (see Eugenius IV., Bessarion). At the same council was present the celebrated Platonist, George Gemistus Pletho, the most powerful opponent of the then dominant Aristotelianism, and consequently the special object of reprobation to Gennadius. In church matters, as in philosophy, the two were opposed—Pletho maintaining strongly the principles of the Greek Church, and being unwilling to accept union through compromise, Gennadius, more politic and cautious, pressing the necessity for union, and instrumental in drawing up a form which from its vagueness and ambiguity might be accepted by both parties. It would seem that at Florence Pletho published the work on the difference between Aristotle and Plato (see Gemistus) which afterwards called forth a reply from Gennadius. Of this reply only the fragments quoted by Pletho in his counter-argument (*Contra Gennadium*) have been preserved. They show that Gennadius, though Aristotelian throughout, had an accurate knowledge of Aristotle, and was more moderate than some of his contemporaries, *e.g.*, George of Trebizond. The next appearance of Gennadius is in 1453. After the capture of Constantinople by the Turks, Mahomet, finding that the patriarchal chair had been vacant for some time, resolved to elect some one to the office. The choice fell on Scholarius, who is described as a layman. While holding the episcopal office Gennadius drew up, apparently for the use of Mahomet, a symbol or confession of faith, which is very valuable as the earliest expression of the principles of the Greek Church. He also at this time had the pleasure of condemning to the flames the great work of his old opponent Pletho, the treatise on *Laws* (Νόμοι), of which considerable fragments have come down to us. The character of this work was accurately apprehended by Gennadius (see his *Letter to the Exarch Joseph*, in Gass, as below), and his opposition to it is intelligible. After a short period of office at Constantinople Gennadius is said to have resigned the episcopal dignity and to have retired into a convent. The date of his death is unknown.

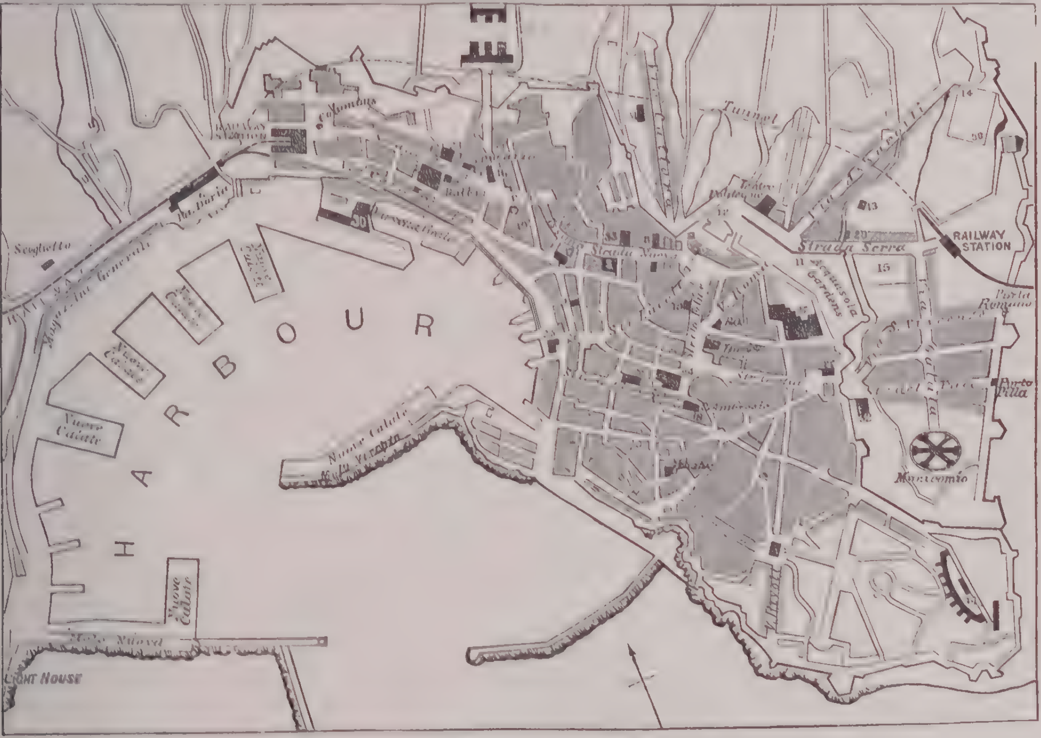
The fullest account of his writings is given in Gass (*Gennadius and Pletho*, 1844), the second part of which contains Pletho's *Contra Gennadium*. See also F. Schultze, *Gesch. der Phil. d. Renaissance*, i., 1874. A list of the known writings of Gennadius is given in Fabricius, *Bibliotheca Græca*, ed. Harless, vol xi.

GENOA, in literary Italian *Genova*, in the local dialect *Zene*, in Latin and German *Genua*, in mediæval Latin *Janua*, and in French *Gênes*, one of the most important cities of Italy, is situated in what was formerly known as Liguria, on the northern coast of the Mediterranean near the middle of the Gulf of Genoa. The latitude of its lighthouse is 44° 24′ 16″ N., and its longitude 8° 54′ 15″ E. By rail Genoa is 115 English miles N. E. of Nice and 119 miles N. W. of Leghorn. The city, as seen from the sea, is "built nobly," and deserves the title it has acquired or assumed of the Superb. Finding only a small space of level ground along the shore, it has been obliged to climb the lower hills of the Ligurian Alps, which afford many a coign of vantage for the effective display of its architectural magnificence. The original nucleus of the city is that portion which lies to the east of the port in the neighborhood of the old pier (Molo Vecchio). In the 10th century it began to feel a lack of room within the limits of its fortifications; and accordingly, in the middle of the 12th century, it was found necessary to extend the line of circumvallation. Even this second circuit, however, was of small compass, and it was not till 1320–30 that a third line took in the greater part of the modern site of the city proper. This presented about 3 miles of rampart towards the land side, and can still be easily traced from point to point through the city, though large portions, especially towards the east, have been dismantled. The present line of circumvallation dates from 1626–1632, the period when the independence of Genoa was threatened by the dukes of Savoy. From the mouth of the Bisagno in the east, and from the lighthouse point in the west, it stretches inland over hill and dale to the great fort of Sperone, *i. e.*, the Spur, on the summits of Monte Peraldo at a height of 1650 feet—the circuit being little less than 12 miles, and all the important points along the line being defended by forts or batteries. Of course a large portion of the enclosed area is open country, dotted only here and there with houses and gardens. There are eight gates in all—the more important being Porta Pila and Porta Romana towards the east, and the new Porta Lanterna or Lighthouse Gate to the west.

The irregular relief of its site, and its long confinement within the limit of fortifications which it had outgrown, have both contributed to render Genoa a picturesque confusion of narrow streets, lanes, and alleys, which it would almost require the delicate diminutives of Italian to name, varied with stairways climbing the steeper slopes, and bridges spanning the deeper valleys. As there are large portions of the town which are quite inaccessible to ordinary carriages, and many even of the more important streets have very little room for traffic, porters and chairs take to a considerable extent the place of cabs, and goods are largely transported by means of mules. In the middle of the 16th century the Government gave commencement to a system of more spacious thoroughfares than had previously been in vogue by laying out the street which still bears the name of Via Nuova; in 1606 the Via Balbi, as it was ultimately called from the palaces of the Balbi family, began to stretch westward; and at length, about 1778, a connection between these two streets was effected by the opening up of Via Nuovissima. The line thus produced, extending as it does from the Piazza Fontane Morose westward for about a mile to the Piazza Verde is still the route most in favor with the fashionable world of Genoa. As early as the middle of the 17th century the Via Giulia was driven through the midst of the small streets between the ducal palace and the Porta d'Arco; but it was not till about 1825 that the Via Carlo Felice gave free route between the palace and the Piazza Fontane Morose. The Via Lorenzo and the long line of street which, under the names of Carlo Alberto, S. Benedetto, and Milano, runs round the port to its western extremity, also belong to this century. The spacious Via Roma, running east from Via Carlo Felice to meet the Via Assarotti, has been built since 1870; and the area of the Piazza Cavour was only about the same time cleared of the old houses. The great public promenade of Acquasola already mentioned was laid out by the architect Carlo Barabino between 1821 and 1837; and it has been connected with the gardens of the Villetta di Negri, purchased by the municipality about 1865.

Cathedral.

Of the churches of Genoa, which number upwards of eighty, the principal is the cathedral of St. Laurence (il duomo di San Lorenzo). Tradition makes its first foundation contemporary with St. Laurence himself; there is distinct historic mention of a church on the site in the latter part of the 9th century; and a document of 987 implies that it was even then the metropolitan church. Reconstructed about the end of the 11th and beginning of the 12th century, it was formally consecrated by Pope Gelasius II., 18th October, 1118; and since then it has undergone a large number of extensive though partial renovations. In the façade the lower part, with its three elaborate doorways in the Gothico-Moorish style, dates from the 12th century; the upper part belongs to the 14th; and the belfry which rises above the right-hand doorway was erected about 1520 by the doge, Ottaviano da Campofragoso. To the 13th century is assigned the central nave, which was, however, both lengthened and heightened in the 14th; and the cupola was erected after the designs of the architect Galeasso Alessi invited to Genoa about 1550. Among the artists who have contributed to the internal decoration the most noteworthy are Damiano of Bergamo, who represented the Slaughter of the Innocents and the Martyrdom of St. Laurence in the woodwork of the choir; Lazzaro Tavarone, who painted the roof about 1622; G. B. Bianco, who furnished the bronze statue of the Madonna of the city in 1652; Gian Giacomo della Porta, the sculptor of the statues of Mark and Luke in the presbyterium; and Giovanni Maria Passalo and Giovanni Angelo Montorsoli, the sculptors of the corresponding statues of Matthew and John. The stained glass windows of the choir, representing the four patron saints of the city, are the work of Giovanni Bertini. To none of the chapels in the cathedral, rich as several of them are in works of artistic value, can a higher rank be assigned than to the chapel of St. John the Baptist. The main design, with its elaborate detail of columns and arabesques, and foliage and statues, was due to Pio Domenico da Bissone, who from 1450 was engaged for ten years on the work. Statues by Matteo Civitali of Lucca and Andrea Contucci of Monte San Savino, a rich and costly baldachin presented by Count Filippino Doria, and stained glass windows designed by Ulisse de' Mattei, are among the later additions to its decoration. On one day only in the course of the year are women allowed to enter the chapel; for was it not a woman who procured the death of the Baptist? Amid the profusion of ecclesiastical bric-a-brac in the nooks and niches of the cathedral, there are objects enough of considerable interest. Here, bound together by craft of goldsmith, is an octagonal bowl, brought from Cæsarea in 1101, which corresponds to the descriptions given of the Holy Grail, and was long regarded as an emerald of matchless price, but which turned out, when broken by its French purloiners, to be only a remarkable piece of ancient glass.



Plan of Genoa.

1. Royal Palace.
2. Palazzo Balbi.
3. " Durazzo.
4. " Spinola.
5. " Brignola.
6. " Doria.
7. " Serra.
8. " Adorno.
9. Palazzo Spinola.
10. " Pallavicini.
11. Acquasola.
12. Villetta di Negro.
13. Peschiere Pallavicini.
14. Giopallo Gardens.
15. Serra Gardens.
16. Church of the Annunziata.
17. Church of San Siro.
18. " S. Ambrozio.
19. " S. Filippo de Neri.
20. Cathedral.
21. Church of Santa Maria di Carignano.
22. " San Stefano.
23. University.
24. Ducal Palace.
25. Dogana or Custom House.
27. Great Hospital.
28. Conservatorio delle Fieschine.
29. Deaf and Dumb Institution.
30. Old Arsenal.
31. Paganini Theatre.
32. Andrea Doria Theatre.
34. Hospital of Sant' Andrea.

Other churches.

Of older date than the cathedral is the church of St. Ambrose and St. Peter, if its first foundation be correctly assigned to the Milanese bishop Honoratus of the 6th century; but the present edifice is due to the Society of Jesus, who obtained possession of the church in 1587, and employed the skill of Pellegrino Tebaldi in its restoration. Among the paintings of this church the first place is naturally given to the Circumcision and St. Ignatius by Rubens, and to the Assumption of Guido Reni. The Annunziata del Guastato is one of the largest and wealthiest churches in the city. It owes its first foundation to the order of the Humiliati, but S. Marta, as it was originally called, was a small building till it passed about 1505 into the hands of the Conventuals of St. Francis, by whom the present gigantic structure was planned and partly erected. The rest of the main edifice was due to the Observantines of the same order, who came into possession in 1537, and gave the church its modern name; and the necessary funds were largely supplied by the Lomellini family. The church is a cruciform structure, with a dome, and the central nave is supported by fourteen columns in the Corinthian style. To the unfinished brick façade an incongruous portal with marble columns was added about 1843, after the plans of Carlo Barabino. Santa Maria delle Vigne probably dates from the 9th century, but the present structure was erected towards the close of the 16th. The campanile, however, is a remarkable work of the 13th century. San Siro, originally the "Church of the Apostles" and the cathedral of Genoa, was rebuilt by the Benedictines in the 11th century, and restored and enlarged by the Theatines in the 16th. Santa Maria di Carignano, or more correctly Santa Maria Assunta e SS. Fabiano e Sebastiano, belongs mainly to the 16th century, and was designed by Galeazzo Alessi, in imitation of Bramante's plan for St. Peter's at Rome. The expense was borne by the Sauli family. From the highest gallery of the dome—368 feet above the sea-level, and 194 feet above the ground—a magnificent view is obtained of the city and the neighboring coast. S. Stefano dates from 969, and keeps its ancient campanile, but it has been several times rebuilt. The famous painting of the martyrdom of St. Stephen, by Giulio Romano, carried off by Napoleon in 1811, was restored to the church in 1815. The Madalena, as it now stands, was built by Andrea Vannone about the close of the 16th century; and San Filippo Neri was rebuilt in the close of the 17th century at the expense of the Pallavicini family. S. Matteo, the church of the D'Oria or Doria family, was founded in 1126 by Martino Doria, and the present edifice, after the designs of Montorsoli, dates from 1543. In the crypt is the tomb of Andrea Doria the Great by the same

Montorsoli, and above the main altar hangs the dagger presented to the doge by Pope Paul III.

Palaces. The palaces of the Genoese patricians are famous for their sumptuous architecture and their artistic collections. The Palazzo Rosso, or Red Palace, erected in the middle of the 17th century, was in 1874 presented to the city by Maria, the wife of Raffaele de Ferrari, duke of Galliera, and her son Filippo de Ferrari, along with its library and picture gallery. The old palace of the doges, now the seat of the prefecture, was rebuilt in the 16th century, and again restored after a great fire in 1777; the neighboring tower, from which the magistrates were summoned by toll of bell, dates from the beginning of the 14th century. A sixteenth century palace, formerly the property of the dukes of Turin, is now occupied by the municipality, and contains among its more curious treasures a bronze tablet (117 A. D.), with an inscription relating to a dispute between Genoa and a neighboring castle, two autograph letters of Columbus, and Paganini's violin. The inscription, discovered in 1506, was printed for the first time in 1520 by Brucelli, whose works form part of Grævius's *Thesaurus*, and among its modern commentators are Serra in the Transactions of the Imperial Academy of Genoa, and Simoni and Grassi in the Transactions of the Ligurian Society of Native History. The palace which was presented in 1528 by the republic to Andrea Doria is a large building of the 15th century, restored and extended under the doge's direction, and decorated with frescoes by Perino del Vaga. The royal palace, built in the middle of the 16th century for the Durazzo family, was acquired by Victor Emmanuel in 1817. Among other buildings of the same class, the Durazzo palaces in the Via Nuovissima, and the Via Balbi, the Balbi Senarega in the Via Balbi, the Sarra palace in the Via Nuova, and the Pallavicino in the Piazza Fontane Morose are worthy of note.

Benevolent institutions. Of most historical interest among the benevolent institutions of Genoa is the hospital of Pammatone (Ospedale civile di Pammatone), a vast edifice contiguous to the public park of Acquasola. It owes its origin to the bequest in 1429 of Bartolommeo Bosco; and the excellence of the infirmary thus established caused the citizens to procure permission from Sixtus V. to divert the funds of all similar minor foundations to its support. New buildings were erected in 1626 by Giacomo Saluzzo, and still larger additions were made in 1758, under the superintendence of Andrea Orsolino. Under the same committee with the general hospital is the hospital for incurables (Ospedale dei Cronici, originally Ridotto degli Incurabili), instituted towards the end of the 15th century by Ettore Vernazza, and taken under the direct control of the civil authorities in 1500. The great poorhouse (Albergo dei Poveri), dating from about 1665, is a vast building, after designs by Stefano Scaniglia, covering no less than 215,280 square feet, and accommodating 1400 inmates, who manufacture cotton and woollen cloth, furniture, embroidery, etc. The so-called Conservatorio delle Fieschine was founded in 1763, in accordance with the will of Domenico Fieschi, as an asylum for destitute girls; and in 1783 his widow left 80,000 lire to provide a dowry of 500 lire for any of the inmates leaving the institution to be married or to take the veil. A considerable reputation has been acquired by the flower-makers of this institution.

The sums bequeathed for charitable purposes during 1863–75 amounted to 3,798,106 francs, in addition to the immense donations (about thirty millions of francs) of the deceased duke of Galliera.

University. The highest educational institution in Genoa is the royal university, which occupies a palace in the Via Balbi, originally built about 1623 for the Jesuit fathers entrusted by the magistrates with the supervision of education in 1572. The republic had received the right of conferring degrees from Pope Sixtus IV. as early as 1471, a privilege confirmed by the emperor Maximilian I. in 1496. On the dissolution of the Jesuits the administration of the college passed into the hands of the republic, and the provisional Government of 1797 reinaugurated it as a university in 1803. In 1808, during the French occupation, it was assimilated to the other imperial academies, so that its present organization may be said to date only from 1812. It numbers about 400 students, who have the advantage of a physical and a natural history museum, an anatomical cabinet, a meteorological observatory, a botanical garden, and a library. The library, originated by the Jesuits, numbers about 80,000 volumes, among which none is considered of greater value by the Genoese than the manuscript collection of the laws and enactments of their republic, *Liber jurium communis Januensis*. **Schools.** In Genoa, as elsewhere in Italy, great advance has been made both in secondary and primary education since 1867: in 1877 the city possessed two gymnasiums, a lyceum named after Christopher Columbus, three technical schools, a high school for female education opened by the municipality in 1874, a female normal school dating from 1859, a teachers' training school founded in 1861, and upwards of 40 infant schools (Asili d'Infanzia), of which the first was opened in 1840. **Institutions for arts and science.** The royal technical institute comprises three distinct sections—a professional industrial institute, an institute of mercantile marine, and a system of evening classes in mathematics, chemistry, mechanics, etc.; and a royal naval college was opened in 1873. The Ligurian academy of the fine arts owed its origin in 1751 to Francesco Maria Doria, and the *palazzo* in which its museums and galleries are situated was erected in 1831 by Carlo Barabino. A musical institute, founded by Antonio Costa and maintained by the municipality, has rooms in the convent of St. Philip Neri. A society for the promotion of the fine arts dates from 1849, the Ligurian society of native history from 1857, and a society for the arts and industries of Liguria from 1871. **Libraries.** Besides the university library there are four public libraries—the Biblioteca Civico-Beriana (40,000), presented to the municipality by Victor Emmanuel I., to whom it had been bequeathed; the Biblioteca della Missione Urbana (40,000), a noble collection rich in manuscripts of Ligurian history and Greek codices, which owes its origin to the legacy of Gerolamo Franzone in 1727; the Biblioteca Franzoniana (12,000), due to the same G. Franzone, and administered by the congregation of "Evangelical Workmen;" and, lastly, the fine library which forms part of the great legacy in the Palazzo Rosso. A museum of natural history (Museo Civico di St. Nat.), opened in the Villetta di Negro in 1873, is worthy of special note for the collections made by Giacomo Doria, Beccari, D'Albertis, and Antinori. **Picture galleries.** Picture galleries are to be found in many of the ancient palaces, and in two at least, the Palazzo Rosso and the Palazzo Bianco, the collections are of great value. An excellent law forbids the removal from the city or province of any object of ancient art without the sanction of a commission under the presidency of the prefect. **Theatres.** In 1877 the Genoese had a choice of about a dozen theatres, small and great, inclusive of those in Sampierdarena. Of these the greatest is the Carlo Felice, erected in 1826–28 under the patronage of the king whose name it bears. The National Theatre, rebuilt in 1790, dates originally from 1702, and it has an older rival in the Teatro del Falcone, which is associated with the life of Goldoni, and now serves as court theatre.

Communication. The mountainous character of the surrounding country has rendered it a difficult task to supply Genoa with sufficient means of railway communication; in the 20 miles, for example, between the city and Arquata there are eleven tunnels, that of Giovi being upwards of 2 miles long. The line to the north through the valley of the Polcevera, which joins the general Italian system at Alessandria, was opened about 1853; but it was not till 1870 that the western line was completed so as to give a continuous route from France, and it was November, 1874, before the eastern section between Sestri di Levante and Spezia established a connection with the lines along the western coast of Italy. Since that date, however, passengers and goods can be conveyed by rail from Calais to Otranto. There are two stations in the city,—one for the west and north, and the other for the east and south,—connected since 1871 by a tunnel 7518 feet in length.

Harbor. Though its existence as a maritime power was originally due to its port, Genoa has only begun since 1870 to construct the conveniences necessary for the modern development of its trade. As early as 1134 the old pier (Molo Vecchio) was in existence, stretching westward into the gulf; and in 1639 the new pier (Molo Nuovo) from the other side of the gulf was commenced, after the plans of Ansaldo de Mari. Up to 1878 the former had a length of 2800 feet, and the latter was only slightly longer. The harbor thus formed was in some respects a good one; the bottom being of clay furnished excellent anchorage, and within the new pier there was depth for the largest class of vessels. But a swell was always felt whenever the wind was at any point between S. W. and S. E. The vast bequests of the duke of Galliera have enabled the authorities to undertake (1878) an elaborate scheme for the extension and improvement of the port, including, not only a great addition of the harbor area. but also the construction of a system of wharves and warehouses, which have hitherto been surprisingly insufficient. It is difficult to believe that in one of the greatest harbors of Europe the goods should be "discharged into lighters, slowly towed by rowing boats to the side of the quays, removed by hand labor from the lighters to uncovered quays, and again transferred by hand labor to the railway." **Trade.** In spite of all these disadvantages the shipping trade of Genoa has rapidly increased since the consolidation of Italy. From 1815 to 1825 there was a large trade in grain, with a corresponding expansion of other branches. A sudden change was produced by a system of differential duties in favor of native grain; instead of 1000 foreign vessels with a tonnage of 95,000 as in 1821–5, there were only 760 vessels on an average in the three years 1825–8; and there was no corresponding increase in native shipping, which rose only from 55 to 70 vessels. The more liberal tariffs attached to the commercial treaties, concluded about 1852 with France, England, and Germany, gave a new impulse to foreign trade, and this was followed up by Count Cavour's law exempting all foreign grain from duty. The principal imports are petroleum, raw cotton, wool, grain, coal, metal goods, hides, tobacco, and English-cured fish. The total value imported in 1876 was £14,324,347, and in 1877 £12,066,911, while the exports for the same years amounted to £2,088,578 and £1,968,503—exclusive in both cases of goods merely in transit. During the five years 1873–7 the total number of vessels arriving at Genoa was on an average 2633 per annum, with an annual tonnage of more than 1,000,000 tons. Of these vessels about 1510 per annum sailed under the Italian flag with 533,900 tons; 421 were English with 284,390 tons, and 320 French with 105,945 tons. The opening of the St. Gotthard Railway is expected to give a great impulse to Genoese trade.

Local industry. The local industry devotes itself mainly to the manufacture of cotton and silk, gold, silver, ivory, and coral, paper and leather goods, macaroni and vermicelli, sugar, and preserved fruits. The coarser cotton cloths or bordatti are the favorite wear of the Ligurian population. Iron-founding and shipbuilding are carried on in the district, and there is a growing export trade in all articles of market gardening and floriculture.

Banks. In Michelet's phrase, it may almost be said that Genoa was a bank before it was a city, and its money business is still greater than that of any other town in Italy. The Bank of St. George, founded in 1407, was "one of the most ancient and celebrated banks of circulation and deposit in Europe," but it never recovered from the damage done to its credit by the appropriation of its treasure, first by the Austrians in 1740, and again by the French in 1800. It no longer exists, and the famous building of the 13th century in which it was accommodated is now used as a customs house. A new bank was founded at Genoa in 1844, which since its union in 1855 with a similar institution at Turin, bears the name of the National Bank. It has branches at Turin, Florence, Milan, and Naples. Up till 1871 its only important rival was the Cassa di Sconto, but about this time the Genoese, in the words of the British consul, "went mad on the subject of new companies, and in a single year they started not less than thirty-three banking, trading, mining, shipping, and manufacturing concerns." The result was a series of bankruptcies. Bank after bank failed; and criminal proceedings were in several cases instituted against the bank directors. The only notes current in Genoa in 1875 were those of the National Bank and the Tuscan National Bank.

Emigration. The Genoese have long been known as a hard-working and frugal people; and the lower classes of the whole Ligurian coast are inured to privation and hardships. Since about 1850 there has been a strong current of emigration to South America. About 1858 the Ligurian settlers in Monte Video, Buenos Ayres, Rio de la Plata, Rio Janeiro, Lima, and Valparaiso were estimated at 60,000; and since that date the number of emigrants leaving northern Italy by way of Genoa has increased to 80,000 or 90,000 per annum. A very considerable proportion of this number return to their native country in their latter years, and the successful adventurer usually assists his younger brethren to follow in his footsteps. A large trade has sprung up with South America, the newest feature of which is an exportation of Piedmontese wine.

Revenue and expenditure. According to the returns of 1876, the income of Genoa was 6,343,175 francs, including octroi dues for 4,326,000 francs. The ordinary, extraordinary, and casual expenses for 1875 were—for municipal administration, 608,461 francs; local police and sanitary expenses, 1,038,418; administration of law, 227,376; public works, 2,312,470; education, 692,662; religious worship, 12,117; and public charities, 648,468 francs. The debt of the city in 1876 was 36,731,457 francs.

Municipal government. The council directing the local government of the city is chosen by a body, according to the last returns, of 41,984 electors, every citizen paying 40 francs of taxes being entitled to vote, and every voter being eligible as a councillor. The head of the council is the syndic or mayor, chosen by the king from the 12 members of the giunta or administrative committee, who are themselves appointed from the entire body of the 60 municipal councillors. Besides possessing this municipal council, Genoa is also the seat of the provincial council, elected in the same way, but presided over by the prefect, or representative of the government.

Population. In 1848 the population of the city was 100,382; by 1862 it had increased to 127,986, but a careful census undertaken by the municipality in 1871 found no more than 120,595, exclusive, however, both of resident strangers and absent natives. The principal causes which had tended to retard the natural growth of the population were the cholera of 1866–67, and the small-pox of 1870,—the latter having actually occasioned an excess of 1178 deaths over the births for the year. To this must be added the removal of the Government arsenal to Spezia in 1870–1, and the tendency, which has gradually made itself felt since the opening of the railways, to settle in the suburban towns. The stretch of coast for miles along the gulf is an almost continuous line of country houses and mansions, and indeed, to quote the words of M. Reclus, the whole riviera from Ventimiglia to Spezia assumes more and more the aspect of a single town where the populous quarters alternate with groups of villas and gardens. Proceeding westwards we are no sooner beyond the fortifications than we find ourselves in the flourishing town of Sampierdarena, that is, San Pier d'Arena, or St. Peter of the Sands. Down to the middle of last century it was mainly inhabited by the wealthier classes, but has since become the seat of great industrial and commercial activity. Its population, which in 1814 was only 5345, was upwards of 17,000 in 1877. From Sampierdarena a stone bridge of the 16th century, memorable as the spot where Masséna signed the capitulation of Genoa, leads across the Polcevera to Corneliano, a market town with 2698 inhabitants at the census of 1871; and Corneliano in its turn connects itself with Sestri Ponente, a busy place of from 9000 to 10,000 inhabitants, with a large shipbuilding trade. Towards the east there is a similar succession of villages and towns.

History. *History.*—The early importance, both political and commercial, of Genoa is attested by the part which it played in the Second Punic War. Its supremacy amongst the neighboring municipalities and populations is not less evident from the inscription on the bronze table still to be seen in the council-hall of the city. Its history during the dark ages, throughout the Lombard and Carolingian periods, is but the repetition of the general history of the Italian communes, which succeeded in snatching from contending princes and barons the first charters of their freedom. The patriotic spirit and naval prowess of the Genoese, developed in their defensive wars against the Saracens, led to the foundation of a popular constitution, and to the rapid growth of a powerful marine. From the necessity of leaguing together against the common Saracen foe, Genoa united with Pisa in expelling the Moslems from the island of Sardinia; but the Sardinian territory thus acquired soon furnished occasions of jealousy to the conquering allies, and there commenced between the two republics the long naval wars destined to terminate so fatally for Pisa. With not less adroitness than Venice, Genoa saw and secured all the advantages of the great carrying trade which the crusades created between Western Europe and the East. The seaports wrested at the same period from the Saracens along the Spanish and Barbary coasts became important Genoese colonies, whilst in the Levant, on the shores of the Black Sea, and along the banks of the Euphrates were erected Genoese fortresses, of which the strength some 40 years ago commanded the admiration of the young traveller Moltke. No wonder if these conquests generated in the minds of the Venetians and the Pisans fresh jealousy against Genoa, and provoked fresh wars; but the struggle between Genoa and Pisa was brought to a disastrous conclusion for the latter state by the battle of Meloria. The commercial and naval successes of the Genoese during the Middle Ages were the more remarkable because, unlike their rivals, the Venetians, they were the unceasing prey to intestine discord—the Genoese commons and nobles fighting against each other, rival factions amongst the nobles themselves striving to grasp the supreme power in the state, nobles and commons alike invoking the arbitration and rule of some foreign captain as the sole means of obtaining a temporary truce. From these contests of rival nobles, in which the names of Spinola and Doria stand forth with greatest prominence, Genoa was soon drawn into the great vortex of the Guelph and Ghibelline factions; but its recognition of foreign authority—successively German, Neapolitan, and Milanese—gave way to a state of greater independence in 1339, when the government assumed a more permanent form with the appointment of the first doge, an office held at Genoa for life, in the person of Simon Boccanera. Alternate victories and defeats of the Venetians and Genoese—the most terrible being the defeat sustained by the Venetians at Chioggia in 1380—ended by establishing the great relative inferiority of the Genoese rulers, who fell under the power now of France, now of the Visconti of Milan, until the national spirit appeared to regain its ancient vigor in 1528, when Andrea Doria succeeded in throwing off the French domination and restoring the old form of government. It was at this very period, the close of the 15th and commencement of the 16th century, that the genius and daring of a Genoese mariner, Christopher Columbus, gave to Spain that new world, which might have become the possession of his native state, had Genoa been able to supply him with the ships and seamen which he so earnestly entreated her to furnish. The government as restored by Andrea Doria, with certain modifications tending to impart to it a more conservative character, remained unchanged until the outbreak of the French Revolution and the creation of the Ligurian republic. During this long period of nearly three centuries, in which the most dramatic incident is the conspiracy of Fieschi, the Genoese found no small compensation for their lost traffic in the East in the vast profits which they made as the bankers of the Spanish crown and outfitters of the Spanish armies and fleets both in the Old World and the New.

The short-lived Ligurian republic was soon swallowed up in the French empire, not, however, until Genoa had been made to experience, by the terrible privations of the siege when Masséna held the city against the Austrians (1800), all that was meant by a participation in the vicissitudes of the French Revolution. In 1814 Genoa rose against the French, on the assurance given by Lord William Bentinck that the allies would restore to the republic its independence. It had, however, been determined by a secret clause of the treaty of Paris that Genoa should be incorporated with the dominions of the king of Sardinia. The discontent created at the time by the provision of the treaty of Paris as confirmed by the congress of Vienna had doubtless no slight share in keeping alive in Genoa the republican spirit which, through the influence of a young Genoese citizen, Joseph Mazzini, assumed forms of permanent menace not only to the Sardinian monarchy but to all the established Governments of the peninsula. Even the material benefits accruing from the union with Sardinia and the constitutional liberty accorded to all his subjects by King Charles Albert were unable to prevent the republican outbreak of 1850, when, after a short and sharp struggle the city, momentarily seized by the republican party, was recovered by General Alfonzo La Marmora. The most important of the later events in the history of Genoa has been the seizure within its port of the five Neapolitan brigands, Cipriano La Gala and his accomplices, who travelling with papal passports were arrested on board the French passenger steamer, the "Aunis," by orders of the Marquis Gualterio, prefect of Genoa. Though the event threatened at first to create a rupture between the French and Italian Governments, the diplomatic discussions which it called forth, and the impression generally produced throughout Europe, had no slight share in weakening the political ties which had hitherto existed between the Papal Government and France.

Among the earlier Genoese historians the most important are Bartolommeo Fazio and Jacopo Bracelli, both of the 15th century, and Paolo Partenopeo, Jacopo Bonfadio, Oberto Foglietta, and Agostino Giustiniano of the 16th. Paganetti wrote the ecclesiastical history of the city; and Accinelli and Gaggero collected material for the ecclesiastical archæology. The memoirs of local writers and artists were treated by Soprani and Ratti. Among more general works are Bréquigny, *Histoire des Révolutions de Gênes jusqu'en 1748*; Serra, *La Storia dell' antica Liguria e di Genova* (Turin, 1834); Varesi, *Storia della republica di Genova sino al 1814* (Genoa, 1835–39); Canale, *Storia dei Genovesi* (Genoa, 1844–54), *Nuova istoria della repubblica di Genova* (Florence, 1858), and *Storia della rep. di Genova dall' anno 1528 al 1550* (Genoa, 1874); Blumenthal, *Zur Verfassungs- und Verwaltungsgeschichte Genua's im 12 Jahrhundert* (Kalbe an der Saale, 1872); Mallison, *Studies from Genoese History* (London, 1875). The *Liber jurium reipublicæ Genuensis* was edited by Ricotti in the 7th, 8th, and 9th volumes of the *Monumenta historiæ patriæ* (Turin, 1854–57). A great variety of interesting matter will be found in the *Atti della Società Ligure di Storia patria* (13 vols., from 1861–1878), and in the *Giornale Ligustico di Archeologia, Storia, e Bell' Arti*. The history of the university has been written by Lorenzo Isnardi, and continued by Em. Celesia (2 vols., Genoa). Belgrano, *Della vita privata dei Genovesi*, P. M. Garibaldi, *Stato meteorologico per la città de Genova* (for 1870, etc.), and Rocca, *Pesi e misure antichi di Genova*, may also be mentioned. A *Vocabulario tascabile genovese-italiano* compiled by P. F. B. is published by the deaf-mute publishing department.

GENOVA, Luchetto da (1527–1585). This is the familiar name given to the painter Luca Cambiasi (written also Cambiaso or Cangiagio), who was born at Moneglia in the Genoese state, son of a painter named Giovanni Cambiasi. He took to drawing at a very early age, imitating his father, and developed great aptitude for foreshortening. At the age of fifteen he painted, along with his father, some subjects from Ovid's *Metamorphoses* on the front of a house in Genoa, and afterwards, in conjunction with Calvi, a ceiling showing great daring of execution, in the Palazzo Doria. He also formed an early friendship with Giambattista Castello; both artists painted together, with so much similarity of style that their works could hardly be told apart; from this friend Cambiasi learned much in the way of perspective and architecture. Luchetto's best artistic period lasted for twelve years after his first successes; from that time he declined in power, though not at once in reputation, owing to the agitations and vexations brought upon him by a passion which he conceived for his sister-in-law. His wife having died, and the sister-in-law having taken charge of his house and children, he endeavored to procure a papal dispensation for marrying her; but in this he was disappointed. In 1583 he accepted an invitation from Philip II. to continue in the Escorial a series of frescoes which had been begun by Castello, now deceased; and it is said that one principal reason for his closing with this offer was that he hoped to bring the royal influence to bear upon the pope, but in this again he failed. Worn out with his disquietudes, he died in the Escorial in the second year of his sojourn. Cambiasi had an ardent fancy, and was a bold designer in a Raphaelesque mode. His extreme facility astonished the Spanish painters; and it is said that Philip II., watching one day with pleasure the offhand zest with which Luchetto was painting a head of a laughing child, was allowed the further surprise of seeing the laugh changed, by a touch or two upon the lips, into a weeping expression. The artist painted sometimes with a brush in each hand, and with a certainty equalling or transcending that even of Tintoret. He made a vast number of drawings, and was also something of a sculptor, executing in this branch of art a figure of Faith. Altogether he ranks as one of the ablest artists of his day. In personal character, nothwithstanding his executive energy, he is reported to have been timid and diffident. His son Orazio became likewise a painter, studying under Luchetto.

The best works of Cambiasi are to be seen in Genoa. In the church of St. George—the martyrdom of that saint: in the Palazzo Imperiali, Terralba, a Genoese suburb—a fresco of the Rape of the Sabines; in S. Maria di Carignano—a Pietà, containing his own portrait and (according to tradition) that of his beloved sister-in-law. In the Escorial he executed several pictures: one is a Paradise on the vaulting of the church, with a multitude of figures. For this picture he received 12,000 ducats, probably the largest sum that had, up to that time, ever been given for a single work.

GENOVESI, Antonio (1712–1769), an Italian writer on philosophy and political economy, was born in November, 1712, at Castiglione, near Salerno. At an early age he was destined by his father for the church and began the study of philosophy and theology. He distinguished himself highly by his acuteness and diligence, and after some struggles, caused by his disinclination for an ecclesiastical life, he took orders at Salerno in 1736. He had not been long in this position when the archbishop of the town, recognizing his rare abilities, nominated him to the chair of rhetoric in the theological seminary. During this period of his life Genovesi began the study of philosophy as it existed outside the limits of theology. He read with eagerness the works of the chief modern philosophers, and was particularly attracted by Locke.

Apparently still dissatisfied with ecclesiastical life, Genovesi, resigning his post at Salerno, proceeded to Rome, undertook the study of law, and qualified as an advocate. The details of legal practice, however, proved as distasteful as theology, and for some years he gave himself entirely to the study of philosophy, attending most of the distinguished lecturers at the university of Naples. At this place, after having obtained the appointment of extraordinary professor of philosophy, he opened a seminary or private college for students. His reputation as a teacher was increased by the publication in 1743 of the first volume of his *Elements of Metaphysics*, and in 1745 of his *Logic*. Both works are imbued with the spirit and principles of the empirical school of philosophy, and the latter, an eminently practical treatise, had long a recognized position as one of the best logical text-books written from the point of view of Locke. On account of the accusations of infidelity and heresy naturally excited by his discussion of metaphysical principles, he had some difficulty in obtaining the professorship of moral philosophy, and failed to be appointed to the chair of theology; but this did not prevent him from following out his philosophical studies. He published a continuation of his *Elements of Metaphysics*; but with every new volume he experienced fresh opposition from the partisans of scholastic routine. Among these were Cardinal Spinelli, archbishop of Naples, and an abbé Magli, whom Genovesi covered with ridicule in his work entitled *Lettere ad un Amico Provinciale*. In spite of this, Genovesi obtained the approbation of Pope Benedict XIV., of several cardinals, and of most of the learned men of Italy. Of this number was Intieri, a Florentine, who founded at his own expense, in the university of Naples, the first Italian chair of political economy, under three conditions—namely, that the lectures should be in Italian, that Genovesi should be the first professor, and that, after his death, no ecclesiastic should succeed him.

Genovesi commenced his first course of lectures on the 5th of November, 1754, with great success,—the novelty and the interest of the subject, and the eloquent style and agreeable manner of the professor, attracting a crowd of auditors. He afterwards published his *Lectures on Commerce*, and Carey's *Account of the Trade of England*, translated into Italian by his brother, with notes by himself. The *Lezioni di Commercio* is the first complete and systematic work in Italian on the science which Italians have done much to advance. On the whole it is to be included among works of the Mercantile school, but in treatment of fundamental problems, such as labor and money, it is distinguished by fairness and breadth of view. Specially noteworthy are the sections on human wants as foundation of economical theory, on labor as the source of wealth, on personal services as economic factors, and on the united working of the great industrial functions. Gioja's more important treatise owes much to Genovesi's lectures.

Till his death in 1769 Genovesi continued his labors at the university of Naples, which owes much of its celebrity to the solidity and excellence of his teaching. It cannot be said that Genovesi takes a high rank in philosophy, but he did much to introduce into Italy the new order of ideas, and his exposition of philosophical doctrines is fair and lucid: His work on *Metaphysics*, divided into the four rubrics, *Ontosophy*, *Cosmosophy*, *Theosophy*, *Psychosophy*, distinguished by its solid erudition, is an excellent specimen of the precritical or dogmatic method of handling speculative problems. His merits in political economy have been indicated above. (For list of works see Fabroni's *Lives*.)

GENSERIC, or GENSERICH, king of the Vandals, and the most formidable of the Gothic invaders of the Roman empire, was the natural son of Godegiselus, the founder of a Vandal kingdom in Spain, and was born at Seville about 406. Though he was only of middle stature, and had a lameness of one leg, such was his renown as a warrior that on the death of his brother Gonderic in 427 he was chosen to succeed him on the throne. At the invitation of Boniface, the Roman general in Africa, who wished to revolt against Valentinian III., Genseric in 429 crossed into Africa, and took possession of Mauretania. Soon afterwards he besieged Boniface in Hippo Regius, and compelled him after a defence of fourteen months to seek safety by a precipitate embarkation, leaving his soldiers and their families to the ruthless cruelty of the Vandals. In 435 Genseric concluded a treaty with the Romans by which he retained possession of western Numidia and Mauretania; but peace was not of long duration, and in October, 439, he captured Carthage, which he made the capital of his kingdom. Genseric was an Arian, and cruelly persecuted the orthodox Catholics in Africa. In 455 at the invitation of Eudocia, who wished to be revenged on Maximus the murderer of her husband Valentinian, he fitted out an expedition against Rome, and after storming the city, gave it up during fourteen days to be pillaged by his soldiers. Eudocia and her daughters he carried captive to Carthage, where she was retained in prison till 462. Two attemps were made by the Romans to avenge themselves on the barbarians,—the first by Majorian, emperor of the West, in 457, and the second by Leo, emperor of the East, in 468. Both attempts, however, signally failed, and in 475 Leo's successor Zeno concluded a truce. Genseric's dominion ultimately included Sicily, Sardinia, Corsica, and the Balearic isles; and he even extended his conquests to Thrace, Egypt, and Asia Minor. He died in 477. He was cruel to blood-thirstiness, cunning, unscrupulous, and grasping; but he possessed great military talents, and his manner of life was austere. Though the effect of his victories was neutralized by the subsequent successes of Belisarius, his name long remained the glory of the Vandal tribes.

GENTIAN, botanically *Gentiana*, a large and typical genus of herbaceous plants forming the type of the natural order *Gentianaceæ*. The genus comprises about 180 species, —most of them perennial plants growing in hilly or mountainous districts, chiefly in the northern hemisphere, some of the blue-flowered species ascending to a height of 16,000 feet in the Himalaya mountains. The leaves are opposite, entire, and smooth, and often strongly ribbed. The flowers are furnished with a persistent calyx and corolla, which is usually 4- or 5-parted, but occasionally 10-parted; the stamens are equal in number to the lobes of the corolla. The ovary is one-celled, with two stigmas, either separate and rolled back or contiguous and funnel-shaped. The fruit when ripe separates into two valves, and contains numerous small seeds. The majority of the genus are remarkable for the deep or brilliant blue color of their blossoms, comparatively few having yellow, white, or more rarely red flowers; the last are almost exclusively found in the Andes.

Only a few species occur in Britain. *G. Amarella* and *G. campestris* are small annual species growing on chalky or calcareous hills, and bear, in autumn, somewhat tubular pale purple flowers; the latter is most easily distinguished by having two of the lobes of the calyx larger than the other two; while the former has the parts of the calyx in fives, and equal in size. Some intermediate forms between these two species occur, although rarely, in England; one of these, *G. germancia*, Willd., has larger flowers of a more blue tint, spreading branches, and a stouter stem. Some of these forms flower in spring. *G. Pneumonanthe*, the Calathian violet, is a rather rare perennial species, growing in moist heathy places from Cumberland to Dorsetshire. Its average height is from 6 to 9 inches. It has linear leaves, and a bright blue corolla 1½ inches long, marked externally with five greenish bands, is without hairs in its throat, and is found in perfection about the end of August. It is the handsomest of the British species; two varieties of it are known in cultivation, one with spotted and the other with white flowers. *G. verna* and *G. nivalis* are small species with brilliant blue flowers and small leaves. The former is a rare and local perennial, occurring, however, in Teesdale and the county of Clare in Ireland in tolerable abundance. It has a tufted habit of growth, and each stem bears only one flower. It is sometimes cultivated as an edging for flower borders. *G. nivalis* in Britain occurs only on a few of the loftiest Scotch mountains. It differs from the last in being an annual, and having a more isolated habit of growth, and in the stem bearing several flowers. On the Swiss mountains these beautiful little plants are very abundant; and the splendid blue color of masses of gentian in flower is a sight which, when once seen, can never be forgotten. For ornamental purposes several species are cultivated. The great difficulty of growing them successfully renders them, however, less common than would otherwise be the case; although very hardy when once established, they are very impatient of removal, and rarely flower well until the third year after planting. Of the ornamental species found in British gardens some of the prettiest are *G. acaulis*, *G. verna*, *G. pyrenaica*, *G. bavarica*, *G. Septemfida*, and *G. gelida*. Perhaps the handsomest and most easily grown is the first named, often called *Gentianella*, which produces its large intensely blue flowers early in the spring.

All the species of the genus are remarkable for possessing an intense but pure bitter taste and tonic properties. About forty species are used in medicine in different parts of the world. The name of felwort given to *G. Amarella*, but occasionally applied to the whole genus, is stated by Dr. Prior to be given in allusion to these properties—*fel* meaning gall, and *wort* a plant. In the same way the Chinese call the *G. asclepiaderi*, and the Japanese the *G. Buergeri*, "dragon's gall plants," in common with several other very bitter plants whose roots they use in medicine. *G. campestris* is sometimes in Sweden and other northern countries a substitute for hops.

By far the most important of the species used in medicine is the *G. lutea*, a large handsome plant 3 or 4 feet high, growing in open grassy places on the Alps, Apennines, and Pyrenees, as well as on some of the mountainous ranges of France and Germany, extending as far east as Bosnia and the Danubian principalities. It has large oval strongly-ribbed leaves and dense whorls of conspicuous yellow flowers. Its use in medicine is of very ancient date. Pliny and Dioscorides mention that the plant was noticed by Gentius, a king of the Illyrians, living 180–167 B. C., from whom the name *Gentiana* is supposed to be derived. During the Middle Ages it was much employed in the cure of disease, and as an ingredient in counter-poisons. In 1552 Tragus mentions the use of the root as a means of dilating wounds.

The root, which is the part used in medicine, is tough and flexible, scarcely branched, and of a brownish color and spongy texture. It has a pure bitter taste and faint distinctive odor. On account of its porous nature it has been used in modern surgery, as in the time of Tragus, as a substitute for sponge tents. The root has been several times analyzed with varying results, but Kromayer in 1862 first obtained the bitter principle in a state of purity. This substance, to which the bitterness of the root is due, he called *gentiopicrin* ($C_{20}H_{30}O_{12}$). It is a neutral glucoside, crystallizing in colorless needles, and is contained in the fresh root in the proportion of about $\frac{1}{10}$th per cent., but has not been obtained in a crystalline state from the dried root. It is soluble in water and spirit of wine, but it does not dissolve in ether. It is easily decomposed, dilute mineral acids splitting it up into *glucose* and *gentiogenin*, the latter being an amorphous yellowish-brown neutral substance. It is not precipitated by tannin or subacetate of lead. A solution of caustic potash or soda forms with gentiopicrin a yellow solution, and the tincture of the root to which either of these alkalies has been added loses its bitterness in a few days. Gentian root also contains *gentianic acid* ($C_{14}H_{10}O_5$), which is inert and tasteless. It forms pale yellow silky crystals, very slightly soluble in water or ether, but soluble in hot strong alcohol and in aqueous alkaline solutions. This substance, which is also called *gentianin*, *gentisin*, and *gentisic acid*, has been shown by Ville to partake of the nature of tannin, giving the reactions of that substance with ferric chloride, gelatin, and albumen. On this account he proposes to change the name to *gentianotannic acid*.

The root also contains 12 to 15 per cent. of an uncrystallizable sugar, of which fact advantage has long been taken in Switzerland and Bavaria, for the production of a bitter cordial spirit called *Enzianbranntwein*. The use of this spirit, especially in Switzerland, has sometimes been followed by poisonous symptoms, which have been doubtfully attributed to inherent narcotic properties possessed by some species of gentian, the roots of which may have been indiscriminately collected with it; but it is quite possible that it may be due to the contamination of the root with that of *Veratrum album*, a poisonous plant growing at the same altitude, and having leaves extremely similar in appearance and size to those of *G. lutea*. Gentian is considered by therapeutists to be one of the most efficient of the simple bitter tonics, that is, of that class of substances which act upon the stomach so as to invigorate digestion and thereby increase the general nutrition, without exerting any direct influence upon any other portion of the body than the alimentary canal. It is used in dyspepsia, chlorosis, anæmia, and various other diseases, in which the tone of the stomach and alimentary canal is deficient, and is sometimes added to purgative medicines to increase and improve their action. In veterinary medicine it is also used as a tonic, and enters into a well-known compound called *diapente* as a chief ingredient.

See Sowerby, *English Botany*, 3d edit., vol. vi. p. 74–81; Hemsley, *Handbook of Hardy Trees, Shrubs, and Herbaceous Plants*, p. 303; *Journal of Botany*, 1864, p. 65; 1872, p. 166; 1878, p. 265; *Pharmacographia*, p. 389; *Pharmaceutical Journal* (1) vol. xii. p. 371; (3) vol. iii. p. 42; (3) vol. vi. p. 90; (3) vol. viii. p. 182; Wood and Bache, *United States Dispensatory*, 14th edit., p. 438; Porter Smith, *Chinese Materia Medica*, p. 102. (E. M. H.)

GENTILESCHI, ARTEMISIA and ORAZIO DE', painters. ORAZIO (1565–1646) is generally named Orazio Lomi de' Gentileschi; it appears that De' Gentileschi was his correct surname, Lomi being the surname which his mother had borne during her first marriage. He was born at Pisa, and studied under his half-brother Aurelio Lomi, whom in course of time he surpassed. He afterwards went to Rome, and was associated with the landscape-painter Agostino Tasi, executing the figures for the landscape backgrounds of this artist in the Palazzo Rospigliosi, and it is said in the great hall of the Quirinal Palace, although by some authorities the figures in the last-named building are ascribed to Lanfranchi. His best works are Saints Cecilia and Valerian, in the Palazzo Borghese, Rome; David after the death of Goliath, in the Palazzo Doria, Genoa; and some works in the royal palace, Turin, noticeable for vivid and uncommon coloring. At an advanced age Gentileschi went to England at the invitation of Charles I., and he was employed in the palace at Greenwich. Vandyck included him in his portraits of a hundred illustrious men. His works generally are strong in shadow and positive in color. He died in England in 1646. ARTEMISIA (1590–1642), Orazio's daughter, studied first under Guido, acquired much renown for portrait-painting, and considerably excelled her father's fame. She was a beautiful and elegant woman; her likeness, limned by her own hand, is to be seen in Hampton Court. Her most celebrated composition is Judith and Holofernes, in the Pitti palace; certainly a work of singular energy, and giving ample proof of executive faculty, but repulsive and unwomanly in its physical horror. She accompanied her father to England, but did not remain there long; the best picture which she produced for Charles I. was David with the head of Goliath. Artemisia refused an offer of marriage from Agostino Tasi, and bestowed her hand on Pier Antonio Schiattesi, continuing however to use her own surname. She settled in Naples, whither she returned after her English sojourn; she lived there in no little splendor, and there she died in 1642. She had a daughter and perhaps other children.

GENTILI, ALBERICO (1552–1608), may fairly be called the founder of the science of international law. He was the second son of Matteo Gentili, a physician of noble family and scientific eminence, and was born 14th January, 1552, at Sanginesio, a small town of the march of Ancona which looks down from the slopes of the Apennines upon the distant Adriatic. After taking the degree of doctor of law at the university of Perugia, and holding a judicial office at Ascoli, he returned to his native city, and was entrusted with the task of recasting its statutes, but, sharing the Protestant opinions of his father, shared also his flight to Carniola, where Matteo was appointed physician to the duchy. The Inquisition condemned the fugitives as contumacious, and they soon received orders to quit the dominions of Austria. Alberico set out for England, travelling by way of Tübingen and Heidelberg, and everywhere meeting with the reception to which his already high reputation entitled him. He arrived at Oxford in the autumn of 1580, with a commendatory letter from the earl of Leicester, at that time chancellor of the university, and was shortly afterwards qualified to teach by being admitted to the same degree which he had taken at Perugia. His lectures on Roman law soon became famous, and the dialogues, disputations, and commentaries, which he published henceforth in rapid succession, established his position as an accomplished civilian, of the older and severer type, and secured his appointment in 1587 to the regius professorship of civil law. It was, however, rather by an application of the old learning to the new questions suggested by the modern relations of states that his labors have produced their most lasting result. In 1584 he was consulted by Government as to the proper course to be pursued with Mendoza, the Spanish ambassador, who had been detected in plotting against Elizabeth. He chose the topic to which his attention had thus been directed as a subject for a disputation when Leicester and Sir Philip Sidney visited the schools at Oxford in the same year; and this was six months later expanded into a book, the *De legationibus libri tres*. In 1588 Alberico selected the law of war as the subject of the law disputations at the annual "Act" which took place in July; and in the autumn published in London the *De Jure Belli commentatio prima*. A second and a third *Commentatio* followed, and the whole matter, with large additions and improvements, appeared at Hanau, in 1598, as the *De Jure Belli libri tres*. It was doubtless in consequence of the reputation gained by these works that Gentili became henceforth more and more engaged in forensic practice, and resided chiefly in London, leaving his Oxford work to be partly discharged by a deputy. In 1600 he was admitted to be a member of Gray's Inn, and in 1605 was appointed standing counsel to the king of Spain. He died 19th June, 1608, and was buried, by the side of Dr. Matteo Gentili, who had followed his son to England, in the churchyard of St. Helen's, Bishopsgate. By his wife, Hester de Peigni, he left two sons and a daughter. His notes of the cases in which he was engaged for the Spaniards were posthumously published in 1613 at Hanau, as *Hispanicæ advocationis libri duo*. This was in accordance with his last wishes; but his direction that the remainder of his MSS. should be burnt was not complied with, since fifteen volumes of them found their way, at the beginning of this century, from Amsterdam to the Bodleian library.

The true history of Gentili and of his principal writings has only been ascertained quite recently, in consequence of a revived appreciation of the services which he rendered to international law. The movement to do him honor, which originated four or five years since, has in spreading through Europe encountered two curious cross-currents of opinion,—one the ultra-Catholic, which three centuries ago ordered his name to be erased from all public documents and placed his works in the *Index;* another the narrowly-Dutch, which is, it seems, needlessly careful of the supremacy of Grotius. Preceding writers had dealt with various international questions, but they dealt with them singly, and with a servile submission to the decisions of the church. It was left to Gentili to grasp as a whole the relations of states one to another, to distinguish international questions from questions with which they are more or less intimately connected, and to attempt their solution by principles entirely independent of the authority of Rome. He uses, without yielding to them implicit deference, the reasonings of the civil and even the canon law, but he proclaims as his real guide the *Jus Naturæ*, the highest common sense of mankind, by which historical precedents are to be criticised, and, if necessary, set aside.

His faults are not few. His style is prolix, obscure, and to the modern reader pedantic enough; but a comparison of his greatest work with what had been written upon the same subject by, for instance, Belli, or Soto, or even Ayala, will show that he greatly improved upon his predecessors, not only by the fulness with which he has worked out points of detail, but also by clearly separating the law of war from martial law, and by placing the subject once for all upon a non-theological basis. If, on the other hand, the same work be compared with *De Jure Belli et Pacis* of Grotius, it is at once evident that the later writer is indebted to the earlier, not only for a large portion of his illustrative erudition, but also for all that is commendable in the method and arrangement of the treatise.

The following is probably a complete list of the writings of Gentili, with the places and dates of their first publication :—*De Juris interpretibus dialogi sex*, Lond., 1582; *Lectionum et epist. quæ ad jus civile pertinent libri tres*, Lond., 1583–4; *De divers. temp. appellationibus*, Hanau, 1584; *De Legationibus libri tres*, Lond., 1585; *Legal. comitiorum Oxon. actio.*, Lond., 1585–6; *De nascendi tempore disputatio*, Witteb., 1586; *Disputationum decas prima*, Lond., 1587; *Conditionum liber singularis*, Lond., 1587; *De Jure Belli comm. prima*, Lond., 1588; *secunda, ib.*, 1588–9; *tertia*, 1589; *De injustitia bellica Romanorum*, Oxon., 1590; *De Armis Romanis*, etc., Hanau, 1599; *De ludis scenicis epist. duæ*, Middleburg, 1599; *De actoribus et de abusu mendacii*, Hanau, 1599; *Lectiones Virgilianæ*, Hanau, 1600; *De nuptiis libri septem*, 1601; *Ad 1 Maccab. et de linguarum mistura*, Lond., 1604; *In tit. si quis principi, et ad leg. Jul. maiest.*, Hanau, 1604; *In tit. de Malef. et Math. et de Prof. et Med.*, Hanau, 1604; *De latin. vet. Bibl.*, Hanau, 1604; *De libro Pyano*, Oxon., 1604; *Laudes Acad. Perus. et Oxon.*, Hanau, 1605; *De unione Angliæ et Scotiæ*, Lond., 1605; *Disputationes tres, de libris jur. can., de libris jur. civ., de latinitate vet. vers.*, Hanau, 1605; *Regales disput. tres de pot. regis absoluta, de unione regnorum, de vi civium*, Lond., 1605; *Hispanicæ advocationis libri duo*, Hanau, 1613; *In tit. de verb. signif.*, Hanau, 1614; *De legatis in test.*, Amsterd., 1661. An edition of the *Opera Omnia*, commenced at Naples in 1770, was cut short by the death of the publisher, Gravier, after the second volume. Of his numerous unpublished writings, Gentili complained that four volumes were lost "pessimo pontificiorum facinore," meaning probably that they were left behind in his flight to Carniola.

Authorities.—Several tracts by the Abate Benigni in Colucci, *Antichità Picene*, 1790; a Dissertation by W. Reiger annexed to the *Program of the Groningen Gymnasium* for 1867; an Inaugural Lecture delivered in 1874 by T. E. Holland, and the preface to a new edition of the *Jus Belli*, 1877, by the same; works by Valdarnini and Foglietti, 1875; Speranza and De Giorgi, 1876; Fiorini (a translation of the *Jus Belli*, with essay), 1877; A. Saffi, 1878. See also E. Comba, in the *Rivista Christiana*, 1876–7; and Sir T. Twiss, in the *Law Review*, 1878.

(T. E. H.)

GENTILLY, a town of France, in the department of the Seine, is situated on the Bièvre, a short distance south of the fortifications of Paris. Its manufactures include biscuits, soap, vinegar, mustard, wax candles, buttons, leather, and pottery wares. It possesses a church of the 13th century, a lunatic asylum, a convent, a monastery, and several charitable institutions. The population in 1876 was 10,378.

GENTZ, FRIEDRICH VON (1764–1832), born at Breslau, May 2, 1764, aptly and accurately described by his distinguished friend Varnhagen von Ense as a writer-statesman (Schriftsteller Staatsmann). He was more than a publicist or political writer. His position was peculiar, and his career without a parallel. It is believed that no other instance can be adduced of a man exercising the same amount of influence in the conduct of public affairs, without rank or fortune, without high office, without being a member of a popular or legislative assembly, without in fact any ostensible means or instrumentality besides his pen. Born in the middle class in an aristocratic country, he lived on a footing of social equality with princes and ministers, the trusted partaker of their counsels and the chosen exponent of their policy,

His father held an employment in the Prussian civil service; his mother was an Ancillon distantly related to the statesman of that name. On his father's promotion to the mint directorship at Berlin and consequent removal to the capital, he was sent to a gymnasium there, and in due course completed his education at the university of Frankfort-on-the Oder. He is said to have shown neither liking nor aptitude for intellectual pursuits till after his attendance on the lectures of Kant at Königsberg, in his twentieth or twenty-first year, when, suddenly lighted up as by inspiration, he set to work in right earnest, mastered the Greek and Latin languages, acquired as perfect a knowledge of French as could well be attained by one who was not a Frenchman, and a sufficient familiarity with English to enable him to translate from it with clearness and fluency. He also managed to gain an intimate acquaintance with English commerce and finance, which he afterwards turned to good account. The extent of his acquirements was rendered more remarkable by his confirmed habits of dissipation; for from the commencement to the conclusion of his career he was remarkable for the manner in which, in the midst of the gravest occupations, he indulged his fondness for female society and a ruinous passion for play. In 1786 he was appointed private secretary to the royal general directory, and was soon afterwards promoted to the rank of *Kriegsrath* (war-councillor). Like Mackintosh, he was fascinated by the French Revolution at its dawn, and, like Mackintosh, was converted to a sounder estimate of its then pending results by Burke. He broke ground in literature in 1794, by a translation of the celebrated *Essay on the French Revolution*, followed in 1794 and 1795 by translations from Mallet du Pan and Mounier. In 1795 he founded and edited a monthly journal which soon came to an untimely end. In November, 1797, he published a pamphlet under the title of a *Sendscreiben* or *Missive* addressed to Frederick William III. of Prussia on his accession, pointing out the duties of the new sovereign and especially recommending the complete freedom of the press. In the course of the next three years he contributed to the *Historisches Journal* a series of articles "On the Origin and Character of the War against the French Revolution," with express reference to Great Britain. These led to his visiting England, where he formed intimate relations with Mackintosh, Lord Grenville, Pitt, and other eminent men, which proved lasting, flattering, and remunerative. The first entries in his published diary, beginning April 14, 1800, and continued (with breaks) to the end of 1828, run thus:—

"On the 14th of April, an agreeable surprise. The Jew elder, Hirsch, brought me 50 thalers for drawing up I know not what representation (*Vorstellung*). *May 28.*—Received through Baron Krüdener a watch set with (small) brilliants, a present from the emperor of Russia. *June 1.*—Received through Garlicke a letter from Lord Grenville, together with a donation of £500, the first of its kind."

The last entry for this year, 1800, is:—"At the end of the year great pecuniary embarrassment. Received £100 from Garlicke and negotiated with Carysfort."

The diary for 1801 begins:—"*February.*—Very remarkable that on the one side Lord Carysfort charged me with the translation into French of the English Notes against Prussia, and shortly afterwards Count Haugwitz with the translation into German of the Prussian Notes against England."

Frequently recurring entries of this kind illustrate his position through life. He was to all intents and purposes a mercenary of the pen, but he was so openly and avowedly, and he was never so much as suspected by those who knew him best of writing contrary to his own convictions at the time. This is why he never lost the esteem or confidence of his employers,—of Prince Metternich, for example, who, when he was officially attached to the Austrian government, was kept regularly informed of the sources from which the greater part of his income was derived. Embarrassments of all sorts, ties and temptations from which he was irresistibly impelled to tear himself, led to his change of country; and an entry for May, 1802, runs:—"On the 15th I take leave of my wife, and at three in the morning of the 20th I leave Berlin with Adam Müller, never to see it again." It does not appear that he ever saw his wife again either; and his intimacies with other women, mostly of the highest rank, are puzzling from their multiplicity. He professes himself unable to explain the precise history of his settlement in Vienna. All he remembers is that he was received with signs of jealousy and distrust, and that the emperor, to whom he was presented by Count Colloredo, showed no desire to secure his services. Many years were to elapse before the formation of the connection with Metternich, the most prominent feature and crowning point of his career.

Before entering into any kind of engagements with the Austrian government he applied to the king of Prussia for a formal discharge, which was granted with an assurance that his Majesty, "in reference to his merits as a writer, coincided in the general approbation which he had so honorably acquired." A decisive proof of the confidence placed in him was his being invited by Count Haugwitz to the Prussian headquarters shortly before the battle of Jena, and commissioned to draw up the Prussian manifesto and the king's letter to Napoleon. It was in noticing this letter that Napoleon spoke of the known and avowed writer as "a wretched scribe named Gentz, one of those men without honor who sell themselves for money." In the course of 1806 he published *War between Spain and England,* and *Fragments upon the Balance of Power in Europe*, on receiving which (at Bombay) Mackintosh wrote:—"I assent to all you say, sympathize with all you feel, and admire equally your reason and your eloquence throughout your masterly fragment." The bond of union between him and Metternich was formed in 1810. This was one reason, joined to his general reputation, for his being named first secretary to the congress of Vienna in 1814, where, besides his regular duties, he seems to have made himself useful to several of the plenipotentiaries, as he notes in his diary that he received 22,000 florins in the name of Louis XVIII. from Talleyrand, and £600 from Lord Castlereagh, accompanied by "*les plus folles promesses.*" He acted in the same capacity at the congress or conference of Paris in 1815, of Aix in 1818, Karlsbad and Vienna in 1819, Troppau and Laybach in 1820 and 1821, and Verona in 1822. The following entry in his diary for December 14, 1819, has exposed him to much obloquy as the interested advocate of reactionary doctrines:—"About eleven, at Prince Metternich's: attended the last and most important sitting of the commission to settle the 13th article of the Bundes-Akt, and had my share in one of the greatest and worthiest results of the transactions of our time. A day more important than that of Leipsic." The 13th article provides that in all states of the Bund the constitutional government shall be by estates instead of by a representative body in a single chamber: "in allen Bundestaaten wird eine landständische Verfassung stattfinden." Remembering what ensued in France from the absorption of the other estates in the Tiers Etat, it would have been strange if Gentz had not supported this 13th article. He was far from a consistent politician, but he was always a sound conservative at heart; and his reputation rests on his foreign policy, especially on the courage, eloquence, and efficiency with which he made head against the Napoleonic system till it was struck down.

The most remarkable phase of Gentz's declining years was his passion, in his sixty-seventh year, for Fanny Elssler, the celebrated *danseuse*, which forms the subject of some very remarkable letters to his attached friend Rahel (the wife of Varnhagen von Ense) in 1830 and 1831. He died June 9, 1832. There is no complete edition of his works. The late Baron von Prokesch was engaged in preparing one when the Austrian government interfered, and the design was perforce abandoned. (A. H.)

GEODESY (*γῆ*, the earth, *δαίω*, to divide) is the science of surveying extended to large tracts of country, having in view not only the production of a system of maps of very great accuracy, but the determination of the curvature of the surface of the earth, and eventually of the figure and dimensions of the earth. This last, indeed, may be the sole object in view, as was the case in the operations conducted in Peru and in Lapland by the celebrated French astronomers Bouguer, La Condamine, Maupertuis, Clairaut, and others; and the measurement of the meridian arc of France by Mechain and Delambre had for its end the determination of the true length of the "metre" which was to be the legal standard of length of France.

The basis of every extensive survey is an accurate triangulation, and the operations of geodesy consist in—the measurement, by theodolites, of the angles of the triangles; the measurement of one or more sides of these triangles on the ground; the determination by astronomical observations of the azimuth of the whole network of triangles; the determination of the actual position of the same on the surface of the earth by observations, first for latitude at some of the stations, and secondly for longitude.

To determine by actual measurement on the ground the length of a side of one of the triangles, wherefrom to infer the lengths of all the other sides in the triangulation, is not the least difficult operation of a trigonometrical survey. When the problem is stated thus—To determine the number of times that a certain standard or unit of length is contained between two finely marked points on the surface of the earth at a distance of some miles asunder, so that the error of the result may be pronounced to lie between certain very narrow limits,—then the question demands very serious consideration. The representation of the unit of length by means of the distance between two fine lines on the surface of a bar of metal at a certain temperature is never itself free from uncertainty and probable error, owing to the difficulty of knowing at any moment the precise temperature of the bar; and the transference of this unit, or a multiple of it, to a measuring bar, will be affected not only with errors of observation, but with errors arising from uncertainty of temperature of both bars. If the measuring bar be not self-compensating for temperature, its expansion must be determined by very careful experiments. The thermometers required for this purpose must be very carefully studied, and their errors of division and index error determined.

The base apparatus of Bessel and that of Colby have been described in Figure of the Earth (vol. vii. p. 517). The average probable error of a single measurement of a base line by the Colby apparatus is, according to the very elaborate investigations of Colonel Walker, C.B., R.E., the Surveyor-General of India, $\pm\ 1{\cdot}5\mu$ (μ meaning "one millionth"). W. Struve gives $\pm\ 0{\cdot}8\mu$ as the probable error of a base line measured with his apparatus, being the mean of the probable errors of seven bases measured by him in Russia; but this estimate is probably too small. Struve's apparatus is simple: there are four wrought iron bars, each two toises (rather more than 13 feet) long; one end of each bar is terminated in a small steel cylinder presenting a slightly convex surface for contact, the other end carries a contact lever rigidly connected with the bar. The shorter arm of the lever terminates below in a polished hemisphere, the upper and longer arm traversing a vertical divided arc. In measuring, the plane end of one bar is brought into contact with the short arm of the contact lever (pushed forward by a weak spring) of the next bar. Each bar has two thermometers, and a level for determining the inclination of the bar in measuring. The manner of transferring the end of a bar to the ground is simply this: under the end of the bar a stake is driven very firmly into the ground, carrying on its upper surface a disk, capable of movement in the direction of the measured line by means of slow-motion screws. A fine mark on this disk is brought vertically under the end of the bar by means of a theodolite which is planted at a distance of 25 feet from the stake in a direction perpendicular to the base. Struve investigates for each base the probable errors of the measurement arising from each of these seven causes:—alignment, inclination, comparisons with standards, readings of index, personal errors, uncertainties of temperature, and the probable errors of adopted rates of expansion.

The apparatus used in the United States Coast Survey consists of two measuring bars, each 6 metres in length, supported on two massive tripod stands placed at one quarter length from each end, and provided, as in Colby's apparatus, with the necessary mechanism for longitudinal, transverse, and vertical adjustment. Each measuring rod is a compensating combination of an iron and a brass bar, supported parallel to one another and firmly connected at one end, the medium of connection between the free ends being a lever of compensation so adjusted as to indicate a constant length independent of temperature or changes of temperature. The bars are protected from external influences by double tubes of tinned sheet iron, within which they are movable on rollers by a screw movement which allows of contacts being made within $\frac{1}{10000}$ of an inch. The abutting piece acts upon the contact lever which is attached to the fixed end of the compound bar, and carries a very sensitive level, the horizontal position of which defines the length of the bar. It is impossible here to give a full description of this complicated apparatus, and we must refer for details to the account given in full in the United States Coast Survey Report for 1854. This apparatus is doubtless a very perfect one, and the manipulation of it must offer great facilities, for it appears to be possible, under favorable circumstances, to measure a mile in one day, 1·06 mile having been measured on one occasion in eight and a half hours. In order to test to the utmost the apparatus, the base at Atlanta, Georgia, was measured twice in winter and once in summer 1872–73, at temperatures 51°, 45°, 90° F.; the difference of the first and second measurements was +0·30 in., of the second and third +0·34 in.,—the actual length and computed probable error expressed in metres being 9338·4763 ± 0·0166. It is to be noted that in the account of a base recently measured in the United States Lake Survey, some doubt is expressed as to the perfection of the particular apparatus of this description there used, on account of a liability to permanent changes of length.

The last base line measured in India with Colby's compensation apparatus had a length of 8912 feet only, and in consequence of some doubts which had arisen as to the accuracy of this compensation apparatus, the measurement was repeated four times, the operations being conducted in such a manner as to indicate as far as possible the actual magnitudes of the probable errors to which such measures are liable. The direction of the line (which is at Cape Comorin) is north and south, and in two of the measurements the brass component was to the west, in the other two it was to the east. The differences between the individual measurements and the mean of the four are +·0017, −·0049, −·0015, +·0045 in feet. The measurements occupied from seven to ten days each,—the average rate of such work in India being about a mile in five days.

The method of M. Porro, adopted in Spain, and by the French in Algiers, is essentially different from those just described. The measuring rod, for there is only one, is a thermometric combination of two bars, one of platinum and one of brass, in length 4 metres, furnished with three levels and four thermometers. Suppose A, B, C three micrometer microscopes very firmly supported at intervals of 4 metres with their axes vertical, and aligned in the plane of the base line by means of a transit instrument, their micrometer screws being in the line of measurement. The measuring bar is brought under say A and B, and those micrometers read; the bar is then shifted and brought under B and C. By repetition of this process, the reading of a micrometer indicating the end of each position of the bar, the measurement is made. The probable error of the central base of Madridejos, which has a length of 14664·500 metres, is estimated at $\pm 0{\cdot}17\mu$. This is the longest base line in Spain; there are seven others, six of which are under 2500 metres in length; of these one is in Majorca, another in Minorca, and a third in Iviça. The last base just measured in the province of Barcelona has a length of 2483·5381 metres according to the first measurement, and 2483·5383 according to the second.

The total number of base lines measured in Europe up to the present time is about eighty, fifteen of which do not exceed in length 2500 metres, or about a mile and a half, and two—one in France, the other in Bavaria—exceed 19,000 metres. The question has been frequently discussed whether or not the advantage of a long base is sufficiently great to warrant the expenditure of time that it requires, or whether as much precision is not obtainable in the end by careful triangulation from a short base. But the answer cannot be given generally; it must depend on the circumstances of each particular case.

It is necessary that the altitude above the level of the sea of every part of a base line be ascertained by spirit levelling, in order that the measured length may be reduced to what it would have been had the measurement been made on the surface of the sea, produced in imagination. Thus if l be the length of a measuring bar, h its height at any given position in the measurement, r the radius of the earth, then the length radially projected on to the level of the sea is $l-\frac{h}{r}l$. In the Salisbury Plain base line the reduction to the level of the sea is −0·6294 feet.

In working away from a base line *ab*, stations *c*, *d*, *e*, *f* are carefully selected so as to obtain from well-shaped triangles gradually increasing sides. Before, however, finally leaving the base line it is usual to verify it by triangulation thus: during the measurement two or more points, as *p*, *q* (fig. 1), are marked in the base in positions such that the lengths of the different segments of the line are known; then, taking suitable external stations, as *h*, *k*, the angles of the triangles *bhp*, *phq*, *hqk*, *kqa* are measured. From these angles can be computed the ratios of the segments, which must agree, if all operations are correctly performed, with the ratios resulting from the measures. Leaving the base line, the sides increase up to ten, thirty, or fifty miles, occasionally, but seldom, reaching a hundred miles. The triangulation points may either be natural objects presenting themselves in suitable positions, such as church towers; or they may be objects specially constructed in stone or wood on mountain tops or other prominent ground. In every case it is necessary that the precise centre of the station be marked by some permanent mark. In India no expense is spared in making permanent the principal trigonometrical stations—costly towers in masonry being erected. It is essential that every trigonometrical station shall present a fine object for observation from surrounding stations.

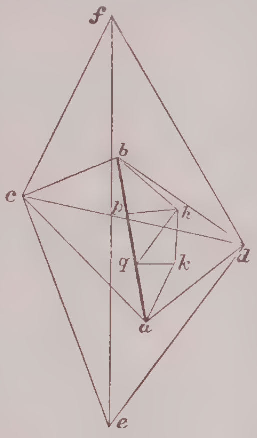


Fig. 1.

Horizontal Angles.

In placing the theodolite over a station to be observed from, the first point to be attended to is that it shall rest upon a perfectly solid foundation. The method of obtaining this desideratum must depend entirely on the nature of the ground; the instrument must if possible be supported on rock, or if that be impossible a solid foundation must be obtained by digging. When the theodolite is required to be raised above the surface of the ground in order to command particular points, it is necessary to build two scaffolds,—the outer one to carry the observatory, the inner one to carry the instrument,—and these two edifices must have no point of contact. Many cases of high scaffolding have occurred on the English Ordnance Survey, as for instance at Thaxted Church, where the tower, 80 feet high, is surmounted by a spire of 90 feet. The scaffold for the observatory was carried from the base to the top of the spire; that for the instrument was raised from a point of the spire 140 feet above the ground, having its bearing upon timbers passing through the spire at that height. Thus the instrument, at a height of 178 feet above the ground, was insulated, and not affected by the action of the wind on the observatory.

At every station it is necessary to examine and correct the adjustments of the theodolite, which are these:—the line of collimation of the telescope must be perpendicular to its axis of rotation; this axis perpendicular to the vertical axis of the instrument; and the latter perpendicular to the plane of the horizon. The micrometer microscopes must also measure correct quantities on the divided circle or circles. The method of observing is this. Let A, B, C . . . be the stations to be observed taken in order of azimuth; the telescope is first directed to A and the cross-hairs of the telescope made to bisect the object presented by A, then the microscopes or verniers of the horizontal circle (also of the vertical circle if necessary) are read and recorded. The telescope is then turned to B, which is observed in the same manner; then C and the other stations. Coming round by continuous motion to A, it is again observed, and the agreement of this second reading with the first is some test of the stability of the instrument. In taking this round of angles—or "arc," as it is called on the Ordnance Survey—it is desirable that the interval of time between the first and second observations of A should be as small as may be consistent with due care. Before taking the next arc the horizontal circle is moved through 20° or 30°; thus a different set of divisions of the circle is used in each arc, which tends to eliminate the errors of division.

It is very desirable that all arcs at a station should contain one point in common, to which all angular measurements are thus referred,—the observations on each arc commencing and ending with this point, which is on the Ordnance Survey called the "referring object." It is usual for this purpose to select, from among the points which have to be observed, that one which affords the best object for precise observation. For mountain tops a "referring object" is constructed of two rectangular plates of metal in the same vertical plane, their edges parallel and placed at such a distance apart that the light of the sky seen through appears as a vertical line about 10″ in width. The best distance for this object is from one to two miles.

It is clear that no correction is required to the angles measured by a theodolite on account of its height above the sea-level; for its axis of rotation coincides with the normal to the surface of the earth, and the angles measured between distant points are those contained between the vertical planes passing through the axis of the instrument and those points.

The theodolites used in geodesy vary in pattern and in size—the horizontal circles ranging from 10 inches to 36 inches in diameter. In Ramsden's 36-inch theodolite the telescope has a focal length of 36 inches and an aperture of 2·5 inches, the ordinarily used magnifying power being 54; this last, however, can of course be changed at the requirements of the observer or of the weather. The probable error of a single observation of a fine object with this theodolite is about 0″·2.

Fig. 2 represents an altazimuth theodolite of an improved pattern now used on the Ordnance Survey. The horizontal circle of 14 inches diameter is read by three micrometer microscopes; the vertical circle has a diameter of 12 inches, and is read by two microscopes.

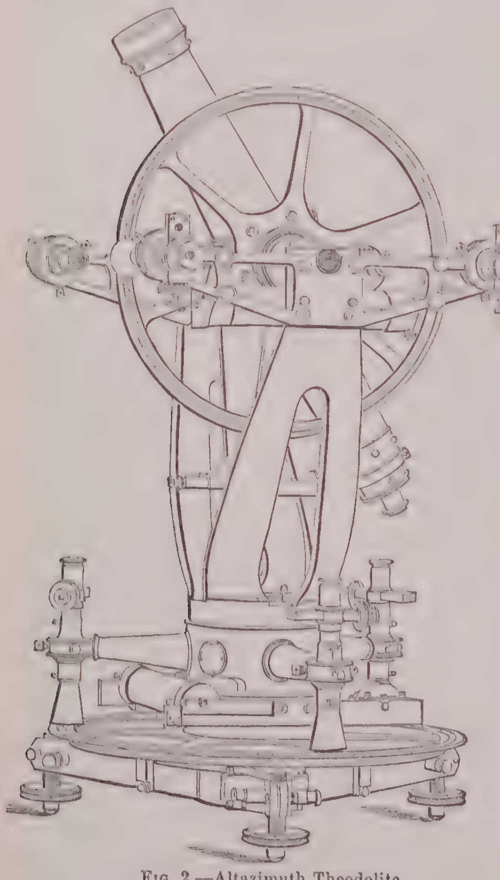


Fig. 2.—Altazimuth Theodolite.

In the Great Trigonometrical Survey of India the theodolites used in the more important parts of the work have been of 2 and 3 feet diameter—the circle read by five equidistant microscopes. Every angle is measured twice in each position of the zero of the horizontal circle, of which there are generally ten; the entire number of measures of an angle is never less than 20. An examination of 1407 angles showed that the probable error of an observed angle is on the average ± 0″·28.

For the observations of very distant stations it is usual to employ a heliotrope. In its simplest form this is a plane mirror 4, 6, or 8 inches in diameter, capable of rotation round a horizontal and a vertical axis. This mirror is placed at the station to be observed, and in fine weather it is kept so directed that the rays of the sun reflected by it strike the distant observing telescope. To the observer the heliotrope presents the appearance of a star of the first or second magnitude, and is generally a pleasant object for observing.

Astronomical Observations.

The direction of the meridian is determined either by a theodolite or a portable transit instrument. In the former case the operation consists in observing the angle between a terrestrial object—generally a mark specially erected and capable of illumination at night—and a close circumpolar star at its greatest eastern or western azimuth, or, at any rate, when very near that position. If the observation be made t minutes of time before or after the time of greatest azimuth, the azimuth then will differ from its maximum value by

$$(450t)^2 \sin 1'' \frac{\sin 2\delta}{\sin z} \pm \;.\;.\;.\;.$$

in seconds of angle, omitting smaller terms. Here the symbol δ is the star's declination, z its zenith distance. The collimation and level errors are very carefully determined before and after these observations, and it is usual to arrange the observations by the reversal of the telescope so that collimation error shall disappear. If b, c be the level and collimation errors, the correction to the circle reading is $b \cot z \pm c \operatorname{cosec} z$, b being positive when the west end of the axis is high. It is clear that any uncertainty as to the real state of the level will produce a corresponding uncertainty in the resulting value of the azimuth—an uncertainty which increases with the latitude, and is very large in high latitudes. This may be partly remedied by observing in connection with the star its reflexion in mercury. In determining the value of "one division" of a level tube, it is necessary to bear in mind that in some the value varies considerably with the temperature. By experiments on the level of Ramsden's 3-foot theodolite, it was found that though at the ordinary temperature of 66° the value of a division was about one second, yet at 32° it was about five seconds.

The portable transit in its ordinary form hardly needs description. In a very excellent instrument of this kind used on the Ordnance Survey, the uprights carrying the telescope are constructed of mahogany, each upright being built of several pieces glued and screwed together; the base, which is a solid and heavy plate of iron, carries a reversing apparatus for lifting the telescope out of its bearings, reversing it, and letting it down again. Thus is avoided the change of temperature which the telescope would incur by being lifted by the hands of the observer. Another form of transit is the German diagonal form, in which the rays of light after passing through the object glass are turned by a total reflexion prism through one of the transverse arms of the telescope, at the extremity of which arm is the eye-piece. The unused half of the ordinary telescope being cut away is replaced by a counterpoise. In this instrument there is the advantage that the observer without moving the position of his eye commands the whole meridian, and that the level may remain on the pivots whatever be the elevation of the telescope. But there is the disadvantage that the flexure of the transverse axis causes a variable collimation error depending on the zenith distance of the star to which it is directed; and moreover it has been found that in some cases the personal error of an observer is not the same in the two positions of the telescope.

To determine the direction of the meridian, it is well to erect two marks at nearly equal angular distances on either side of the north meridian line, so that the pole star crosses the vertical of each mark a short time before and after attaining its greatest eastern and western azimuths.

If now the instrument, perfectly levelled, is adjusted to have its centre wire on one of the marks, then when elevated to the star, the star will traverse the wire, and its exact position in the field at any moment can be measured by the micrometer wire. Alternate observations of the star and the terrestrial mark, combined with careful level readings and reversals of the instrument, will enable one, even with only one mark, to determine the direction of the meridian in the course of an hour with a probable error of less than a second. The second mark enables one to complete the station more rapidly, and gives a check upon the work. As an instance, at Findlay Seat, in latitude 57° 35′ the resulting azimuths of the two marks were 177° 45′ 37″·29 ± 0″·20 and 182° 17′ 15″·61 ± 0″·13, while the angle between the two marks directly measured by a theodolite was found to be 4° 31′ 37″·43 ± 0″·23.

We now come to the consideration of the determination of time with the transit instrument. Let fig. 3 represent the sphere stereographically projected on the plane of the horizon—*ns* being the meridian, *we* the prime vertical, Z, P the zenith and the pole. Let *p* be the point in which the production of the axis of the instrument meets the celestial sphere, S the position of a star when observed on a wire whose distance from the collimation centre is *c*. Let *a* be the azimuthal deviation, namely, the angle *wZp*, *b* the level error so that $Zp = 90° - b$. Let also the hour angle corresponding to *p* be $90° - n$, and the declination of the same $= m$, the star's declination being δ, and the latitude ϕ. Then to find the hour angle $ZPS = \tau$ of the star when observed, in the triangles *pPS*, *pPZ* we have, since $pPS = 90 + \tau - n$,

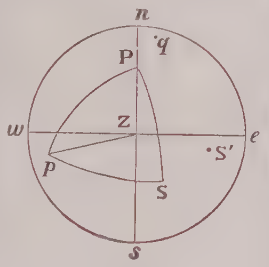


FIG. 3.

$$
\begin{aligned}
-\text{Sin}\ c &= \sin m \sin \delta + \cos m \cos \delta \sin (n - \tau),\\
\text{Sin}\ m &= \sin b \sin \phi - \cos b \cos \phi \sin a,\\
\text{Cos}\ m \sin n &= \sin b \cos \phi + \cos b \sin \phi \sin a.
\end{aligned}
$$

And these equations solve the problem, however large be the errors of the instrument. Supposing, as usual, *a*, *b*, *m*, *n* to be small, we have at once $\tau = n + c \sec \delta + m \tan \delta$, which is the correction to the observed time of transit. Or, eliminating *m* and *n* by means of the second and third equations, and putting *z* for the zenith distance of the star, *t* for the observed time of transit, the corrected time is

$$t + \frac{a \sin z + b \cos z + c}{\cos \delta}.$$

Another very convenient form for stars near the zenith is this—

$$\tau = b \sec \phi + c \sec \delta + n (\tan \delta - \tan \phi).$$

Suppose that in commencing to observe at a station the error of the chronometer is not known; then having secured for the instrument a very solid foundation, removed as far as possible level and collimation errors, and placed it by estimation nearly in the meridian, let two stars differing considerably in declination be observed—the instrument not being reversed between them. From these two stars, neither of which should be a close circumpolar star, a good approximation to the chronometer error can be obtained; thus let ε_1, ε_2 be the apparent clock errors given by these stars, if δ_1, δ_2 be their declinations the real error is

$$\varepsilon = \varepsilon_1 + (\varepsilon_1 - \varepsilon_2)\frac{\tan \phi - \tan \delta_1}{\tan \delta_1 - \tan \delta_2}.$$

Of course this is still only approximative, but it will enable the observer (who by the help of a table of natural tangents can compute ε in a few minutes) to find the meridian by placing at the proper time, which he now knows approximately, the centre wire of his instrument on the first star that passes—not near the zenith.

The transit instrument is always reversed at least once in the course of an evening's observing, the level being frequently read and recorded. It is necessary in most instruments to add a correction for the difference in size of the pivots.

The transit instrument is also used in the prime vertical for the determination of latitudes. In the preceding figure let *q* be the point in which the northern extremity of the axis of the instrument produced meets the celestial sphere. Let *nZq* be the azimuthal deviation $= a$, and *b* being the level error, $Zq = 90° - b$; let also $nPq = \tau$ and $Pq = \psi$. Let S′ be the position of a star when observed on a wire whose distance from the collimation centre is *c*, positive when to the south, and let *h* be the observed hour angle of the star, viz., ZPS′. Then the triangles *q*PS′, *q*PZ give

$$
\begin{aligned}
-\text{Sin}\ c &= \sin \delta \cos \psi - \cos \delta \sin \psi \cos (h + \tau),\\
\text{Cos}\ \psi &= \sin b \sin \phi + \cos b \cos \phi \cos a,\\
\text{Sin}\ \psi \sin \tau &= \cos b \sin a.
\end{aligned}
$$

Now when *a* and *b* are very small, we see from the last two equations that $\psi = \phi - b$, $a = \tau \sin \psi$, and if we calculate ϕ' by the formula $\cot \phi' = \cot \delta \cos h$, the first equation leads us to this result—

$$\phi = \phi' + \frac{a \sin z + b \cos z + c}{\cos z},$$

the correction for instrumental error being very similar to that applied to the observed time of transit in the case of meridian observations. When *a* is not very small and *z is* small, the formulæ required are more complicated.

The method of determining latitude by transits in the prime vertical has the disadvantage of being a somewhat slow process, and of requiring a very precise knowledge of the time, a disadvantage from which the zenith telescope is free. In principle this instrument is based on the proposition that when the meridian zenith distances of two stars at their upper culminations—one being to the north and the other to the south of the zenith—are equal, the latitude is the mean of their declinations; or, if the zenith distance of a star culminating to the south of the zenith be Z, its declination being δ, and that of another culminating to the north with zenith distance Z′ and declination δ', then clearly the latitude is $\frac{1}{2}(\delta + \delta') + \frac{1}{2}(Z - Z')$. Now the zenith telescope does away with the divided circle, and substitutes the measurement micrometrically of the quantity $Z' - Z$.

The instrument (fig. 4) is supported on a strong tripod, fitted with levelling screws; to this tripod is fixed the azimuth circle and a long vertical steel axis. Fitting on this axis is a hollow axis which carries on its upper end a short transverse horizontal axis. This latter carries the telescope, which, supported at the centre of its length, is free to rotate in a vertical plane. The telescope is thus mounted excentrically with respect to the vertical axis around which it revolves. An extremely sensitive level is attached to the telescope, which latter carries a micrometer in its eyepiece, with a screw of long range for measuring differences of zenith distance. For this instrument stars are selected in pairs, passing north and south of the zenith, culminating within a few minutes of time and within about twenty minutes (angular) of zenith distance of each other. When a pair of stars is to be observed, the telescope is set to the mean of the zenith distances and in the plane of the meridian. The first star on passing the central meridional wire is bisected by the micrometer; then the telescope is rotated very carefully through 180° round the vertical axis, and the second star on passing through the field is bisected by the micrometer on the centre wire. The micrometer has thus measured the difference of the zenith distances, and the calculation to get the latitude is most simple. Of course it is necessary to read the level, and the observations are not necessarily confined to the centre wire. In fact, if *n*, *s* be the north and south readings of the level for the south star, *n′*, *s′* the same for the north star, *l* the value of one division of the level, *m* the value of one division of the micrometer, *r*, *r′* the refraction corrections, μ, μ' the micrometer readings of the south and north star, the micrometer being supposed to read *from* the zenith, then, supposing the observation made on the centre wire,—

$$\phi = \tfrac{1}{2}(\delta + \delta') + \tfrac{1}{2}(\mu - \mu')\, m + \tfrac{1}{4}(n + n' - s - s')\, l + \tfrac{1}{2}(r - r').$$

It is of course of the highest importance that the value *m* of the screw be well determined. This is done most effectually by observing the vertical movement of a close circumpolar star when at its greatest azimuth.

In a single night with this instrument a very accurate result, say with a probable error of about 0″·3 or 0″·4, could be obtained for latitude from, say, twenty pairs of stars; but when the latitude is required to be obtained with the highest possible precision, four or five fine nights are necessary. The weak point of the zenith telescope lies in the circumstance that its requirements prevent the selection of stars whose positions are well fixed; very frequently it is necessary to have the declinations of the stars selected for this instrument specially observed at fixed observatories. The zenith telescope is made in various sizes from 30 to 54 inches in focal length; a 30-inch telescope is sufficient for the highest purposes, and is very portable. The zenith telescope is a particularly pleasant instrument to work with, and an observer has been known (a sergeant of Royal Engineers, on one occasion) to take every star in his list during eleven hours on a stretch, namely, from 6 o'clock P. M. until 5 A. M., and this on a very cold November night on one of the highest points of the Grampians. Observers accustomed to geodetic operations attain considerable powers of endurance. Shortly after the commencement of the observations on one of the hills in the Isle of Skye a storm carried away the wooden houses of the men and left the observatory roofless. Three observatory roofs were subsequently demolished, and for some time the observatory was used without a roof, being filled with snow every night and emptied every morning. Quite different, however, was the experience of the same party when on the top of Ben Nevis, 4406 feet high. For about a fortnight the state of the atmosphere was unusually calm, so much so that a lighted candle could often be carried between the tents of the men and the observatory, whilst at the foot of the hill the weather was wild and stormy.

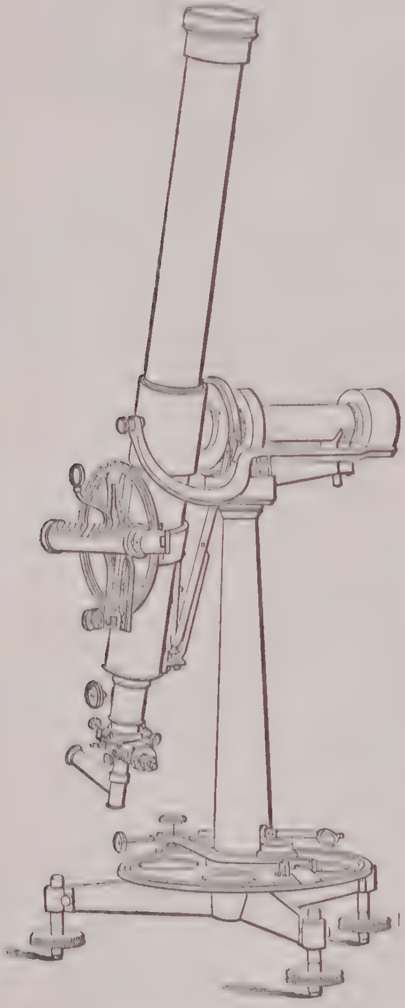


Fig. 4.—Zenith Telescope.

Calculation of Triangulation.

The surface of Great Britain and Ireland is uniformly covered by triangulation, of which the sides are of various lengths from 10 to 111 miles. The largest triangle has one angle at Snowden in Wales, another on Slieve Donard in Ireland, and a third at Scaw Fell in Cumberland; each side is over a hundred miles, and the spherical excess is 64″.

The more ordinary method of triangulation is, however, that of chains of triangles, in the direction of the meridian and perpendicular thereto. The principal triangulations of France, Spain, Austria, and India are so arranged. Oblique chains of triangles are formed in Italy, Sweden, and Norway, also in Germany and Russia, and in the United States. Chains are composed sometimes merely of consecutive plain triangles; sometimes, and more frequently in India, of combinations of triangles forming consecutive polygonal figures. In this method of triangulating, the sides of the triangles are generally from 20 to 30 miles in length—seldom exceeding 40.

The inevitable errors of observation, which are inseparable from all angular as well as other measurements, introduce a great difficulty into the calculation of the sides of a triangulation. Starting from a given base in order to get a required distance, it may generally be obtained in several different ways—that is, by using different sets of triangles. The results will certainly differ one from another, and probably no two will agree. The experience of the computer will then come to his aid, and enable him to say which is the most trustworthy result; but no experience or ability will carry him through a large network of triangles with anything like assurance. The only way to obtain trustworthy results is to employ the method of least squares, an explanation of which will be found in FIGURE OF THE EARTH (vol. vii. p. 523). We cannot here give any illustration of this method as applied to general triangulation, for it is most laborious, even for the simplest cases. We may, however, take the case of a simple chain—commencing with the consideration of a single triangle in which all three angles have been observed.

Suppose that the sum of the observed angles exceeds the proper amount by a small quantity ϵ: it is required to assign proper corrections to the angles, so as to cause this error to disappear. To do this we must be guided by the *weight* of the determinations of each angle. When a series of direct and independent observations is made, under similar circumstances, of any measurable magnitude—as an angle—the weight of the result is equal to half the square of the number of observations divided by the sum of the squares of the differences of the individual measures from the mean of all. Now let h, k, l be the weights of the three measured angles, and let x, y, z be the corrections which should be applied to them. We know that $x + y + z + \epsilon = 0$; and the theory of probabilities teaches us that the most probable values are those which make $hx^2 + ky^2 + lz^2$ a minimum. Here we arrive at a simple definite problem, the result of which is $hx = ky = lz$, showing that ϵ has to be divided into three parts which shall be proportional to the reciprocals of the weights of the corresponding angles. In what follows we shall, for simplicity, suppose the weights of the observed angles to be all equal.

Suppose now that A, B, C are the three angles of a triangle, and that the observed values are $A + e_1$, $B + e_2$, $C + e_3$; then, although e_1, e_2, e_3, the errors of observation, are unknown, yet by adding up the observed angles and finding that the sum is in excess of the truth by a small quantity e, we get $e_1 + e_2 + e_3 = e$. Now according to the last proposition, if we suppose the angles to be equally well observed, we have to subtract $\frac{1}{3}e$ from each of the observed values, which thus become $A + \frac{2}{3}e_1 - \frac{1}{3}e_2 - \frac{1}{3}e_3$, $B - \frac{1}{3}e_1 + \frac{2}{3}e_2 - \frac{1}{3}e_3$, $C - \frac{1}{3}e_1 - \frac{1}{3}e_2 + \frac{2}{3}e_3$. Then to obtain a and b by calculation from the known side c, we have

$$a \sin\left(C - \tfrac{1}{3}e_1 - \tfrac{1}{3}e_2 + \tfrac{2}{3}e_3\right) = c \sin\left(A + \tfrac{2}{3}e_1 - \tfrac{1}{3}e_2 - \tfrac{1}{3}e_3\right),$$

with a similar expression for the relation between b and c. Put α, β, γ for the cotangents of A, B, C, then the errors of the computed values of a and b are expressed thus—

$$\begin{aligned} \delta a &= \tfrac{1}{3}a\,\{e_1(2\alpha + \gamma) + e_2(-\alpha + \gamma) + e_3(-\alpha - 2\gamma)\} \\ \delta b &= \tfrac{1}{3}b\,\{e_1(-\beta + \gamma) + e_2(2\beta + \gamma) + e_3(-\beta - 2\gamma)\}. \end{aligned}$$

Now these actual errors must remain unknown; but we here make use of the following theorem, proved in the doctrine of probabilities. The probable error of a quantity which is a function of several independently observed elements is equal to the square root of the sum of the squares of the probable errors that would arise from each of the observed elements taken singly. Now suppose that each angle in a triangle has a probable error ε, then we replace e_1, e_2, e_3 by ε, and adding up the squares of the coefficients find for the probable error of a, $\pm \frac{1}{3}a\varepsilon\sqrt{6}\sqrt{(\alpha^2 + \alpha\gamma + \gamma^2)}$, and for that of b, $\pm \frac{1}{3}b\varepsilon\sqrt{6}\sqrt{(\beta^2 + \beta\gamma + \gamma^2)}$. Suppose the [illegible] of [illegible] observed angle [illegible] the computed sides will [illegible] to be 0·60 inches.

Take a chain [illegible] cated in the di[illegible] pose all the an[illegible] that the sides [illegible] ured bases; it is [illegible] gate the necessa[illegible] that [illegible] each [illegible]

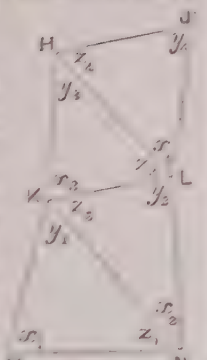


FIG. 5.

[illegible] $X^1 = X + x$, $Y^1 = Y + y$, etc., then

$$\frac{HJ}{MN} = \frac{\sin X_1^1 \sin X_2^1 \sin X_3^1 \sin X_4^1}{\sin Y_1^1 \sin Y_2^1 \sin Y_3^1 \sin Y_4^1}$$

$$= \frac{\sin X_1 \sin X_2 \sin X_3 \sin X_4}{[illegible]} [illegible]$$

Let $\alpha_1, \beta_1, \gamma_1 \ldots$ be the cotangents of the angles, so that sin $X^1 = \sin X (1 + \alpha x)$, then u in this last equation is easily seen to be the right hand member of the equation

[illegible]

Here f is known numerically, for the ratio of the measured bases is known, and the product of the ratios of the sines of the observed angles is known by computation. The most probable values of $x_1, y_1, z_1, \ldots$ are those which make the sum $\Sigma (x^2 + y^2 + z^2)$, a minimum or, as we may write it,

$$\phi = \Sigma (x^2 + y^2 + (e + x + y)^2)$$

a minimum. This, and the previous equation in f, determine all the corrections. Differentiate both and multiply the former by a multiplier P, then

$$\begin{aligned} 2x_t + y_t + e_t + P\alpha_t &= 0, \\ 2y_t + x_t + e_t - P\beta_t &= 0, \\ 3x_t &= -P(2\alpha_t + \beta_t) - e_t, \\ 3y_t &= P(\alpha_t + 2\beta_t) - e_t. \end{aligned}$$

[illegible] substitute these values in the f equation, and P becomes known: then follow at once all the corrections from the two last written equations. These corrections being applied to the [illegible] every side in the triangulation has a definite value which is obtained by the ordinary method of calculation.

A spheroidal triangle differs from a spherical triangle, not [illegible] from another, but [illegible] meet at [illegible] α [illegible] γ respectively. Now the angle A of [illegible] as measured by a theodolite is the inclination [illegible] BAa and CAa, and the angle at B is that [illegible] and ABβ containing the line AB in common cut the [illegible]ce in two distinct plane curves. In order, therefore, [illegible] spheroidal triangle may be exactly defined, it is [illegible] nature [illegible]

$$\mathfrak{A} = A + \frac{\sigma}{12}(2a + b + c),$$

$$\mathfrak{B} = B + \frac{\sigma}{12}(a + 2b + c),$$

$$\mathfrak{C} = C + \frac{\sigma}{12}(a + b + 2c).$$

The geodesic line being the shortest that can be drawn on any surface between two given points, we may be conducted to its most important characteristics by the following considerations: let p, q be adjacent points on a curved surface; through s the middle point of the chord pq imagine a plane drawn perpendicular to pq, and let S be any point in the intersection of this plane with the surface; then $pS + Sq$ is evidently least when sS is a minimum, which is when sS is a normal to the surface; hence it follows that of all plane curves on the surface joining p, q, when those points are indefinitely near to one another, that is the shortest which is made by the normal plane. That is to say, the osculating plane at any point of a geodesic line contains the normal to the surface at that point. Imagine now three points in space, A, B, C, such that AB = BC = c; let the direction cosines of AB be l, m, n, those of BC l', m', n', then x, y, z being the co-ordinates of B, those of A and C will be respectively—

$$x - cl : y - cm : z - cn$$
$$x + cl' : y + cm' : z + cn'.$$

Hence the co-ordinates of the middle point M of AC are $x + \frac{1}{2}c(l' - l)$, $y + \frac{1}{2}c(m' - m)$, $z + \frac{1}{2}c(n' - n)$, and the direction cosines of BM are therefore proportional to $l' - l : m' - m : n' - n$. If the angle made by BC with AB be indefinitely small, the direction cosines of BM are as $\delta l : \delta m : \delta n$. Now if AB, BC be two contiguous elements of a geodesic, then BM must be a normal to the surface, and since $\delta l, \delta m, \delta n$ are in this case represented by $\delta\frac{dx}{ds}, \delta\frac{dy}{ds}, \delta\frac{dz}{ds}$, we have

$$\frac{\frac{d^2x}{ds^2}}{\frac{du}{dx}} = \frac{\frac{d^2y}{ds^2}}{\frac{du}{dy}} = \frac{\frac{d^2z}{ds^2}}{\frac{du}{dz}},$$

which, however, are equivalent to only one equation. In the case of the spheroid this equation becomes

$$y\frac{d^2x}{ds^2} - x\frac{d^2y}{ds^2} = 0,$$

which integrated gives $ydx - xdy = Cds$. This again may be put in the form $r \sin \alpha = C$, where α is the azimuth of the geodesic at any point—the angle between its direction and that of the meridian—and r the distance of the point [illegible]

[illegible] The [illegible] Suppose that for a moment we drop the consideration of the earth's non-sphericity, and draw a perpendicular from the pole C on AB, meeting it in S between A and B. Then A being that point which is nearest the pole, the geodesic will cross the plane curve if AS be between $\frac{1}{4}$AB and $\frac{3}{8}$AB. If AS lie between this last value and $\frac{1}{2}$AB, the geodesic will lie wholly to the north of both plane curves, that is, supposing both points to be in the northern hemisphere.

The circumstance that the angles of the geodesic triangle do not coincide with the true angles as observed renders it inconvenient to regard the geodesic lines as sides of the triangle. A more convenient curve to regard as the side of the spheroidal triangle is this: let L be a point on the curve surface between A and B, λ the point in which the normal at L intersects the axis of revolution, then if L be subject to the condition that the planes ALλ, BLλ coincide, it traces out a curve which touches at A and B the two plane curves before specified. Joining A, B, C by three such lines, the angles of the triangle so formed coincide with the true angles.

Let the azimuths (at the middle point, say) of the sides BC, CA, AB of a spheroidal triangle be α, β, γ, these being measured from 0° to 360° continuously, and the angles of the triangle lettered in the same cyclical direction, and let a, b, c be the lengths of the sides. Let there be a sphere of radius r, such that r is a mean proportional between the principal radii of curvature at the mean latitude ϕ of the spheroidal triangle, and on this sphere a triangle having sides equal respectively to a, b, c. If A′, B′, C′ be the angles of the spheroidal triangle, A, B, C those of the spherical triangle, then

$$A' - A = \frac{e^2}{12r^2}\cos^2\phi(b^2\sin 2\beta - c^2\sin 2\gamma)\,,$$

$$B' - B = \frac{e^2}{12r^2}\cos^2\phi(c^2\sin 2\gamma - a^2\sin 2\alpha)\,,$$

$$C' - C = \frac{e^2}{12r^2}\cos^2\phi(a^2\sin 2\alpha - b^2\sin 2\beta)\,.$$

By adding these together, it appears that, to the order of terms here retained, the sum of the angles of the spheroidal triangle is equal to the sum of the angles of the spherical triangle. The spherical excess of a spheroidal triangle is therefore obtained by multiplying its area by $\frac{1}{\rho\rho'}$ Gauss's measure of curvature.

Further, let A₁, B₁, C₁ be the angles of a plane triangle having still the same sides a, b, c, then it may be shown by spherical trigonometry that r being the radius of the sphere as before,

$$A - A_1 = \frac{\Delta}{3r^2}\left(1 + \frac{a^2 + 7b^2 + 7c^2}{120r^2}\right)\,,$$

$$B - B_1 = \frac{\Delta}{3r^2}\left(1 + \frac{7a^2 + b^2 + 7c^2}{120r^2}\right)\,,$$

$$C - C_1 = \frac{\Delta}{3r^2}\left(1 + \frac{7a^2 + 7b^2 + c^2}{120r^2}\right)\,.$$

It is but seldom that the terms of the fourth order are required. Omitting them, we have Legendre's theorem, viz., "If from each of the angles of a spherical triangle, the sides of which are small in comparison with the radius, one-third of the spherical excess be deducted, the sines of the angles thus diminished will be proportional to the length of the opposite sides, so that the triangle may be computed as a plane triangle." By this means the spherical triangles which present themselves in geodesy are computed with very nearly the same ease as plane triangles. And from the expressions given above for the spheroidal angles A′, B′, C′ it may be proved that no error of any consequence can arise from treating a spheroidal triangle as a spherical, the radius of the sphere being as stated above.

When the angles of a triangulation have been adjusted by the method of least squares, the next process is to calculate the latitudes and longitudes of all the stations starting from one given point. The calculated latitudes, longitudes, and azimuths, which are designated geodetic latitudes, longitudes, and azimuths, are not to be confounded with the observed latitudes, longitudes, and azimuths, for these last are subject to somewhat large errors. Supposing the latitudes of a number of stations in the triangulation to be observed, practically the mean of these determines the position in latitude of the network, taken as a whole. So the orientation or general azimuth of the whole is inferred from all the azimuth observations. The triangulation is then supposed to be projected on a spheroid of given elements, representing as nearly as one knows the real figure of the earth. Then, taking the latitude of one point and the direction of the meridian there as given—obtained, namely, from the astronomical observations there—one can compute the latitudes of all the other points with any degree of precision that may be considered desirable. It is necessary to employ for this purpose formulæ which will give results true even for the longest distances to the second place of decimals of seconds, otherwise there will arise an accumulation of errors from imperfect calculation which should always be avoided. For very long distances, eight places of decimals should be employed in logarithmic calculations; if seven places only are available very great care will be required to keep the last place true. Now let ϕ, ϕ' be the latitudes of two stations A and B; α, α' their mutual azimuths counted from north by east continuously from 0° to 360°; ω their difference of longitude measured from west to east; and s the distance AB.

First compute a latitude ϕ_1 by means of the formulæ $\phi_1 = \phi + \frac{s}{\rho}\cos\alpha$, where ρ is the radius of curvature of the meridian at the latitude ϕ; this will require but four places of logarithms. Then, in the first two of the following, five places are sufficient—

$$\epsilon = \frac{s^2}{2\rho n}\sin\alpha\cos\alpha\,,$$

$$\eta = \frac{s^2}{2\rho n}\sin^2\alpha\tan\phi_1\,,$$

$$\phi - \phi = \frac{s}{\rho_0}\cos(\alpha - \tfrac{2}{3}\epsilon) - \eta\,,$$

$$\omega = \frac{s}{n}\,\frac{\sin(\alpha - \frac{1}{3}\epsilon)}{\cos(\phi' + \frac{1}{3}\eta)}\,,$$

$$\alpha' - \alpha = \omega\sin(\phi' + \tfrac{2}{3}\eta) - \epsilon + 180°.$$

Here n is the normal or radius of curvature perpendicular to the meridian; both n and ρ correspond to latitude ϕ_1, and ρ_0 to latitude $\frac{1}{2}(\phi + \phi')$. For calculations of latitude and longitude, tables of the logarithmic values of $\rho\sin 1''$, $n\sin 1''$, and $2n\rho\sin 1''$ are necessary. The following table contains these logarithms for every ten minutes of latitude from 52° to 53° computed with the elements $a = 20926060$ and $a : c = 295 : 294$:—

Lat.		$\text{Log.}\frac{1}{\rho\sin 1''}$.	$\text{Log.}\frac{1}{n\sin 1''}$.	$\text{Log.}\frac{1}{2\rho n\sin 1''}$.
°	′			
52	0	7·9939434	7·9928231	0·37131
	10	9309	8190	29
	20	9185	8148	28
	30	9060	8107	26
	40	8936	8065	24
	50	8812	8024	23
53	0	8688	7982	22

The logarithm in the last column is that required also for the calculation of spherical excesses, the spherical excess of a triangle being expressed by $\frac{ab\sin C}{2\rho n\sin 1''}$.

It is frequently necessary to obtain the co-ordinates of one point with reference to another point; that is, let a perpendicular arc be drawn from B to the meridian of A meeting it in P, then α being the azimuth of B at A, the co-ordinates of B with reference to A are

$$AP = s\cos(\alpha - \tfrac{2}{3}\epsilon),$$
$$BP = s\sin(\alpha - \tfrac{1}{3}\epsilon),$$

where ϵ is the spherical excess of APB, viz., $s^2\sin\alpha\cos\alpha$ multiplied by the quantity whose logarithm is in the fourth column of the above table.

Irregularities of the Earth's Surface.

In considering the effect of unequal distribution of matter in the earth's crust on the form of the surface, we may simplify the matter by disregarding the considerations of rotation and eccentricity. In the first place, supposing the earth a sphere covered with a film of water, let the density ρ be a function of the distance from the centre so that surfaces of equal density are concentric spheres. Let now a disturbance of the arrangement of matter take place, so that the density is no longer to be expressed by ρ, a function of r only, but is expressed by $\rho + \rho'$, where ρ' is a function of three co-ordinates θ, ϕ, r. Then ρ' is the density of what may be designated disturbing matter; it is positive in some places and negative in others, and the whole quantity of matter whose density is ρ' is zero. The previously spherical surface of the sea of radius a now takes a new form. Let P be a point on the disturbed surface, P′ the corresponding point vertically below it on the undisturbed surface, PP′ $= u$. The knowledge of u over the whole surface gives us the form of the disturbed or actual surface of the sea; it is an equipotential surface, and if V be the potential at P of the disturbing matter ρ', M the mass of the earth,

$$\frac{M}{a+u} + V = C = \frac{M}{a} - \frac{M}{a^2}u + V\,.$$

As far as we know, u is always a very small quantity, and we have with sufficient approximation $u = \frac{3V}{4\pi\delta a}$, where δ is the mean density of the earth. Thus we have the disturbance in elevation of the sea-level expressed in terms of the potential of the disturbing matter. If at any point P the value of u remain constant when we pass to any adjacent point, then the actual surface is there parallel to the ideal spherical surface; as a rule, however, the normal at P is inclined to that at P′, and astronomical observations have shown that this inclination, amounting ordinarily to one or two seconds, may in some cases exceed 10, or, as at the foot of the Himalayas, even 30 seconds. By the expression "mathematical figure of the earth" we mean the surface of the sea produced in imagination so as to percolate the continents. We see then that the effect of the uneven distribution of matter in the crust of the earth is to produce small elevations and depressions on the mathematical surface which would be otherwise spheroidal. No geodesist can proceed far in his work without encountering the irregularities of the mathematical surface, and it is necessary that he know how they affect his astronomical observations. The whole of this subject is dealt with in his usual elegant manner by Bessel in the *Astronomische Nachrichten*, Nos. 329, 330, 331, in a paper entitled "Ueber den Einfluss der Unregelmässigkeiten der Figur der Erde auf geodätische Arbeiten, etc." But without entering into further details it is not difficult to see how local attraction at any station affects the determinations of latitude, longitude, and azimuth there.

Let there be at the station an attraction to the north-east throwing the zenith to the south-west, so that it takes in the celestial sphere a position Z′, its undisturbed position being Z. Let the rectangular components of the displacement ZZ′ be ξ measured southwards and η measured westwards. Now the great circle joining Z′ with the pole of the heavens P makes there an angle with the meridian $PZ = \eta \operatorname{cosec} PZ' = \eta \sec \phi$, where ϕ is the latitude of the station. Also this great circle meets the horizon in a point whose distance from the great circle PZ is $\eta \sec \phi \sin \phi = \eta \tan \phi$. That is, a meridian mark, fixed by observations of the pole star, will be placed that amount to the east of north. Hence the observed latitude requires the correction ξ; the observed longitude a correction $\eta \sec \phi$; and any observed azimuth a correction $\eta \tan \phi$. Here it is supposed that azimuths are measured from north by east, and longitudes eastwards.

The expression given for u enables one to form an approximate estimate of the effect of a compact mountain in raising the sea-level. Take, for instance, Ben Nevis, which contains about a couple of cubic miles; a simple calculation shows that the elevation produced would only amount to about three inches. In the case of a mountain mass like the Himalayas, stretching over some 1500 miles of country with a breadth of 300 and an average height of 3 miles, although it is difficult or impossible to find an expression for V, yet we may ascertain that an elevation amounting to several hundred feet may exist near their base. The geodetical operations, however, rather negative this idea, for it is shown in a paper in the *Philosophical Magazine* for August, 1878, by Colonel Clarke that the form of the sea-level along the Indian arc departs but slightly from that of the mean figure of the earth. If this be so, the action of the Himalayas must be counteracted by subterranean tenuity.

Suppose now that A, B, C, ... are the stations of a net-work of triangulation projected on or lying on a spheroid of semiaxis major and eccentricity a, e, this spheroid having its axis parallel to the axis of rotation of the earth, and its surface coinciding with the mathematical surface of the earth at A. Then basing the calculations on the observed elements at A, the calculated latitudes, longitudes, and directions of the meridian at the other points will be the true latitudes, etc., of the points as projected on the spheroid. On comparing these geodetic elements with the corresponding astronomical determinations, there will appear a system of differences which represent the inclinations, at the various points, of the actual irregular surface to the surface of the spheroid of reference. These differences will suggest two things—first, that we may improve the agreement of the two surfaces, by not restricting the spheroid of reference by the condition of making its surface coincide with the mathematical surface of the earth at A; and secondly, by altering the form and dimensions of the spheroid. With respect to the first circumstance, we may allow the spheroid two degrees of freedom, that is, the normals of the surfaces at A may be allowed to separate a small quantity, compounded of a meridional difference and a difference perpendicular to the same. Let the spheroid be so placed that its normal at A lies to the north of the normal to the earth's surface by the small quantity ξ and to the east by the quantity η. Then in starting the calculation of geodetic latitudes, longitudes, and azimuths from A, we must take, not the observed elements ϕ, α, but for ϕ, $\phi+\xi$, and for α, $\alpha+\eta \tan \phi$, and zero longitude must be replaced by $\eta \sec \phi$. At the same time suppose the elements of the spheroid to be altered from a, e to $a+da$, $e+de$. Confining our attention at first to the two points, A, B, let (ϕ'), (α'), (ω) be the numerical elements at B as obtained in the first calculation, viz., before the shifting and alteration of the spheroid; they will now take the form

$$\begin{aligned}
&(\phi') + f\xi + g\eta + h\,da + k\,de,\\
&(\alpha') + f'\xi + g'\eta + h'da + k'de,\\
&(\omega) + f''\xi + g''\eta + h''da + k''de,
\end{aligned}$$

where the coefficients f, g, . . . etc. can be numerically calculated. Now these elements, corresponding to the projection of B on the spheroid of reference, must be equal severally to the astronomically determined elements at B, corrected for the inclination of the surfaces there. If ξ', η' be the components of the inclination at that point, then we have

$$\begin{aligned}
\xi' &= (\phi') - \phi' + f\xi + g\eta + h\,da + k\,de,\\
\eta' \tan \phi' &= (\alpha') - \alpha' + f'\xi + g'\eta + h'da + k'de,\\
\eta' \sec \phi' &= (\omega) - \omega + f''\xi + g''\eta + h''da + k''de,
\end{aligned}$$

where ϕ', α', ω are the observed elements at B. Here it appears that the observation of longitude gives no additional information, but is available as a check upon the azimuthal observations.

If now there be a number of astronomical stations in the triangulation, and we form equations such as the above for each point, then we can from them determine those values of ξ, η, da, de, which make the quantity $\xi^2 + \eta^2 + \xi'^2 + \eta'^2 + \ . \ . \ . \ .$ a minimum. Thus we obtain that spheroid which best represents the surface covered by the triangulation.

In the *Account of the Principal Triangulation of Great Britain and Ireland* will be found the determination, from 75 equations, of the spheroid best representing the surface of the British Isles. Its elements are $a = 20927005 \pm 295$ feet, $b : a - b = 280 \pm 8$; and it is so placed that at Greenwich Observatory $\xi = 1''{\cdot}864$, $\eta = -0''{\cdot}546$.

Taking Durham Observatory as the origin, and the tangent plane to the surface (determined by $\xi = -0''{\cdot}664$, $\eta = -4''{\cdot}117$) as the plane of x and y, the former measured northwards, and z measured vertically downwards, the equation to the surface is

$$\begin{gathered}
{\cdot}99524953x^2 + {\cdot}99288005y^2 + {\cdot}99763052z^2\\
- 0{\cdot}00671003xz - 41655070z = 0.
\end{gathered}$$

Altitudes.

The precise determination of the altitude of his station is a matter of secondary importance to the geodesist; nevertheless it is usual to observe the zenith distances of all trigonometrical points. The height of a station does indeed influence the observation of terrestrial angles, for a vertical line at B does not lie generally in the vertical plane of A, but the error (which is very easily investigated) involved in the neglect of this consideration is much smaller than the errors of observation. Again, in rising to the height h above the surface, the centrifugal force is increased and the magnitude and direction of the attraction of the earth are altered, and the effect upon the observation of latitude is a very small error expressed by the formula $\frac{h}{a} \cdot \frac{g'-g}{g} \sin 2\phi$, where g, g' are the values of gravity at the equator and at the pole. This is also a quantity which may be neglected, since for ordinary mountain heights it amounts to only a few hundredths of a second.

The uncertainties of terrestrial refraction render it impossible to determine accurately by vertical angles the heights of distant points. Generally speaking, refraction is greatest at about daybreak; from that time it diminishes, being at a minimum for a couple of hours before and after mid-day; later in the afternoon it again increases. This at least is the general march of the phenomenon, but it is by no means regular. The vertical angles measured at the station on Hart Fell showed on one occasion in the month of September a refraction of double the average amount, lasting from 1 P.M. to 5 P.M. The mean value of the coefficient of refraction k determined from a very large number of observations of terrestrial zenith distances in Great

Britain is ·0792 ± ·0047; and if we separate those rays which for a considerable portion of their length cross the sea from those which do not, the former give $k = \cdot 0813$ and the latter $k = \cdot 0753$. These values are determined from high stations and long distances; when the distance is short, and the rays graze the ground, the amount of refraction is extremely uncertain and variable. A case is noted in the Indian Survey where the zenith distance of a station 10·5 miles off varied from a depression of 4′ 52″·6 at 4.30 P. M. to an elevation of 2′ 24″·0 at 10.50 P. M.

If h, h' be the heights above the level of the sea of two stations, $90° + \delta$, $90° + \delta'$ their mutual zenith distances (δ being that observed at h), s their distance apart, the earth being regarded as a sphere of radius $= a$, then, with sufficient precision.

$$h' - h = s \tan\left(s\frac{1-2k}{2a} - \delta\right),$$

$$h - h' = s \tan\left(s\frac{1-2k}{2a} - \delta'\right).$$

If from a station whose height is h the horizon of the sea be observed to have a zenith distance $90° + \delta$, then the above formula gives for h the value

$$h = \frac{a}{2} \cdot \frac{\tan^2\delta}{1-2k}.$$

Suppose the depression δ to be n minutes, then $h = 1{\cdot}054n^2$ if the ray be for the greater part of its length crossing the sea; if otherwise, $h = 1{\cdot}040n^2$. To take an example: the mean of eight observations of the zenith distance of the sea horizon at the top of Ben Nevis is 91° 4′ 48″, or $\delta = 64{\cdot}8$; the ray is pretty equally disposed over land and water, and hence $h = 1{\cdot}047n^2 = 4396$ feet. The actual height of the hill by spirit-levelling is 4406 feet, so that the error of the height thus obtained is only 10 feet.

Longitude.

The determination of the difference of longitude between two stations A and B resolves itself into the determination of the local time at each of the stations, and the comparison by signals of the clocks at A and B. Whenever telegraphic lines are available these comparisons are made by electro-telegraphy. A small and delicately-made apparatus introduced into the mechanism of an astronomical clock or chronometer breaks or closes by the action of the clock a galvanic circuit every second. In order to record the minutes as well as seconds, one second in each minute, namely that numbered 0 or 60, is omitted. The seconds are recorded on a chronograph, which consists of a cylinder revolving uniformly at the rate of one revolution per minute covered with white paper, on which a pen having a slow movement in the direction of the axis of the cylinder describes a continuous spiral. This pen is deflected through the agency of an electro-magnet every second, and thus the seconds of the clock are recorded on the chronograph by offsets from the spiral curve. An observer having his hand on a contact key in the same circuit can record in the same manner his observed times of transits of stars. The method of determination of difference of longitude is, therefore, virtually as follows. After the necessary observations for instrumental corrections, which are recorded only at the station of observation, the clock at A is put in connection with the circuit so as to write on both chronographs, namely, that at A and that at B. Then the clock at B is made to write on both chronographs. It is clear that by this double operation one can eliminate the effect of the small interval of time consumed in the transmission of signals, for the difference of longitude obtained from the one chronograph will be in excess by as much as that obtained from the other will be in defect. The determination of the personal errors of the observers in this delicate operation is a matter of the greatest importance, as therein lies probably the chief source of residual error.

Since the article FIGURE OF THE EARTH was written, considerable additions to the data for the determination of the semiaxes of the earth have been obtained from India, viz., a new meridian arc of 20°, the southern point of which is at Mangalore, together with several arcs of longitude, the longest of which, between Bombay and Nizagapatam, extends over 10° 30′. The effect of the accession of these new measures is to alter the figure previously given to the following: the semiaxes of the spheroid best representing the large arcs now available are

$$a = 20926202; \quad c = 20854895; \quad c : a = 292{\cdot}465 : 293{\cdot}465.$$

This value of the major semiaxis exceeds that previously given by 140 feet, whereas the new polar semiaxis is less than the old by 226 feet. If we admit that the figure may possibly be an ellipsoid (not of revolution), then the investigation leads us, through the solution of 51 equations, to these values of the semiaxes—

$$a = 20926629,$$
$$b = 20925105,$$
$$c = 20854407.$$

The greater axis of the equator lies in longitude 8° 15′ west of Greenwich, a meridian which, passing through Ireland and Portugal, cuts off a portion of the north-west corner of Africa, and in the opposite hemisphere cuts off the north-east corner of Asia. The apparent ellipticity of the equator is much reduced by the addition of the new data, and it would not be right to put too much confidence in the ellipsoidal figure until many more arcs of longitude shall have furnished the means of testing the theory more decisively than can be done at present. (See *Philosophical Magazine*, August, 1878.) (A. R. C.)

GEOFFREY OF MONMOUTH (1110?–1154), one of the most famous of the Latin chroniclers, was born at Monmouth early in the 12th century. Very little is known of his life. He became archdeacon of the church in Monmouth, and in 1152 was elected bishop of St. Asaph. He died in 1154. Three works have been attributed to him—the *Chronicon sive Historia Britonum*; a metrical *Life and Prophecies of Merlin*; and the *Compendium Gaufredi de Corpore Christi et Sacramento Eucharistiæ*. Of these the first only is genuine; internal evidence is fatal to the claims of the second; and the *Compendium* is known to be written by Geoffrey of Auxerre. The *Historia Britonum* appeared in 1147, and created a great sensation. Geoffrey professed that the work was a translation of a Breton work he had got from his friend Walter Calenius, archdeacon of Oxford. It is highly probable that the Breton work never existed. The plea of translation was a literary fiction extremely common among writers in the Middle Ages, and was adopted to give a mysterious importance to the communications of the author and to deepen the interest of his readers. We may compare with this Sir Walter Scott's professed quotations from "Old Plays," which he wrote as headings for chapters in his novels. If Geoffrey consulted a Breton book at all, it would probably be one of the Arthurian romances then popular in Armorica. His history is a work of genius and imagination, in which the story is told with a Defoe-like minuteness of detail very likely to impose on a credulous age. It is founded largely on the previous histories of Gildas and the so-called Nennius; and many of the legends are taken direct from Virgil. The history of Merlin, as embodied in the *Historia*, is found in Persian and Indian books. Geoffrey's imagination may have been greatly stimulated by local English legends, especially in the numerous stories he gives in support of his fanciful derivations of names of places. Whatever hints Geoffrey may have got from popular tales, and whatever materials he may have accumulated in the course of his reading, the *Historia* is to be thought of as largely his own creation and as forming a splendid poetical whole. Geoffrey, at all events, gave these stories their permanent place in literature. We have sufficient evidence to prove that in Wales the work was considered purely fabulous. (See *Giraldus Cambrensis, Itinerarium Cambriæ*, lib. i., c. 5, and *Cambriæ Descriptio*, c. vii.) And William of Newbury says "that fabler (Geoffrey) with his fables shall be straightway spat out by us all." Geoffrey's *Historia* was the basis of a host of other works. It was abridged by Alfred of Beverley (1150), and translated into Anglo-Norman verse, first by Geoffrey Gaimar (1154) and then by Wace (1180), whose work, *Li Romans de Brut*, contained a good deal of new matter. Early in the 13th century was published Layamon's *Brut*; and in 1278 appeared Robert of Gloucester's rhymed *Chronicle of England*. These two works, being written in English, would make the legends popular with the common people. The same influence continued to show itself in the works of Roger of Wendover (1237), Matthew Paris (1259), Bartholomew Cotton (1300?) Matthew of Westminster (1310), Peter Langtoft, Robert de Brunne, Ralph Higden, John Harding, Robert Fabyan (1512), Richard Grafton (1569), and Raphael Holinshed (1580), who is especially important as the immediate source of some of Shakespeare's dramas. A large part of the introduction of Milton's *History of England* consists of

Geoffrey's legends, which are not accepted by him as historical. The stories, thus preserved and handed down, have had an enormous influence on literature generally, but especially on English literature. They became familiar to the Continental nations; and they even appeared in Greek, and were known to the Arabs. With the exception of the translation of the Bible, probably no book has furnished so large an amount of literary material to English writers. The germ of the popular nursery tale, *Jack the Giant-Killer*, is to be found in the adventures of his Corineus, the companion of Brutus, who settled in Cornwall, and had a desperate fight with giants there. Goëmagot, one of these giants, is said to be the origin of Gog and Magog,—two effigies formerly exhibited on the Lord Mayor's day in London, which are referred to in several of the English dramatists, and still have their well-known representatives in the Guildhall of the city. Chaucer gives Geoffrey a place in his "House of Fame," where he mentions "Englyssh Gaunfride" (Geoffrey) as being "besye for to bere up Troye."

Meanwhile the Arthurian romances had assumed a unique place in literature. The Arthur of later poetry is a grand ideal personage, seemingly unconnected with either space or time, and performing feats of extraordinary and superhuman valor. The real Arthur—if his historical existence is to be conceded—was most probably a Cumbrian or Strathclyde Briton; and Geoffrey is responsible for the blunder of transferring him to South Wales. So intimately is Geoffrey connected with Arthur's celebrity, that he is often called Galfridus Arturus. Although the wondrous cycle of Arthurian romances scarcely originated with Geoffrey, he made the existing legends radiant with poetic coloring. They thus became the common property of Europe; and after being modified by the trouvères in France, the minnesingers in Germany, and by such writers as Gaimar, Wace, Mapes, Robert de Borron, Luces de Gast, and Hélie de Borron, they were converted into a magnificent prose poem by Sir Thomas Malory, in 1461. Malory's *Morte Darthur*, printed by Caxton in 1485, is as truly *the* epic of the English mind as the *Iliad* is the epic of the Greek mind.

The first English tragedy, *Gorboduc, or Ferrex and Porrex* (1565), which was written mainly by Sackville, is founded on the *Historia Britonum*. John Higgins, in *The Mirror for Magistrates* (1587), borrows largely from the old legends. This work was extremely popular in the Elizabethan period, and furnished dramatists with plots for their plays. Spenser's *Faërie Queene* is saturated with the ancient myths; and, in his *Arthur*, the poet gives us a noble spiritual conception of the character. In the tenth canto of Book ii. there is—

> "A chronicle of Briton kings,
> From Brut to Uther's rayne."

Warner's lengthy poem entitled *Albion's England* (1586) is full of legendary British history. Drayton's *Polyolbion* (1613) is largely made up of stories from Geoffrey, beginning with *Britain-founding Brute.* Geoffrey's good faith and historic accuracy are warmly contended for by Drayton, in Song x. of his work.

In Shakespeare's time Geoffrey's legends were still implicitly believed by the great mass of the people, and were appealed to as historical documents by so great a lawyer as Sir Edward Coke. They had also figured largely in the disputes between the Edwards and Scotland. William Camden was the first to prove satisfactorily that the *Historia* was a romance. Shakespeare's *King Lear* was preceded by an earlier play entitled *The Chronicle History of King Lear and his Three Daughters, Gonorill, Ragan, and Cordelia, as it hath been divers and sundry times lately acted.* Shakespeare's immediate authority was Holinshed; but the later chronicles, in so far as they were legendary, were derived from Geoffrey. The story of *Cymbeline* is another illustration of the fascination these legends exercised over Shakespeare. An early play, ascribed by some to Shakespeare, on *Locrine*, Brutus's eldest son, is a further example of how the dramatists ransacked Geoffrey's stores. The *Historia* was a favorite book with Milton; and he once thought of writing a long poem on King Arthur, whose qualities he would probably have idealized, as Spenser has done, but with still greater moral grandeur. In addition to the evidence afforded by the introduction to his *History of England*, Milton shows in many ways that he was profoundly indebted to early legendary history. His exquisite conception of Sabrina, in *Comus*, is an instance of how the original legends were not only appropriated but ennobled by many of our writers. In his Latin poems, too, there are some interesting passages pertinent to the subject.

Dryden once intended to write an epic on Arthur's exploits; and Pope planned an epic on Brutus. Mason's *Caractacus* bears witness to Geoffrey's charm for poetic minds. Wordsworth has embalmed the beautiful legend of *Pious Elidure* in his own magic verse. In chapter xxxvi. of the *Pickwick Papers* Dickens gives what he calls "The True Legend of Prince Bladud," which is stamped throughout with the impress of the author's peculiar genius, and lit up with his sunny humor. Alexander Smith has a poem treating of *Edwin of Deira*, who figures towards the close of Geoffrey's history. And Tennyson's *Idylls of the King* furnish the most illustrious example of Geoffrey's influence; although the poet takes his stories, in the first instance, from Malory's *Morte Darthur.* The influence the legends have had in causing other legends to spring up and in creating a love for narrative, is simply incalculable. In this way Geoffrey was really, for Englishmen, the inventor of a new literary form, which is represented by the romances and novels of later times.

There are several MSS. of Geoffrey's work in the old Royal Library of the British Museum, of which one formerly belonging to Margan Abbey is considered the best. The titles of the various editions of Geoffrey are given in Wright's *Biog. Brit. Lit.*, in the volume devoted to the Anglo-Norman period, which also contains an excellent notice of Geoffrey. The work compiled by Bale and Pits gives a mythical literary history, corresponding to Geoffrey's mythical political history. Of the *Life and Prophecies of Merlin*, falsely attributed to Geoffrey, 42 copies were printed for the Roxburghe Club in 1830. The *Historia* was translated into English by Aaron Thompson (London, 1718); and a revised edition was issued by Dr. Giles (London, 1842), which is to be found in the volume entitled *Six Old English Chronicles* in Bohn's Antiquarian Library. A discussion of Geoffrey's literary influence is given in "Legends of Pre-Roman Britain," an article in the *Dublin University Magazine* for April, 1876. The latest instance of the interest in Geoffrey is the publication of the following work:—*Der Münchener Brut Gottfried von Monmouth in französ. Versen des zwölften Jahrhunderts*, herausgeg. von R. Hofmann und K. Vollmöller, Halle, 1877.

For further information about Geoffrey, consult Warton's *English Poetry;* Morley's *English Writers;* Skene's *Four Ancient Books of Wales;* and a valuable paper on "Geoffrey of Monmouth's History of the Britons," in the 1st vol. of Mr. Thomas Wright's *Essays on Archæological Subjects* (London, 1861). (T. GI.)

GEOFFROY SAINT-HILAIRE, ÉTIENNE (1772–1844), a celebrated French naturalist, was the son of Jean Gérard Geoffroy, procurator and magistrate of Étampes, Seine-et-Oise, where he was born, April 15, 1772. His early education was carefully superintended by his mother and paternal grandmother, and when still a boy he had already become acquainted with the masterpieces of the literature of the ancients, and of the age of Louis XIV. Destined by his friends for the church, he entered, as an exhibitioner, the college of Navarre, in Paris, where he studied natural philosophy under Brisson; and in 1788 he obtained one of the canonicates of the chapter of Sainte Croix at Étampes, and also a benefice. Science, however, offered to him a career more congenial to his tastes than that of an ecclesiastic, and, after some persuasion, he gained from his father permission to remain in Paris, and to attend the lectures at the Collége de France and the Jardin des Plantes, on the condition that he should likewise read law. He accordingly took up his residence at Cardinal Lemoine's college, and there became the pupil and soon the esteemed associate of Brisson's friend, Haüy, the eminent mineralogist, under whose guiding influence his passion for the natural sciences daily deepened. Having, before the close of the year 1790, taken the degree of bachelor in law, he became a student of medicine, but the lectures of Fourcroy at the Jardin des Plantes, and of Daubenton at the Collége de France, and his favorite scientific pursuits gradually came to occupy his almost exclusive attention. His studies at Paris were at length suddenly interrupted, for, on the 12th or 13th of August, 1792, Haüy and the other professors of Lemoine's college, as also those of the college of Navarre, were arrested by the revolutionists as priests, and confined in the prison of St. Firmin. Through Daubenton and other persons of distinction with whom he was acquainted, Geoffroy on the 14th August obtained an order for the release of Haüy in the name of the Academy; still the other professors of the two colleges, save Lhomond who had been rescued by his pupil Tallien, remained in confinement. Geoffroy, foreseeing their certain destruction if they remained in the hands of the revolutionists, determined if possible to secure their liberty by stratagem. By bribing one of the officials at St. Firmin, and disguising himself as a commissioner of prisons, he gained admission to his friends, and entreated them to effect their escape by following him. All, however, dreading lest their deliverance should render the doom of their fellow-captives the more certain, refused the offer, and one priest only, who was unknown to Geoffroy, left the prison. Already on the night of the 2d of September the massacre of the proscribed had begun, when Geoffroy, yet intent on saving the life of his friends and teachers, repaired to St. Firmin. At 4 o'clock on the morning of the 3d Sept., after 8 hours' waiting, he by means of a ladder assisted the escape of twelve ecclesiastics, not of the number of his acquaintance, and then the approach of dawn and the discharge of a gun directed at him warned him, his chief purpose unaccomplished, to return to his lodgings. Leaving Paris he retired to Étampes, where, in consequence of the anxieties of which he had lately been the prey, and the horrors which he had witnessed, he was for some time seriously ill. At the beginning of the winter of 1792 he returned to his studies in Paris, and in March of the following year Daubenton, through the interest of Bernardin de Saint Pierre, procured him the office of sub-keeper and assistant demonstrator of the cabinet of natural history, vacant by the resignation of Lacépède. By a law passed June 10th, 1793, Geoffroy was appointed one of the twelve professors of the newly constituted museum of natural history, being assigned the chair of zoology. In the same year he busied himself with the formation of a menagerie at that institution. On the 6th May, 1794, commenced his opening course of lectures, and on December 1st he read to the society of natural history his first paper, on the subject of the Aye-aye. It was in 1794, also, that through the introduction of Tessier he entered into correspondence with Georges Cuvier, to whom, after the perusal of some of his manuscripts, he wrote: "Venez jouer parmi nous le rôle de Linné, d'un autre législateur de l'histoire naturelle." Shortly after the appointment of Cuvier as Mertrud's assistant (see vol. vi. p. 653), Geoffroy received him into his house. The two friends wrote together five memoirs on natural history, one of which, on the classification of mammals, puts forward the idea of the subordination of characters upon which Cuvier based his zoological system. It was in a paper entitled "Histoire des Makis, ou singes de Madagascar," written in 1795, that Geoffroy first gave expression to his views on "the unity of organic composition," the influence of which is perceptible in all his subsequent writings: nature, he observes, presents us with only one plan of construction, the same in principle, but varied in its accessory parts.

In 1798 Geoffroy was chosen a member of the great scientific expedition to Egypt. With Delile and Larrey, on the capitulation of Alexandria in August, 1801, he resisted the claim made by the British general Hutchinson to the collections of the expedition, sending him word that, were his demand persisted in, history would have to record of him that he also had burnt a library in Alexandria. Early in January, 1802, Geoffroy returned to his accustomed labors in Paris. He was elected a member of the academy of sciences of that city in September, 1807. In March of the following year the emperor, who had already recognized his national services by the award of the cross of the legion of honor, selected him to visit the museums of Portugal, for the purpose of procuring from them collections, and these, though in the face of considerable opposition from the British, he eventually was successful in retaining as a permanent possession for his country. In 1809, the year after his return to France, he was made professor of zoology of the faculty of sciences at Paris, and from that period he devoted himself more exclusively than before to the study of anatomical philosophy. In 1815 he was elected political representative for his native town. Three years later he gave to the world the first part of his celebrated *Philosophie Anatomique*, the second volume of which, published in 1822, and memoirs subsequently written account for the formation of monstrosities on the principle of arrest of development, and of the attraction of similar parts. When, in 1830, Geoffroy proceeded to apply to the invertebrata his views as to the unity of animal composition, he found a vigorous opponent in Georges Cuvier, and the discussion between them, continued up to the time of the death of the latter, soon attracted the attention of the scientific throughout Europe. Geoffroy, a synthesist, contended, in accordance with his theory of unity of plan in organic composition, that all animals are formed of the same elements, in the same number, and with the same connections: homologous parts, however they differ in form and size, must remain associated in the same invariable order. With Goethe he held that there is in nature a law of compensation or balancing of growth, so that if one organ take on an excess of development, it is at the expense of some other part (*cf.* Darwin, *Origin of Species*, 5th ed., p. 182); and he maintained that, since nature takes no sudden leaps, even organs which are superfluous in any given species, if they have played an important part in other species of the same family, are retained as rudiments, which testify to the permanence of the general plan of creation. It was his conviction that, owing to the conditions of life, the same forms had not been perpetuated since the origin of all things, although it was not his belief that existing species are becoming modified (see Darwin, *op. cit.*, p. xvi.). Cuvier, who was an analytical observer of facts, admitted only the prevalence of "laws of coexistence" or "harmony" in animal organs, and maintained the absolute invariability of species, which he declared had been created with a regard to the circumstances in which they were placed, each organ contrived with a view to the function it had to fulfil, thus putting, in Geoffroy's consideration, the effect for the cause. In July, 1840, Geoffroy became blind, and some months later he had a paralytic attack. From that time his strength gradually failed him. He resigned his chair at the museum in 1841, and on the 19th June, 1844, at the age of 72, he died.

Geoffroy wrote—*Catalogue des Mammifères du Muséum national d'Histoire naturelle*, 1813, not quite completed; *Philosophie anatomique*,—t. i., *Des organes respiratoires*, 1818, & t. ii., *Des Monstruosités humaines*, 1822; *Système dentaire des Mammifères et des Oiseaux*, 1st pt., 1824; *Sur le Principe de l'Unité de Composition organique*, 1828; *Cours de l'Histoire naturelle des Mammifères*, 1829; *Principes de Philosophie zoologique*, 1830; *Études progressives d'un Naturaliste*, 1835; *Fragments biographiques*, 1838; *Notions synthétiques, historiques, et physiologiques de Philosophie naturelle*, 1838; and other works; also part of the *Description de l'Égypte par la Commission des Sciences*, 1821–30; and, with F. Cuvier, *Histoire naturelle des Mammifères*, 4 vols., 1820–42; besides very numerous papers published in the *Annales du Muséum*, the *Ann. des Sci. nat.*, the *Bulletin philomatique, La Décade égyptienne, La Décade philosophique*, the *Rev. encyclopédique*, *Mém. de l'Acad. des Sciences*, and elsewhere, among the subjects of which are the anatomy of marsupials, ruminants, and electrical fishes, the vertebrate theory of the skull, the opercula of fishes, teratology, palæontology, and the influence of surrounding conditions in modifying animal forms.

See *Vie, Travaux, et Doctrine Scientifique d'Étienne Geoffroy Saint-Hilaire, par son fils M. Isidore Geoffroy Saint-Hilaire*, Paris and Strasburg, 1847, to which is appended a list of Geoffroy's works; and Joly, in *Biog. Universelle*, t. xvi., 1856. (F. H. B.)

GEOFFROY SAINT-HILAIRE, Isidore (1805–61), a French zoologist, son of the preceding, was born at the Jardin des Plantes, Paris, December 16, 1805. In his earlier years he showed an aptitude for mathematics, but eventually he devoted himself to the study of natural history and of medicine, and in 1824 he was appointed assistant naturalist to his father. On the occasion of his taking the degree of doctor of medicine, September 8, 1829, he read a thesis entitled *Propositions sur la monstruosité, considérée chez l'homme et les animaux;* and in 1832–37 was published his great teratological work, *Histoire générale et particulière des anomalies de l'organisation chez l'homme et les animaux*, 3 vols. 8vo, with 20 plates. In 1829 he delivered for his father the second part of a course of lectures on ornithology, and during the three following years he taught zoology at the Athénée, and teratology at the École pratique. He was elected a member at the academy of sciences at Paris on April 15, 1833, was in 1837 appointed to act as deputy for his father at the faculty of sciences in Paris; and in the following year was sent to Bordeaux to organize a similar faculty there. He became successively inspector of the academy of Paris (1840), professor of the museum on the retirement of his father, inspector general of the university (1844), a member of the royal council for public instruction (1845), and, on the death of Blainville, professor of zoology at the faculty of sciences (1850). In 1854 he founded the Acclimatization Society of Paris, of which he was president. He died at Paris, November 10, 1861.

Besides the above-mentioned works, he wrote—*Essais de Zoologie générale*, 1841; *Vie . . . d'Étienne Geoffroy Saint-Hilaire*, 1847; *Acclimatation et Domestication des Animaux utiles*, 1849, 4th ed., 1861; *Lettres sur les substances alimentaires et particulièrement sur la viande de cheval*, 1856; and *Histoire naturelle générale des règnes organiques*, 3 vols., 1854–62, which was not completed, chap. xx. of tome iii. being unfinished. He was the author also of various papers on zoology, comparative anatomy, and palæontology, published for the most part in the *Annales du Muséum*, the *Mémoires des Savants étrangers*, the *Comptes rendus*, and the *Dict. des Sciences naturelles*.

GEOGRAPHY. *Introduction.*—Geography is the science which describes the earth, the term being derived from two Greek words γῆ, the earth, and γράφω, to write. By means of geography the surface of the earth is delineated and described, boundaries are defined, areas are exactly measured, and the relative positions of places are determined. Geography thus embraces a wide range of subjects, and it has been found necessary to divide its study into several distinct sections.

I. Comparative Geography traces the history of discovery, and records the changes which have taken place in land and sea in historic times.

II. Mathematical Geography explains the figure, magnitude, and motion of the earth, teaches how to determine the positions of places on its surface, and shows how the whole or any portion of the earth may, on the principles of projection, be delineated on a map or chart.

III. Physical Geography is the description of the actual state of the earth's surface in its three great divisions—land, sea, and air.

IV. Political Geography describes the earth as divided into countries, occupied by various nations, and improved by human art and industry.

The following article is limited to a view of the progress of geographical discovery, an explanation of the principles of mathematical geography, and a synopsis of physical geography. For details relating to political geography the reader must consult the descriptive articles under their particular headings.

I. View of the Progess of Geographical Discovery.

Four main causes have led to geographical discovery and exploration, namely, commercial intercourse between different countries, the operations of war, pilgrimages and missionary zeal, and in later times the pursuit of knowledge for its own sake, which is the highest of all motives.

Phœnicians.

The Phœnicians are the earliest commercial people of whose discoveries we have any correct accounts. They first explored the shores of the Mediterranean, and eventually extended their voyages through the Straits of Gibraltar, and visited the western shores of Spain and Africa, planting colonies and opening wider fields for their commerce by instructing the natives in their arts and improvements. They also monopolized the trade with India; and their chief emporium, the rich city of Tyre, was the centre whence the products of the East and West were distributed. The trade of the West was brought from the port called Tarshish in Scripture, which is probably identical with Carthage, where the ships arrived from Spain, Africa, and distant Britain. Concerning the far eastern land reached by the Phœnicians, called Ophir in Scripture, there has been much dispute. The voyage to Ophir, we are told, occupied three years thither and homeward, and the cargo consisted of gold, ivory, apes, peacocks, and "algum" wood (1 Kings ix. 26, and x. 11). The following reasons lead to the conclusion that Ophir was the Malabar coast of India. In the Hebrew the word for apes is *koph* (without any etymology in Semitic tongues), in Sanskrit *kafi*. Ivory in Hebrew is *shen-habbim;* in Sanskrit *ibha* is an elephant. Peacocks is in Hebrew *tokki-im* from *togei*, the name still used on the Malabar coast, derived from the Sanskrit. Algum wood, or almug, is corrupted from *valgu* (ka), sandal wood from Malabar. Thus the Phœnicians were the first great carriers of the ancient world, extending their commercial operations from their central mart of Tyre on the Syrian coast to the tin-yielding isles of the Cassiterides in the far west, and to the ports of India in the east.

Carthage.

The great Phœnician colony of Carthage retained in full vigor the commercial spirit of the parent state. The Carthaginians traded on the coasts of Spain and Gaul, and extended their discoveries southwards along the coast of Africa, and to the Fortunate Islands, now known as the Canaries. Herodotus relates how the Phœnicians, setting sail from the Red Sea, made their way to the south, and when autumn approached they drew their vessels to land, sowed a crop, and waited till it was grown, when they reaped it and again put to sea. Having spent two years in this manner, in the third year they reached the pillars of Hercules and returned to Egypt. But the most celebrated voyage of antiquity, undertaken for the purpose of discovery, was the expedition under Hanno, fitted out by the senate of Carthage with the view of attempting the complete survey of the western coast of Africa. Hanno is said, in the *Periplus Hannonis*, to have set sail with a fleet of 60 vessels, and the extent of his voyage has been variously estimated as reaching to the river Nun, to a little beyond Sierra Leone, and even as far as the Gulf of Benin. Another famous navigator, who sailed from the Carthaginian colony of Massilia (Marseilles) in about 320 B. C., was Pytheas. He steered northwards along the coasts of Spain and Gaul, sailed round the island of Albion, and stretching still further to the north, he discovered an island known to the ancients as *Ultima Thule*, which may possibly have been the Shetland Isles.

Alexander the Great.

The conquests of Alexander the Great, by making known the vast empire of Persia, materially enlarged the bounds of geographical knowledge. Although the course of his expedition was mainly by land, the mind of the conqueror was also intent on commerce and maritime discovery. In 327 B. C. Alexander led an army of Greeks down the valley of the Cabul river into the Punjab, and his expedition resulted in a voyage of discovery from the mouth of the Indus to that of the Tigris, and in opening direct intercourse between Grecian and Hindu civilization. The Greeks who accompanied Alexander were accurate observers, and described the towns and villages, the products and the aspect of the country, with care. The conqueror resolved to return through Gedrosia (the modern Baluchistan), but he also intended to open the trade by sea between Europe and India, and his general Nearchus, a native of Crete, volunteered to lead this famous voyage of discovery. His fleet consisted of 30 galleys containing 2000 men. On October 2, 326 B. C., the fleet of Nearchus left the Indus, and the anchorages each night are carefully recorded. On the 17th of December Cape Jask was doubled and the fleet entered the Persian Gulf, and on the 9th of February it was at the mouth of the Karún. Nearchus rejoined Alexander at Susa; and the conqueror himself embarked in the fleet and ascended the Tigris to Opis, above Baghdad. He then ordered his successful admiral to prepare another expedition for the circumnavigation of Arabia; but unfortunately the great conqueror died at Babylon in 324 B. C., and the fleet was dispersed.

The dynasties founded by Alexander's generals, Seleucus, Antiochus, and Ptolemy, encouraged the same spirit of enterprise which their master had so carefully fostered, and extended geographical knowledge in several directions. Seleucus Nicator established the Greco-Bactrian empire, and continued the intercourse with India. The most authentic information respecting the Gangetic valley was supplied by Megasthenes, an ambassador sent by Seleucus, who reached the remote city of Patali-putra, the modern Patna, on the Ganges.

Ptolemies.

The Ptolemies of Egypt showed equal anxiety to extend the bounds of geographical knowledge. Ptolemy Euergetes sent an expedition which discovered Abyssinia, and fitted out a fleet under Eudoxus to explore the Arabian sea. After two successful voyages, Eudoxus left the Egyptian service, and proceeded to Cadiz with the object of fitting out an expedition for the purpose of African discovery; and we learn from Strabo that the veteran explorer made at least two voyages southward along the coast of Africa. The Ptolemies sent fleets annually from their Red Sea ports of Berenice and Myos Hormus to Arabia, as well as to ports on the coasts of Africa and India.

Romans.

The Romans did not encourage navigation and commerce with the same ardor as their predecessors; still the luxury of Rome, which gave rise to demands for the varied products of all the countries of the known world, led to an active trade both by ships and caravans. But it was the military genius of Rome, and the ambition for universal empire, which led not only to the discovery but also to the survey of nearly all Europe, and of large tracts in Asia and Africa. Every new war produced a new survey and itinerary of the countries which were conquered. In the height of their power the Romans had surveyed and explored all the coasts of the Mediterranean, Italy, Greece, the Balkan peninsula, Spain, Gaul, western Germany, and Britain; but the eastern parts of Germany, Denmark, Sweden, and Russia were still unknown regions. In Africa their empire included Egypt, Carthage, Numidia, and Mauritania. In Asia they held Asia Minor and Syria, had sent expeditions into Arabia, and were acquainted with the more distant countries formerly overrun by Alexander, namely, Persia, Scythia, Bactria, and India. Roman intercourse with India especially led to the extension of geographical knowledge.

The first Roman who undertook a journey to India was solely influenced by the desire to acquire a knowledge of the people and their doctrines. This was Apollonius, a resident at Antioch, who set out towards the close of the first half century of our era. He and his attendants, Damis and Philostratus, reached the Indus, and journeying across the Punjab, came to a bronze pillar with the inscription "Here Alexander halted;" but it is doubtful whether the party advanced as far the Ganges. It was, however, in the reigns of Severus and his immediate successors that Roman intercourse with India was at its height.

Attempts at systematizing.

In all time, while warriors and explorers extended the area of geographical knowledge, there have been students who have striven to systematize and put into due form the accumulated information. From the first it was perceived that a knowledge of localities could not be attained without some notion of their relative positions, and their distances from each other. Consequently the attempts to establish fixed principles on which the surface of the earth, or any portion of it, could be delineated, were almost coeval with the earliest voyages of discovery.

The first attempt made to determine the position of places appears to have depended on the division of the earth into "climates," distinguished by the species of animals and plants produced in each. This method, however, was soon abandoned for another, which consisted in observing at places the length of the longest and shortest days by means of a "gnomon." An upright pillar of a known height being erected on a level pavement, by observing the lengths of the meridian shadows the progress of the sun from tropic to tropic was traced. The most ancient observation with the gnomon is that of Pytheas, in the days of Alexander the Great, who observed at the summer solstice at Massilia that the length of the meridian shadow was to the height of the gnomon as 213⅛ to 600, an observation which makes the meridian altitude of the sun at Marseilles on that day 70° 27′. The merit of the invention of the gnomon in Greece is ascribed to the astronomical school of Miletus; but there is reason to believe that this method of observation was invented in Egypt, and that Thales carried the knowledge of it into Greece. This was the first step towards connecting geography with astronomy; and little further advance was made until the establishment of the famous astronomical school of Alexandria.

Eratosthenes.

Eratosthenes (276–196 B. C.) was the first who reduced geography to a regular system, and laid its foundations on clear and solid principles. Under the patronage of the Ptolemies he had access to all the materials collected by Alexander and his generals. The doctrine of the sphericity of the earth had by this time been adopted, and the aim of his labors was to delineate, in conformity with this principle, the known parts of the earth's surface. Founding his system on the use of the gnomon, he supposed a line to be traced through certain places, in all of which the longest day was known to be exactly of the same length. Such a line would evidently be a parallel to the equator. This first parallel passed through Rhodes, and was ever afterwards adopted as the basis of ancient maps. Eratosthenes continued his work by tracing other parallels at certain intervals from the first, one through Alexandria another through Syene, a third through Meroe. He also traced, at right angles to these, a meridian passing through Rhodes and Alexandria, southwards to Syene and Meroe. As the progress which he thus made towards the completion of what he had so skilfully conceived naturally tended to enlarge his ideas concerning geographical science, he attempted next to determine the circumference of the globe by the actual measurement of a segment of one of its great circles. Posidonius made another measurement of an arc of the meridian between Rhodes and Alexandria about 170 years afterwards; but the amount of error in the calculations of Eratosthenes and Posidonius is uncertain, for want of a knowledge of the true length of the stadium in which their results are expressed. The ancients made their first meridian at the sacred promontory of Iberia, and their longitudinal error increased rapidly as they advanced eastwards. This is no doubt due to their longitudes being based entirely on distances calculated in the itineraries of travellers. Such data of course produced very great distortions in the representations given of the countries on the surface of the globe.

Posidonius.

Hipparchus.

The improvements introduced by Eratosthenes were perfected in principle by Hipparchus, who flourished from 160 to 135 B. C. He was the first astronomer who undertook the arduous task of making a catalogue of the stars and fixing their relative positions. His object was to transmit to posterity a knowledge of the state of the heavens at the period of his observations. The extremities of the imaginary axis round which the heavens perform their diurnal revolutions suggest two fixed points by which the position of the great circle of the celestial sphere, called the celestial equator, is determined. If a great circle be supposed to pass through these points and any star, the position of the star will be ascertained if we measure in degrees and parts of a degree the arc of the meridian circle intercepted between the star and the equator, and also the arc of the equator intercepted between a given point in it and the meridian circle passing through the star. Upon this principle Hipparchus arranged the stars according to their places in the heavens; and the great improvement which he introduced into geography consisted in this, that he applied to the determining of the position of any point on the surface of the earth the same rule which he had introduced in the arrangement of the constellations. Thus he furnished the means of ascertaining the relative positions of places with far greater accuracy than could be obtained from itinerary measurements. He made a considerable number of observations for latitude, and pointed out how longitudes might be determined by observing the eclipses of the sun and moon.

Ptolemy.

The most ancient maps that have reached modern times are those which illustrate Ptolemy's geography, but an earlier map made for Aristagoras, king of Miletus (500 B. C.), is minutely described by Herodotus. Ptolemy composed his system of geography in the reign of Antoninus Pius, about 150 A. D. His materials consisted of all the itineraries prepared by the Romans, proportions of the height of the gnomon and its shadow at the time of the equinoxes and solstices taken by different astronomers, calculations founded on the length of the longest days, and various reports of travellers and navigators. Ptolemy undertook the task of comparing and reducing this mass of crude material into one system, following the principles laid down by Hipparchus, but which had been neglected during the two centuries and a half since his time, even by such men as Strabo and Pliny. In Ptolemy's work we find for the first time the mathematical principle of the construction of maps, as well as of several projections of the sphere.

The errors of Ptolemy arose from defective information, and the want in many instances, and especially as regards the remote parts of the then known world, of astronomical observations. He adopted the measure of a degree at 500 stadia; and the latitudes along the chief parallel of Rhodes, as first laid down by Eratosthenes, are tolerably correct. But the elements for determining the longitudes were still derived from itineraries, and errors in latitude accumulated to the north and south of the central parallel.

Strabo.

Pliny.

Although Ptolemy was the first scientific geographer whose work has come down to us in a complete form, the earlier labors of Strabo, who lived in the reigns of Augustus and Tiberius, are of equal value, and we fortunately possess the whole of his 17 books. Pliny also devoted two books of his extensive work to geography; and the scattered geographical notices of other ancient writers were collected into one work of four volumes by Hudson, and published between 1698 and 1712, with notes by Dodwell. From the days of Ptolemy to the revival of letters in Europe, little was done towards the scientific improvement of geographical science, though military and commercial enterprise led to a great extension of knowledge of the earth's surface.

Cosmas.

After the dissolution of the Roman empire, Constantinople became the last refuge of arts, taste, and elegance; while Alexandria continued to be the emporium whence were imported the commodities of the East. The emperor Justinian sent two Nestorian monks to China, who returned with eggs of the silkworm concealed in a hollow cane, and thus silk manufactures were established in the Peloponnesus and the Greek Islands. It was also in the reign of Justinian that Cosmas Indicopleustes, an Egyptian merchant, made several voyages, and afterwards composed his *Topographia Christiana*, containing a particular description of India. The great outburst of Mahometan conquest was followed by an Arabian civilization, having its centres at Cordova and Baghdad, in connection with which geography again received a share of attention.

Mahometan travellers.

From the 9th to the 13th century intelligent Mahometan travellers wrote accounts of what they had seen and heard in distant lands, which have been handed down to us; while the caliphs of Baghdad encouraged the study of geographical science.

The caliph Al-Mamûn, the worthy son and successor of Hârûn er-Rashîd, caused an Arabic version of Ptolemy's great astronomical work (*Σύνταξις μεγίστη*) to be made, which is known as the *Almagest*, the word being nothing more than the Greek *μεγίστη* with the Arabic article *al* prefixed. The geography of Ptolemy is also constantly referred to by Arab writers. The learned men under Al-Mamûn began to apply themselves to astronomy in 813 A. D., following the system of Ptolemy; and the first observations that are properly their own were made by El-Báthany in Mesopotamia, of the vernal and autumnal equinoxes, in 882 A. D. The Arab astronomers also measured a degree on the plains of Mesopotamia, and Ibn Yûnus observed three eclipses at Cairo. The caliph's librarian, Abu Jafar Muhammad Ben Musa, wrote a geographical work, now unfortunately lost, entitled *Rasm el Arsi* ("A Description of the World"), which is often referred to by subsequent writers as having been composed on the model of that of Ptolemy.

The earliest Arabian traveller whose observations have come down to us is the merchant Sulaiman, who embarked in the Persian Gulf and made several voyages to India and China, in the middle of the 9th century. Sulaiman's information was supplemented by that collected by another writer named Abu Zaid; and, so far as India is concerned, this work is the most important that we possess before the grand epoch of the discoveries of Marco Polo. Next to Sulaiman followed the voyages of Sindbad the Sailor, whose narrative, though inserted in the *Arabian Nights*, also forms a distinct and separate work, which was translated into French by M. Langlès in 1814. Baron Walckenaer ascribes to the voyages of Sindbad a date about coincident with those of Sulaiman. Ibn Khurdadra, a fire-worshipper converted to Islam, who died in 912 A. D., also wrote an account of India. Al Masudi, a great traveller who knew all the countries between Spain and China, described the plains, mountains, and seas, the dynasties and peoples, in his *Murúju-l Zahab* ("Meadows of Gold"). He died in 956. His contemporaries were Al Istakhri, who travelled through all the Mahometan countries, and wrote his *Book of Climates* in 950, and Ibn Haukal, whose *Book of Roads and Kingdoms* was written in 976. Al Idrisi was born at Ceuta, and after travelling far and wide, settled in Sicily, where he was induced by Roger II., the Norman king, to write his book on geography, the full title of which is *The Delight of those who seek to wander through the Regions of the World.* Finally Al Kazwíní, who was a compiler from the works of Istakhri and Ibn Haukal in about 1263, brings us down to the times when the Italian explorers began to make known the vast realms of Asia to the people of Europe.

Mongol tables.

The Mongol and Turkish dynasties, which succeeded each other after the fall of the Arabian caliphs, also produced rulers who encouraged geographical science. Philosophers assembled at the court of Hulaku Khan (1253–1264) at Maraghah in the north of Persia; and his friend Nâsiru-'d-Dîn was the most famous astronomer of the age. He constructed the tables known as the Tables of the Ilkhany, which corrected some important errors in the former mode of adjusting the commencement of the new year. Nearly two centuries later, in 1446, Ulugh Begh, of the house of Timur, succeeded to the throne of Samarkand, and under his auspices the famous tables called "Zij Ulugh Begh" were composed. They continued to be authorities for long afterwards, and even Kinneir, in determining the latitudes of places in Persia, often quotes the tables of Ulugh Begh.

Northmen.

The Northmen of Denmark and Norway, who were the terror of all the coasts of Europe, and who established themselves in England and Ireland, in France and Sicily, were also great promoters of geographical discovery during the darkest period of the Middle Ages. The Northmen were far from being always vikings, bent only on rapine and plunder. They were very often peaceful merchants. King Alfred sent Ulfsten and the Norwegian Ottar on voyages of discovery towards the White Sea; and the Scandinavian merchants brought the products of India to England and Ireland. From the 8th to the 11th century a commercial route from India passed through Kharism and Novgorod to the Baltic, and immense quantities of Arabian coins have been found in Sweden, and particularly in the island of Gothland, which are preserved at Stockholm. Five-sixths of them were from the mints of the Samanian dynasty, which reigned in Khorasan and Transoxiana from about 900 to 1000 A. D. It was the trade with the East that originally gave importance to the city of Visby in Gothland.

Early knowledge of America.

In the end of the 9th century Iceland was colonized from Norway; and in 985 the intrepid viking Erik, surnamed the Red, discovered Greenland, and induced some of his Icelandic countrymen to settle on its inhospitable shores. In 986 young Bjorni, son of one of Erik's comrades, sailed from Iceland to join his father in Greenland, but shaped his course too far to the south, and was the discoverer of America. He sailed along the coasts of Connecticut, Massachusetts, and Nova Scotia, before he eventually found the fjord on the Greenland coast where his father dwelt. Then Leif, the son of Erik, bought the ship from young Bjorni and made another voyage of discovery, and once more the coast of America was visited. Other expeditions were undertaken by his two brothers, intercourse was kept up between Greenland and Norway, and the saga of Thorfinn tells us of other voyages to America. The last that was heard of the Norwegian colonies in Greenland was in a brief of Pope Nicolas V. in 1448, where it is stated that, 30 years before, the settlements had been destroyed by the attacks of savages. Two noble Venetians, Nicolo and Antonio Zeno, who were in the service of the prince of the Faroe Islands in the end of the 13th century, recorded their observations respecting the Norse colonies. Antonio actually went to Greenland, and heard of the visits of fishermen to two parts of North America called Estotiland and Drogeo.

Crusades.

At length the long period of barbarism which accompanied and followed the fall of the Roman empire drew to a close in Europe. The crusades had a very favorable influence on the intellectual state of the Western nations. Interesting regions, known only by the scant reports of pilgrims, were made the objects of attention and research; while religious zeal, and the hope of gain, combined with motives of mere curiosity, induced several persons to travel by land into remote regions of the East, far beyond the countries to which the operations of the crusaders extended. Among these was Benjamin of Tudela, who set out from Spain in 1160, travelled by land to Constantinople, and having visited India and some of the eastern islands, returned to Europe by way of Egypt after an absence of 13 years.

Franciscan missionaries.

Christian missionary zeal was another motive for exploration. John of Plano Carpini in Perugia, a Franciscan monk, was the head of one of the missions despatched by Pope Innocent to call the chief and people of the Tatars to a better mind. He reached the headquarters of Batu, on the Volga, in February, 1246; and, after some stay, went on to the camp of the great khan near Karakorum, and returned safely in the autumn of 1247. A few years afterwards, a Fleming named Rubruquis was sent by St. Louis on a mission to the Tatar chiefs, and wrote a very interesting narrative. He entered the Black Sea in May, 1253, visited Batu and the court of the great khan Mangu near Karakorum, and got back to Antioch about the end of June, 1255. Rubruquis had the merit of being the first modern traveller who gave a correct account of the Caspian Sea. He ascertained that it had no outlet. At nearly the same time Hayton, king of Armenia, made a journey to Karakorum in 1254, by a route far to the north of that followed by Carpini and Rubruquis. He was treated with honor and hospitality, and returned by way of Otrar, Samarkand, and Tabriz, to his own territory, The curious narrative of king Hayton was translated by Klaproth.

Marco Polo.

While the republics of Italy, and above all the state of Venice, were engaged in distributing the jewels, the spices, and the fine cloths of India over the Western world, it was impossible that motives of curiosity, as well as a desire of commercial advantage, should not be awakened to such a degree as to impel some to brave all the obstacles and dangers to be encountered in visiting those remote countries. Among these were Nicolo and Maffeo Polo, two brothers who traded with the East and visited Tatary. The recital of their travels fired the youthful imagination of young Marco Polo, the son of Nicolo, and he set out for the court of Kublai Khan, with his father and uncle, in 1265. After a journey of three years and a half they reached Yeu-king, near the spot where Peking now stands, and young Marco was enrolled among the attendants of honor of the Grand Khan. During the seventeen years that he remained in this service, Marco Polo was employed on important missions; and besides what he learnt from his own observation, he collected from others much information concerning countries which he did not visit. He returned to Europe possessed of a vast store of knowledge respecting the eastern parts of the world, and, being afterwards made a prisoner by the Genoese, he dictated the narrative of his travels during his captivity. The work of Marco Polo is the most valuable narrative of travels that appeared during the Middle Ages, and its latest and ablest editor truly says, "All other travellers of that time are but stars of a low magnitude beside the full orb of Marco Polo."

Still these minor orbs continued to do useful geographical work, while striving to spread the truths of the Gospel. Among them were John of Monte Corvino, a Franciscan monk, Andrew of Perugia, John Marignioli, and Friar Jordanus, who visited the west coast of India, and above all Friar Odoric of Pordenone. Odoric set out on his travels in about 1318, and was in western India and northern China between 1321 and 1328, dying in 1331. He went by Constantinople to Trebizond, thence through Persia to Ormuz, where he embarked for Tana in Salsette. He then went to Malabar, Sumatra, and Java, and by the ports of China to Cambaluc or Peking, where he remained for three years. Turning westward he journeyed by Shensi into Tibet, and was the first European to visit Lassa. His homeward journey led him by Cabul and Khorasan to Tabriz, and thence to Venice. His companion was an Irishman named Friar James.[1]

Ibn Batuta.

Ibn Batuta, the great Arab traveller is separated by a wide space of time from his countrymen already mentioned, and he finds his proper place in a chronological notice after the days of Marco Polo—for he was not born at Tangier until 1304. He began his wanderings in 1325, his career thus coinciding in time with that of Sir John Mandeville (1322–1356), but the Moor was more trustworthy than the Englishman. Ibn Batuta went by land from Tangier to Cairo, then visiting Syria, and performing the pilgrimages to Medina and Mecca. After exploring Persia, and again residing for some time at Mecca, he made a voyage down the Red Sea to Yemen, and travelled through that country to Aden, which remarkable place he correctly describes. Thence he visited the African coast, touching at Mombas and Quiloa, and then sailed across to Ormuz and the Persian Gulf. He crossed Arabia from Bahreyn to Jiddah, traversed the Red Sea and the desert to Syene, and descended the Nile to Cairo. After this he revisited Syria and Asia Minor, crossed the Black Sea to Caffa, and proceeded to the camp of the khan of Kipchak at the foot of the Caucasus. Ibn Batuta crossed the desert from Astrakhan to Bokhara, and went over the Hindu Kush to Cabul, reaching the Indus somewhere below Larkhana, in 1333. He gives an interesting account of Muhammad Tughluk, then ruler of Delhi, in whose service the great traveller remained for about eight years. He was sent on an embassy to China in 1342, travelling by land from Delhi to the seaport; whence the ambassadors sailed down the west coast of India to Calicut, and then visited the Maldive Islands and Ceylon. He made a voyage through the Islands to China, and on his return he proceeded from Malabar to Baghdad and Damascus, where he got his first news from home and heard of his father's death. Finally he reached Fez, the capital of his native country, in November, 1349, after an absence of twenty-four years, and came to the conclusion that there was no place like home. After a journey into Spain, he set out for Central Africa in 1352, and reached Timbuctoo and the Niger, returning to Fez in 1353. He had travelled over a length of at least 75,000 English miles. His narrative was committed to writing from his dictation, by order of the sultan of Fez, and the work was completed in December, 1355. Ibn Batuta died at the age of seventy-three, in the year 1377. His wnole work was carefully edited in the original, with a translation into French under the auspices of the Asiatic Society of Paris, and published in 1858. Colonel Yule has given us an English version of the portion relating to China.

Ibn Batuta was certainly the greatest of Arab travellers, and soon after his death in the kingdom of Fez, the opposite realm of Spain began to send forth explorers to distant lands. The peaceful reign of Henry III. of Castile is famous for the attempts of that prince to extend the diplomatic relations of Spain to the remotest parts of the earth. Mariana tells us that he sent embassies to the princes of Christendom and to the Moors. In 1403 the Spanish king sent a knight of Madrid, named Ruy Gonzalez de Clavijo, to the court of the mighty Timur, at Samarkand. He returned in 1406, and died soon after, but not before he had written a most valuable and interesting narrative of his travels from Constantinople through Persia and Khorasan to the Oxus, and thence by the Iron Gates to Samarkand.

Italian travellers.

Several Italians continued to make important journeys in the East during the 15th century. Among them was Nicolo Conti, who passed through Persia, sailed along the coast of Malabar, visited Sumatra, Java, and the south of China, returned by the Red Sea, and got home to Venice in 1444, after an absence of twenty-five years. He related his adventures to Poggio Bracciolini, secretary to Pope Eugenius IV.; and the narrative contains much interesting information. Towards the end of the same century, the Venetians sent several embassies to Uzun Hassan, the ruler of Persia, and to Shah Ismail, his successor; and the narratives of the envoys furnish some new geographical information. The first of these was Caterino Zeno, who induced Uzun Hassan to make war on the Turks in 1472; and he was followed by Josafat Barbaro and Ambrogio Contarini. Another Venetian traveller of this period, whose narrative has been preserved, was Giovan Maria Angiolello. He was in the service of the Turks, and was present in their campaign against the Persians. One of the most remarkable of the Italian travellers was Ludovico di Varthema, whose insatiable desire to see foreign countries induced him to leave his native land in the year 1502. He went to Egypt and Syria, and for the sake of visiting the holy cities became a Mahometan. After many extraordinary adventures he got on board a ship at Aden. Varthema is the first European who gave an account of the interior of Yemen. He afterwards visited and described many places in Persia, India, and the Eastern Archipelago, returning to Europe in a Portuguese ship after an absence of five years.

Mariner's compass.

In mentioning Varthema we have anticipated events; but in the 15th century the time was approaching when the discovery of the Cape of Good Hope was almost indefinitely to widen the scope of geographical enterprise. The great event was preceded by the discovery of the polarity of the magnetic needle, and the consequent construction of the mariner's compass. This most important discovery appears to have been made in China, and it is uncertain when the compass was first used by Western nations. Its introduction has been attributed to Flavio Gioia, a citizen of Amalfi, in the kingdom of Naples, about the year 1307. Encouraged by the possession of this sure guide, by which at all times and in all places he could with certainty steer his course, the navigator gradually abandoned the method of sailing along the shore, and boldly committed his bark to the open sea. Navigation was then destined to make rapid progress. The growing spirit of enterprise, combined with the increasing light of

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[1] Sir John Mandeville copied largely from Odoric, and the substance of his travels to the Indies and Cathay is entirely stolen from the Italian traveller, though amplified with fables from Pliny and other ancients, as well as from his own imagination. See Colonel Yule in his account of Odoric (*Cathay, and the Way Thither*, i. p. 27).

science, prepared the states of Europe for entering upon that great career of discovery, of which the details constitute the materials for the history of modern geography. Portugal took the lead in this new and brilliant path, and foremost in the front rank of the worthies of this little heronation stands the figure of Prince Henry the Navigator.

Prince Henry the Navigator.

The work of Prince Henry is well defined by his biographer, Mr. Major. Until his day the pathways of the human race had been the mountain, the river, and the plain, the strait, the lake, and the inland sea. It was he who first conceived the thought of opening a road through the unexplored ocean,—a road replete with danger but abundant in promise. Born on March 4, 1394, Prince Henry was a younger son of King João of Portugal and of Philippa of Lancaster, the grandchild of Edward III.; so that he was half an Englishman. Prince Henry relinquished the pleasures of the court, and took up his abode on the inhospitable promontory of Sagres, at the extreme south-western angle of Europe. To find the sea-path to the "thesauris Arabum et divitis Indiæ" was the object to which he devoted his life. He collected the information supplied by ancient geographers, unweariedly devoted himself to the study of navigation and cartography, and invited, with princely liberality of reward, the co-operation of the boldest and most skilful navigators of every country. The prince's motto was "Talent de bien faire,"—the word "talent," in those days, conveying not the idea of power or faculty, but of desire. Having acquired military renown by the capture of Ceuta in 1415, he set his mind upon the conquest of Guinea, and sent every year two or three vessels to examine the coasts beyond Cape Nun, which was then the limit of exploration. Yet none of his ships for many years had the hardihood to round Cape Bojador.

The first fruit of Prince Henry's explorations was the rediscovery of Madeira and Porto Santo, in 1418 and 1420. The truth of the romantic story of the first discovery of Madeira by two English lovers named Robert Machim and Anna d'Arfet, in the time of Edward III., has been demonstrated by Mr. Major. Madeira and Porto Santo were granted to Prince Henry by his brother, King Duarte, in 1433. In the same year one of the prince's ships, commanded by Gil Eannes, at length doubled Cape Bojador. In 1435 Affonso Gonsalves Baldaya, the prince's cup-bearer, passed 50 leagues beyond the cape; and eight years afterwards Nuño Tristam got to a point 25 miles beyond Cape Blanco. But it was not until 1445 that the mouth of the Senegal was reached by Diniz Dias; and in those days the Portuguese gave the name of Guinea to the country commencing at Cape Nun. In 1481 the king of Portugal assumed the title of lord of Guinea. Up to 1446 there had been 51 caravels to the Guinea coast, and almost every year some new advance was made. Meanwhile the Canaries and Azores were brought within the realms of Spain and Portugal. In 1402 a Norman named Jean de Bethencourt, accompanied by Gadifer de la Salle, had landed on the island of Lançarote, and with reinforcements from Spain he subjugated Forteventura and Ferro, and received the sovereignty of the Canaries from the king of Castile. But he returned to his lands in Normandy in 1406, and died there in 1425. Gomera, Palma, Teneriffe, and the Great Canary were still unconquered. Prince Henry made several attempts to establish Portuguese rule on these islands; the right was long disputed with Spain; and it was not until 1479 that the treaty of Alcaçora provided for the concession of the sovereignty of the Canaries to Spain. Prince Henry, however, successfully colonized the Azores, and in 1444 St. Michael's was discovered, the settlement of the other islands following soon afterwards.

In 1455 an important expedition was despatched by Prince Henry, under the command of a young Venetian adventurer named Alvise Cadamosto. Touching at Madeira and the Canaries, Cadamosto made his way to Cape Blanco on the African coast, and thence to Senegal and the Gambia. He returned with a full report of all he had seen, and in the following year he again sailed from Lagos direct for Cape Blanco, with three ships, and discovered the mouth of a river which he named the Rio Grande (Jeba ?). In 1457 Diogo Gomez sailed with orders to proceed as far as he could, and made his way to the Gambia. The Cape Verd Islands were discovered and colonized about 1462.

Prince Henry the Navigator died on the 13th of November, 1460, and was buried near his father and mother in the monastery of Batalha. In 1839 a monument to his memory was erected at Sagres. During the long period in which the prince was continuing his maritime explorations, he did not cease to cultivate the science of cartography. The geographer Jayme of Majorca superintended his school of navigation at Sagres, and at the prince's instance the finest specimen of mediæval map-making that has been preserved was prepared at Venice under the superintendence of Fra Mauro of the Camaldolese convent of San Miguel de Marano. The geographical knowledge of the 15th century is also shown by the famous Borgia map (see Plate II.), a bronze planisphere which came into the possession of Cardinal Borgia about 1794, and was published in 1797 by the cardinal's nephew. The Borgia map, however, is of the very beginning of the 15th century.

Plate II.

The progress of discovery for a time received a check from the death of Prince Henry, but only for a time. In 1462 Pedro de Cintra extended Portuguese exploration 600 miles beyond the furthest point reached by Cadamosto, and discovered Sierra Leone. Fernan Gomez followed in 1469, and opened the trade with the Gold Coast; and in 1484 Diogo Cam discovered the mouth of the Congo. The king of Portugal next despatched two vessels of 50 tons in August, 1486, under the command of Bartholomeu Dias, to continue discoveries southwards; while, in the following year, he sent Pedro de Covilham and Affonso de Payva to discover the country of Prester John. Dias succeeded in rounding the southern point of Africa, which he named Cabo Tormentoso; but king João II., foreseeing the realization of the long-sought passage to India, gave it the enduring name of the Cape of Good Hope. Dias returned to Lisbon in December, 1487; meanwhile Payva had died at Cairo; but Covilham, having heard that a Christian ruler reigned in the mountains of Ethiopia, penetrated into Abyssinia in 1490. He delivered the letter which João II. had addressed to Prester John to the negûs Alexander of Abyssinia, but he was detained by that prince and never allowed to leave the country.

The results westward and eastward of the exertions of Prince Henry were the discovery of America by Columbus and of the Cape route to India by Vasco da Gama.

Columbus.

Christopher Columbus was born at Genoa about 1435. His name in Italian was Colombo, and in Spain he is known as Cristoval Colon. The fame of the Portuguese discoveries attracted strangers from all parts of the world, and in 1470 Columbus arrived at Lisbon. He was in Portugal from 1470 to 1484, during which time he made several voyages to the coast of Guinea in the Portuguese service. He married a daughter of Bartholomeu Perestrello, to whom Prince Henry had granted the commandership of Porto Santo, and lived for some time on that island. He learned, from many pilots experienced in the western voyages to the Azores, facts and signs which convinced him that there was an unknown land towards the west. Columbus also studied the *Imago Mundi* of Cardinal Pierre d'Ailly, whence he culled all he knew of Aristotle and Strabo; and he read the narrative of Marco Polo. By 1474 his grand project of discovery was established in his mind, and nothing afterwards could divert him from the pursuit of it. On the refusal of the king of Portugal to entertain his proposal, Columbus left Lisbon with his son in 1484, and he spent the interval until 1492 in appeals to the Spanish court. At length, having overcome all obstacles, he set sail with a fleet of three ships from Palos, on the 3d of August, 1492, on his unprecedented and perilous voyage. On the 12th of October, having crossed the Atlantic, Columbus sighted land, which was named San Salvador. Mr. Major has recently proved that this island is one of the Bahamas, now known as Watling Island. After discovering Cuba, Hispaniola, and many small islands, Columbus set sail on his return voyage on January 16, 1493, and arrived at Palos on the 15th of March. His reception in Spain was enthusiastic, and commensurate with the grandeur of his achievement; and on the 25th of September, 1493, he sailed from Cadiz on his second voyage, with a fleet of three large ships and fourteen caravels. On the 3d of November he discovered the island of Dominica, and during the voyage his discoveries included the Windward Islands and Jamaica. He returned to Cadiz on June 11, 1496; and it was not until May 30, 1498, that he set sail on his third voyage. The first land he came to formed a new discovery, which he named the island of Trinidad, and it was in this voyage that he reached the mainland of

Discovery of America.

South America, and discovered the islands of Cubagua and Margarita. A colony had been formed on Hispaniola, and soon afterwards a judge named Francisco de Bobadilla arrived from Spain, having been sent, at the instigation of the great discoverer's enemies, to inquire into his conduct. Bobadilla seized upon the government, and sent Columbus home in chains. Ferdinand and Isabella were overwhelmed with shame, and the people with astonishment, on his arrival. He was at once released, and false promises of restitution and reward were profusely made. But Bobadilla was superseded, not by Columbus, but by Nicolas de Ovando. On the 9th of May, 1502, however, Columbus was allowed to sail on a fourth and last voyage of discovery. He reached the island of Martinique on the 13th of June, and touched at Dominica and Hispaniola. Thence he sailed westward, discovering the coast of Veragua and the harbor of Porto Bello. After a stay in Jamaica, he set sail for Spain on the 12th of September, 1504, and arrived at San Lucar on the 7th of November. He lived for two years longer, experiencing the blackest ingratitude from the Spanish court. At length, in debt and poverty, and bowed down by disappointment, this great man died May 20, 1506. His body was buried at Valladolid, and removed in 1513 to Cartuja de las Cuevas near Seville. A monument was erected over his grave, with the inscription—

> A Castilla y Leon,
> Nuevo Mundo dió Colon.

In 1536 the bodies of Columbus and his son Diego were transported to St. Domingo; and thence they were removed to Havana in 1795. The ashes of the immortal discoverer now repose in the cathedral of Havana.

Da Gama.

While Columbus was discovering a new world, the Portuguese continued their persevering efforts to reach India by sea. Vasco da Gama sailed from Lisbon on the 8th of July, 1497, with four vessels built expressly for the voyage, the largest not exceeding 120 tons, and called the "Sam Gabriel." His brother Paolo commanded the "Sam Raphael," and the "Berrio" was under Nicolas Coelho. On November 22, with a fair wind, Da Gama rounded the Cape of Good Hope, and anchored in the bay named San Bras by Bartholomeu Dias, on the 25th. On Christmas Day he sighted land, which, on that account, he named Natal. He reached Mombas on the 7th of April, and on the 20th of May, 1498, he anchored before Calicut. Da Gama returned to Lisbon in August, 1499; and at his recommendation another fleet was fitted out, consisting of thirteen well-armed ships, under Pedro Alvarez Cabral, with Bartholomeu Dias and Nicolas Coelho under his orders. The expedition sailed on the 9th of March, 1500; and on the 22d of April Cabral discovered the coast of Brazil, and took formal possession for the king of Portugal. Resuming his voyage to the East, he reached Calicut in September, and obtained permission to build a factory, establishing friendly relations also at Cananor and Cochin. He returned to Lisbon in July, 1501. Vasco da Gama set sail, with a much larger fleet, on his second voyage in 1502. He visited several ports on the west coast of India, engaged in war as well as in commerce, and returned in September, 1503. In 1503 Antonio da Saldanha and Affonso de Albuquerque sailed for India, and made terms of friendship with the chief of Quilon. Dom Francisco de Almeida, the first viceroy of the Indies, was sent out in 1505. He founded the ports of the Angediva and Cananor, and his son Laurenço discovered Ceylon. Tristam da Cunha, with Affonso de Albuquerque under his orders, was sent to occupy Socotra, and in 1506 Albuquerque came to India as second viceroy. He explored the coasts of Arabia and Persia, made the king of Ormus tributary to Portugal, and sent embassies to Abyssinia. In 1509 (?) a factory was established at Malacca; and on November 25, 1510, the great Albuquerque conquered Goa, and established the seat of his government there. In 1512 the Moluccas were discovered; and in 1517 Fernam Peres de Andrade reached China, and entered into commercial relations with the governor of Canton. In 1524 Vasco da Gama arrived in India for a third time as viceroy, and landed at Goa on the 11th of September. He died at Cochin on the 24th of December, 1524, and in 1538 his body was transported to Portugal, and buried in his tomb at Vidigueira, of which town he was count.

Eastern trade.

The voyages of Vasco da Gama revolutionized the commerce of the East. Until then the Venetians held the carrying trade of India, which was brought by the Persian Gulf and Red Sea into Syria and Egypt, the Venetians receiving the rich products of the East at Alexandria and Beyrout, and distributing them over Europe. This commerce was a great source of wealth to Venice; but after the discovery of the new passage round the Cape, and the conquests of the Portuguese, the trade of the East passed into other hands.

The astrolabe.

The achievements of Columbus and Da Gama are immeasurably enhanced when we consider the inadequate means at their disposal, their small and ill-formed ships, and their defective knowledge of navigation. The mariner's compass had been in use for nearly two centuries, and it was Columbus himself who first observed the phenomena of variation. But the compass and rough sea-card were the only appliances, until the learned Nuremberger, Martin Behaim, invented the application of the astrolabe to purposes of navigation, which enabled mariners to ascertain their latitude. This was in the year 1480. The astrolabe was used by Vasco da Gama on his first voyage round the Cape of Good Hope; but the movement of a ship rendered accuracy impossible, and the liability to error was increased by the necessity for three observers. One held the astrolabe by a ring passed over the thumb, the second measured the altitude, and the third read off. The astrolabe was a metal circle graduated round the edge, with a limb called the *alhidada* fixed to a pin in the centre, and working round the graduated circle. The instrument had two sights fitted upon it, one at each end, and was suspended by a ring so as to hang vertically on one hand, while the *alhidada* was worked up and down until the sun could be seen through both the sights. It then gave the zenith distance. The *Ordenanzas* of the Spanish councils of the Indies record the course of instruction prescribed for pilots, which included the *De Sphæra Mundi* of Sacrobosco, the spherical triangles of Regiomontanus, the *Almagest* of Ptolemy, the use of the astrolabe and its mechanism, the adjustments of instruments, cartography, and the methods of observing the movements of heavenly bodies. The only observations employed by the ancients for finding the longitude were those of the eclipses of the moon, and it was not until 1610 that Galileo discovered another method by observation of Jupiter's satellites.

Spanish enterprise.

Amerigo Vespucci.

The discoveries of Columbus awakened a spirit of enterprise in Spain which continued in full force for a century; adventurers flocked eagerly across the Atlantic, and discovery followed discovery in rapid succession. Many of the companions of Columbus continued his work. Pinzon in 1499 reached the mouth of the Amazon; and in the same year Alonzo de Ojeda, accompanied by a Florentine named Amerigo Vespucci, touched the coast of South America somewhere near Surinam, following the shore as far as the Gulf of Maracaibo. Vespucci afterwards made three voyages to the Brazilian coast; and in 1504 he wrote an account of his four voyages, which was widely circulated, and became the means of procuring for its author the high honor of giving his name to the whole continent. Mr. Major has discussed the hitherto obscure question of the way in which the name "America" originated, in a paper distinguished for great learning and very able criticism. He has shown that the word "America" first appeared on the *Mappe Monde* drawn by Leonardo da Vinci, and he explains the chain of circumstances which led to its adoption. The first map known to exist with America delineated upon it is that drawn by Juan de la Cosa, the pilot of Columbus in his second voyage, which is dated 1500. Juan de la Cosa was with Ojeda and Vespucci, and afterwards with Ojeda in his last ill-fated expedition. In May, 1507, just a year after the death of Columbus, one Martin Waldseemüller (Hylacomulus) wrote a work called *Cosmographiæ Introductio,* to which was appended a Latin edition of the four voyages of Vespucci. In this book, which was printed at St. Dié in Lorraine, he proposed that the name of America should be given to the New World. In 1508 the first engraved map containing the New World appeared, in an edition of Ptolemy, printed at Rome, but it does not bear the name of America. But in 1509 the name "America," proposed by Hylacomulus in 1507, appears, as if it was already accepted as a well-known denomination, in an anonymous work entitled *Globus*

Mundi, published at Strasburg. This was three years before the death of Vespucci. The *Mappe Monde* of Leonardo da Vinci, to which Major assigns the date of 1514, has the name of America across the South American continent.

Ojeda.

In 1508 Ojeda obtained the government of the coast of South America from Cabo de la Vela to the Gulf of Darien; and at the same time Diego Nicuesa was appointed governor of Veragua from the Gulf of Darien to Cape Gracias a Dios. The two adventurers arrived at Hispaniola together; but Ojeda set out first for his government, landed at Carthagena in 1510, and sustained a bloody defeat from the natives, in which his lieutenant, Juan de la Cosa, was killed. Ojeda then embarked, and eventually selected a site on the east side of the Gulf of Darien for his seat of government. Here he was again defeated by the natives, and, returning to Hispaniola for aid, he died there in extreme poverty. Nicuesa was still more unfortunate, and died at sea. The Spaniards in the Gulf of Darien were left by Ojeda under the command of Francisco Pizarro, the future conqueror of Peru. After suffering from famine and disease, Pizarro embarked the survivors in small vessels, but outside the harbor they met a ship which proved to be that of the bachiller Martin Fernandez Enciso, Ojeda's partner, coming with provisions and reinforcements. They all returned to their settlement called San Sebastian, but found that the Indians had destroyed the fort, and Enciso determined to abandon it.

Balboa.

One of the crew of Enciso's ship, Vasco Nuñez de Balboa, the future discoverer of the Pacific Ocean, induced his commander to form a settlement on the other side of the Gulf of Darien. The soldiers became discontented and deposed Enciso, when Vasco Nuñez, a clever and courageous adventurer, took command of the Darien settlement in March, 1511. Enciso was a man of learning, and an accomplished cosmographer. His work *Suma de Geografia*, which was printed in 1519, is the first Spanish book which gives an account of America. Vasco Nuñez, the new commander, entered upon a career of conquest in the neighborhood of Darien, which ended in the discovery of the Pacific Ocean on the 25th of September, 1513. In 1514 Pedrarias de Avila, an old man of rank and some reputation, but with no ability, and of a malicious disposition, was appointed to supersede Vasco Nuñez as governor of Darien, and the bachiller Enciso came out in his fleet. Pedrarias, on a false pretext, beheaded Vasco Nuñez in 1517, which was one of the greatest calamities that could have happened to South America at that time; for the discoverer of the South Sea was on the point of sailing with a little fleet into his unknown ocean, and a humane and judicious man would have been the conqueror of Peru, instead of the cruel and ignorant Pizarro. In the year 1519 Panama was founded by Pedrarias; and the conquest of Peru by Pizarro followed a few years afterwards. Hernan Cortes overran and conquered Mexico from 1518 to 1521, and the discovery and conquest of Guatemala by Alvarado, of Florida by Hernando de Soto, and of Nueva Granada by Quesada, followed in rapid succession. The first detailed account of the west coast of South America was written by that keenly observant old soldier, Pedro de Cieza de Leon, who was travelling in South America from 1533 to 1550, and published his story at Seville in 1553.

Magellan.

But the great anxiety of the Spanish Government at that time was to find a westward route to the Moluccas. For this purpose Juan Diaz de Solis was despatched in October, 1515, and in January, 1516, he discovered the mouth of the Rio de la Plata. He was, however, killed by the natives, and his ships returned. In the following year Magellan laid before Charles V., at Valladolid, a scheme for reaching the Spice Islands by sailing westward. He had already served with his own countrymen, the Portuguese, on the coast of India and at the taking of Malacca, and he was an accomplished and resolute seaman. With a fleet of five ships, and the rank of captain-general, Magellan sailed from San Lucar on the 21st of September, 1519. After touching on the coast of Brazil, at the Rio de la Plata, and at the ports on the east coast of Patagonia, Magellan entered the straits which bear his name in October, 1520. In consequence of many fires being seen on the southern shores of the strait, he named that country Tierra del Fuego. The fleet, now consisting of the "Trinidad," "Vittoria," and "Concepcion," emerged from the strait and entered the Pacific Ocean on the 27th of November, 1520. They then steered north-west, crossed the line on the 13th of February, 1521, and on the 6th of March reached the Ladrone Islands. Thence Magellan proceeded to the Philippines. He was killed in an attack on the island of Matan, which he made in order to bring it under subjection to his ally the king of Zebu, on the 26th of April, 1521. Thus fell this great navigator, who was second only to Columbus in the history of nautical exploration. His brother-in-law, Duarte Barbosa, was selected to succeed Magellan in command of the fleet, with João Serrao as his colleague. They were both killed in battles with the natives, and eventually a Biscayan named Sebastian del Cano, sailing home by way of the Cape of Good Hope, reached San Lucar in command of the "Vittoria" on the 6th of September, 1522, with eighteen survivors. Del Cano was received with great distinction by the emperor, who granted him a globe for his crest, and the motto "Primus circumdedisti me."

While the Spaniards were circumnavigating the world and completing their knowledge of the coasts of Central and South America, the Portuguese were actively engaged on similar work as regards Africa and the East Indies.

Exploration of Africa.

In Abyssinia the mission of Covilham led to further intercourse. In April, 1520, the Portuguese viceroy of the Indies took a fleet into the Red Sea, and landed an embassy consisting of Dom Rodriguez de Lima and Father Francisco Alvarez, a priest whose detailed narrative is the earliest and not the least interesting account we possess of Abyssinia. It was not until 1526 that the embassy was dismissed; and not many years afterwards the negûs entreated the help of the Portuguese against Mahometan invaders, and the viceroy sent an expeditionary force, commanded by his brother Cristoforo da Gama, with 450 musketeers. Da Gama was taken prisoner and killed, but his Portuguese enabled the Christians of Abyssinia to regain their power, and a Jesuit mission remained in the country. While Abyssinia was thus opened to the enterprise of the Portuguese on the east side of Africa, they also established a close connection with the kingdom of Congo on the west side, and obtained much information respecting the interior of the continent. Duarte Lopes, a Portuguese settled in the country, was sent on a mission to Rome by the king of Congo, and Pope Sixtus V. caused him to recount to his chamberlain, Felipe Pigafetta, all he had learned during the nine years he had been in Africa, from 1578 to 1587. This narrative, under the title of *Description of the Kingdom of Congo*, was published at Rome by Pigafetta in 1591. A map was attached on which the two equatorial lakes, Victoria and Albert Nyanza, and Lake Tanganyika are shown, and the empire of Monomoezi or Uniamuezi is laid down. The most valuable work on Africa during the 16th century is, however, that written by Leo Africanus. This famous traveller was born at Granada, and retired into Africa when his native town was captured by the Spaniards. He travelled extensively in the north and west of Africa, and was eventually taken by pirates and sold to a master who presented him to Pope Leo X. At the pope's desire he translated his work on Africa into Italian, and died in about the year 1526.

Portuguese in the East.

In the East Indies the Portuguese acquired predominating influence at sea, establishing factories on the Malabar coast, in the Persian Gulf, at Malacca, and in the Spice Islands, and extending their commercial enterprises from the Red Sea to China. Their missionaries were received at the court of Akbar, and Benedict Goes, a native of the Azores, was despatched on a journey overland from Agra to China. He started in 1603, and after traversing the least known parts of Central Asia, he reached the confines of China. He appears to have ascended from Cabul to the plateau of the Pamir, and thence onwards by Yarkand, Khotan, and Aksu. He died at a place called Socieu in March, 1607; and thus, as one of the brethren pronounced his epitaph, "seeking Cathay he found heaven."

English enterprise.

The activity and love of adventure, which became a passion for two or three generations in Spain and Portugal, spread to other countries. It was the spirit of the age; and England, Holland, and France soon began to enter upon the same glorious career. English enterprise was first aroused by John and Sebastian Cabot, father and son, who came from Venice and settled at Bristol in the time of Henry VII. The Cabots received a patent, dated March 5, 1496, empowering them to seek unknown lands; and John Cabot discovered Newfoundland and part

The Cabots.

Willoughby.

Chancellor.

of the coast of America. Sebastian afterwards made a voyage to Rio de la Plata in the service of Spain, but he returned to England in 1548, and received a pension from Edward VI. "in consideration of the good and acceptable services done and to be done." He was placed at the head of the Society of Merchant Adventurers, and by his knowledge and experience, he was the means of keeping alive the spirit of enterprise in England, and of extending her foreign commerce. At his suggestion a voyage was undertaken for the discovery of a north-east passage to Cathay, with Sir Hugh Willoughby as captain-general of the fleet, and Richard Chancellor as pilot-major. They sailed in May, 1553, but Willoughby and all his crew perished in a harbor on the Lapland coast. Chancellor, however, was more fortunate. He reached the White Sea, performed the journey overland to Moscow, where he was well received, and may be said to have been the founder of the trade between Russia and England. He returned to Archangel and brought his ship back in safety to England. On a second voyage, in 1556, Chancellor was drowned; and the three subsequent voyages, led by Stephen Burrough, Pet, and Jackman, effected an examination of the straits which lead into the Sea of Kara.

French enterprise.

Cartier.

The French followed closely on the track of John Cabot, and the hardy Norman and Breton seamen frequented the banks of Newfoundland at the commencement of the 16th century. In 1524 Francis I. sent Giovanni da Verazzano of Florence on an expedition of discovery to the coast of North America; and the details of his voyage were embodied in a letter addressed by him to the king of France from Dieppe, in July, 1524. On April 20, 1534, Jacques Cartier sailed from St. Malo with two vessels of 60 tons each, for the purpose of continuing the discoveries of Verazzano, and he visited Newfoundland and the Gulf of St. Lawrence. In the following year he made another voyage, discovered the island of Anticosti, and ascended the St. Lawrence to a place called Hochelaga, now Montreal. He returned, after passing two winters in Canada; and on another occasion he also failed to establish a colony. Admiral de Coligny made several unsuccessful endeavors to form a colony in Florida under Jean Ribault of Dieppe, René de Laudonnière, and others, but the settlers were furiously assailed by the Spaniards and the attempt was abandoned.

Age of Elizabeth.

Hakluyt.

The reign of Elizabeth is famous for the gallant enterprises that were undertaken by sea and land to discover and bring to light the unknown parts of the earth. The great promoter and father of English geographical discovery was Richard Hakluyt, who was born near London in 1553. He was at Westminster School, and when quite a boy he imbibed a love for cosmography and maritime discovery. At Oxford he read all the narratives of voyages and travels that came within his reach, and delivered lectures on cartography. In 1585 he was at Paris, as chaplain to the English embassy, and in 1605 he became a prebendary of Westminster. He was the chief promoter in the formation of the two companies for colonizing Virginia in 1606; and he devoted his life to the encouragement of similar undertakings, and to their record. Hakluyt died in 1616, and was buried in Westminster Abbey. He was incessantly employed in the collection, examination, and translation of accounts of voyages and travels, and of charters, letters, and other documents bearing on the subject, and in correspondence with men eager either to impart or receive information. Sir Philip Sidney, Sir Francis Walsingham, Lord Thomas Howard, and Sir Francis Drake were among those who supported and encouraged him, and Ortelius and Mercator were his correspondents. His first work was the *Divers Voyages touching the Discoverie of America;* and the second was brought out while he was in Paris in 1586, entitled *A Notable Historie containing Foure Voyages made by French Captaynes unto Florida.* In 1587 he published at Paris a revised edition of the *De Orbe Novo* of Peter Martyr Anghiera. His *Principal Navigations* was published in folio in 1589, and dedicated to Sir Francis Walsingham; and the new edition, in three volumes, appeared in 1598. Hakluyt also got translations made of Leo Africanus, of Mendoza's *History of China,* and of Galvano's *Discoveries of the World,* which were published. His last publication was a translation of Hernando de Soto's discoveries in Florida. He left many valuable papers at his death, most of which, together with a vast number of other narratives, were published in 1622 in the great work of the Rev. Samuel Purchas, entitled "Hakluytus Posthumus, or Purchas his Pilgrimes."

Purchas.

It is from the rich treasure-house of Hakluyt and Purchas that our knowledge of the gallant deeds of the English and other explorers of the Elizabethan age is mainly derived. The great collections of voyages and travels of De Bry and Hulsius served a similar useful purpose on the continent of Europe. One important object of English maritime adventurers of those days was to discover a route to Cathay by the north-west, a second was to settle Virginia, and a third was to beat up the Spanish settlements in the Indies. Nor was the trade to Muscovy and Turkey neglected; while latterly a resolute and successful attempt was made to establish commercial relations with East India.

North-west passage.

Frobisher.

Martin Frobisher led the way in the direction of the north-west, sailing from the Thames in 1576, and sighting the southern part of Greenland on the 11th of July. In this voyage he discovered a part of the coast of Labrador, and the strait (now known to be a deep bay) which bears his name. He brought home some stones which were believed to be gold, and the consequence was that there arose an eager desire to obtain more. Many speculators subscribed, and Frobisher was sent out on a second voyage, "more for the searching of this gold ore than for the searching any further discovery of the passage." He left Gravesend on May 27, 1577, wasted his time in picking up stones on the shores of Frobisher's Strait, and returned on the 22d of August. The excitement about the gold ore still continued. The queen gave the name of *Meta Incognita* to the newly discovered country; and on May 21, 1578, Frobisher set out on a third voyage with a fleet of fifteen ships. After touching at Greenland, they made for the opposite shore through an ice-encumbered sea, and the fleet was separated during a heavy gale. They reached various ports in England during October, and by that time the bubble about the gold ore had burst, and the enterprise was considered a failure. The first of the three voyages alone was a voyage of discovery.

Davis.

In 1585 John Davis, an admirable seaman and most resolute explorer, was employed by some merchants, chief among whom was Mr. William Sanderson of London, to take up the glorious work where Frobisher had left off. He sailed from Dartmouth on the 7th of June, 1585, and, reaching the south-west coast of Greenland, he called it the "Land of Desolation." He then stood over to the opposite coast, which he examined in the neighborhood of Cape Walsingham, returning to Dartmouth on September 30. In 1588 he sailed on the 7th of June and coasted along Greenland, having friendly intercourse with the Eskimo. He also examined part of the Labrador coast. In his third voyage he sailed from Dartmouth on the 17th of May, and sighted Greenland on the 14th of June. On this occasion he went as far north as 72° 12′, naming the great island bluff—which is now so well known to voyagers up Baffin's Bay—"Sanderson his Hope of a North-West Passage." Crossing over Davis Strait, the bold explorer discovered the strait which now bears the name of Hudson. Davis was followed in his northern voyages by Waymouth, Hall, and Knight; and in 1607 Henry Hudson was despatched on a voyage of discovery in a small vessel of 80 tons. He sighted the east coast of Greenland in 73° N., examined the north-west end of Spitzbergen, as far as a point which he named Hakluyt Headland, and reached 80° 23′ N. In 1608 he made a second voyage, during which he examined the edge of the ice between Spitzbergen and Greenland. In his third voyage, in 1609, he was employed by the Dutch, and discovered the Hudson River. In 1610 he was again employed by English merchants, and entered Hudson's Bay, but was infamously abandoned in an open boat by his crew. In 1612 Sir Thomas Button continued the exploration of Hudson's Bay, which was completed by Thomas James and Luke Fox in 1631.

Baffin.

In 1616 the little bark "Discovery," of 35 tons, was fitted out by those persevering adventurers Sir Thomas Smith, Sir Dudley Digges, John Wolstenholme, and Alderman Jones, for another attempt in the icy seas. This was the most successful Arctic voyage of the 17th century. Robert Bylot was appointed master of the "Discovery," and William Baffin was pilot. They sailed from Gravesend, with 17 souls on board, on the 26th of March, and were off Hope Sanderson, the extreme point of

Davis, on the 30th of May. The "Discovery" reached what is now called "the north water" of Baffin's Bay on the 1st of July, and, after discovering the head of the great bay which bears his name, the pilot Baffin returned by sailing down the west side of it. On August 30 the "Discovery" was again safely anchored in Dover roads. It was exactly 200 years before any other vessel followed in her track, and reached "the north water." Both Davis and Baffin afterwards served and were killed in the East Indies.

Dutch exploration.

Barents.

The Dutch emulated the English in the Arctic seas during this period. Their merchants opened a trade with Kola and Archangel as early as 1578, but the difficulty of penetrating into the Sea of Kara led them to try the possibility of finding a passage round the northern end of Novaya Zemlya. The credit of the conception of this voyage is due to the great cosmographer Peter Plancius, and the merchants of Amsterdam adopted the idea, and despatched a vessel of 100 tons called the "Mercurius," under the command of William Barents. He sailed from the Texel on June 4, 1594, and sighted Novaya Zemlya on the 4th of July. Sailing northwards along the coast he rounded Cape Nassau and reached the edge of the ice. For many days he perseveringly sought for a passage through it. In his second voyage he merely went to the entrance of the Sea of Kara. But his third voyage was the most important. Heemskerk was the commander, Barents was pilot, and the mate, Gerrit de Veer, was the historian of the voyage. They sailed from Amsterdam on May 13, 1596. On June 19 Spitzbergen was discovered, and the whole western coast and part of the northern examined. The record of the subsequent proceedings of Barents and his crew, of their famous voyage round the north-western end of Novaya Zemlya, and of their terrible sufferings in the first Arctic winter ever faced by Europeans, is deeply interesting as it is told in the simple narrative of Gerrit de Veer. Barents had long been ill, and when they set sail from their dismal winter harbor on June 14, 1597, in open boats, he was too weak to stand, and was carried from the house. He died on the 19th, and found a grave in the midst of his discoveries.

English circumnavigators.

The maritime enterprise of England, in the days of Elizabeth, was mainly directed towards the discovery of a north-west passage; but many voyages were also made to Guinea and the West Indies, and twice English vessels followed in the track of Magellan, and circumnavigated the globe.

Drake.

In 1577 Francis Drake, who had previously served with Hawkins in the West Indies, undertook his celebrated voyage round the world. His fleet consisted of three ships and two pinnaces, which were broken up during the voyage. The ships were the "Pelican" of 100 tons, on board of which Drake himself embarked, the "Elizabeth" of 80, and the "Marigold" of 30 tons. After some stay at Port San Julian on the coast of Patagonia, the fleet entered the Straits of Magellan on the 20th of August, 1578, when Drake changed the name of his ship to the "Golden Hind." They reached the western entrance on the 6th of September, and soon afterwards the "Marigold" parted company in a gale of wind, and was never heard of again, while the "Elizabeth" basely deserted her consort and returned to England. Drake, in the "Golden Hind," continued the voyage alone. At first he was driven to the southernmost point of Tierra del Fuego, and thus discovered that there was a passage, though he did not round Cape Horn. He then proceeded northward along the west coast of America, touching at the island of Mocha off the Chilian coast, at Valparaiso, Coquimbo, Tarapaca, Arica, Callao, and Payta. Off Cape San Francisco, nearly on the equator, he captured a very rich Spanish treasure-ship called the "Cacafuego;" and it is right to observe that England was then at peace with Spain. Drake resolved to attempt the discovery of a passage from the Pacific to the Atlantic, and with this object he continued to shape a course northwards along the American continent. On the 5th of June, 1579, the "Golden Hind" reached her most northern point in 48°, when the attempt was abandoned, and Drake put into a harbor to refit, named Port Drake, which appears to have been the modern harbor of San Francisco, on the coast of California. The coast from the southern extremity of the Californian peninsula to Cape Mendocino was discovered by Juan Rodriguez Cabrillo and Francisco de Ulloa in 1539. Drake's discoveries extend from Cape Mendocino to 48° N.

Leaving California, Drake sailed across the Pacific and reached the Philippine Islands in October. He touched at Ternate and Java, and rounded the Cape of Good Hope on June 15, 1580. The "Golden Hind" anchored safely at Plymouth on the 26th of the following September. Drake was graciously received and knighted by the queen, and the "Golden Hind," the first English ship that circumnavigated the globe, was preserved for many years at Deptford. When at last she was broken up, a chair was made from one of her planks and presented to the university of Oxford.

Cavendish.

Hawkins.

Mr. Thomas Cavendish, a gentleman of Suffolk, emulous of Drake's example, fitted out three vessels for an expedition to the South Sea, and sailed from Plymouth on July 21, 1586. Cavendish passed through Magellan's Straits in January, 1587, and, taking the same route as Drake along the west coast of America, he reached Mazatlan in September. A rich Spanish treasure-ship was captured off Cape San Lucas, the southern extremity of California, on the 4th of November, and Cavendish then steered across the Pacific, seeing no land until he reached the Ladrone Islands. He arrived safely at Plymouth on the 9th of September, 1588. The third English voyage into the Pacific was not so fortunate. Sir Richard Hawkins sailed from Plymouth on the 12th of June, 1593, in the good ship "Dainty," passed through Magellan's Straits, and all went well until they reached the bay of Atacames, 57 miles north of the equator, in June, 1594. Here the English were attacked by a Spanish fleet, and, after a desperate naval engagement, Hawkins was forced to surrender. Hawkins declared his object to be discovery and the survey of unknown lands, and his voyage, though terminating in disaster, bore good fruit. *The Observations of Sir Richard Hawkins in his Voyage into the South Sea*, published in 1622, are very valuable, and form the most charming work of the kind which was written during that period. It was long before another English ship entered the Pacific Ocean. Sir John Narborough took two ships through the Straits of Magellan in 1670 and touched on the coast of Chili; but it was not until 1685 that Cook and Dampier sailed over the part of the Pacific where, nearly a century before, the "Dainty" had to strike her flag to the Spaniard.

Spanish exploration.

The exploring enterprise of the Spanish nation did not wane after the conquest of Peru and Mexico, and the acquisition of the vast empire of the Indies. It was rather spurred into renewed activity by the audacity of Sir John Hawkins in the West Indies, and by the appearance of Drake, Cavendish, and Richard Hawkins in the Pacific.

In the interior of South America the Spanish conquerors had explored the region of the Andes from the isthmus of Panama to Chili; and in 1541 Francisco de Orellana discovered the whole course of the Amazon from its source in the Quitenian Andes to the Atlantic. A second voyage down the great river was made in 1561 by the mad pirate Lope de Aguirre; but it was not until 1639 that a full account was written of the mighty stream by Father Cristoval de Acuña, who ascended it from its mouth to the city of Quito. The voyage of Drake across the Pacific was preceded by that of Alvaro de Mendaña, who was despatched from Peru in 1567 to discover the Australian land which was believed to exist in the South Sea. After a voyage of eighty days across the Pacific, Mendaña discovered the Salomon Islands; and the expedition returned in safety to Callao. The appearance of Drake on the Peruvian coast led to an expedition being fitted out at Callao, to go in chase of him, under the command of Pedro Sarmiento. He sailed from Callao in October, 1579, and made a careful survey of the Straits of Magellan, with the object of fortifying that entrance to the South Sea. The colony which he afterwards took out from Spain was a complete failure, and is only remembered now from the name of "Port Famine" which Cavendish gave to the site at which he found the starving remnant of Sarmiento's settlers. In June, 1595, Mendaña sailed from the coast of Peru in command of a second expedition to colonize the Salomon Islands. After discovering the Marquesas, he reached the island of Santa Cruz of evil memory, where he and many of the settlers died. His young widow took command of the survivors and brought them safely to Manila. The viceroys of Peru still persevered in their attempts to plant a colony in Australia. Pedro Fernandez de Quiros, who was pilot under Mendaña and Luis Vaez de Torres were sent in command of two ships to continue the work of exploration. They sailed from Callao on December 21, 1605, and discovered several islands of the New Hebrides group. They anchored in a bay of a large island which Quiros named "Australia del Espiritu Santo." From this place Quiros returned to America, but Torres continued the voyage, passed through the strait between Australia and New Guinea which bears his name, and explored and mapped the southern and (as has recently been proved) also the eastern coast of New Guinea.

Portuguese explorers.

The Portuguese, in the early part of the 17th century (1578–1640), were under the dominion of Spain, and their enterprise was to some extent damped; but their missionaries extended geographical knowledge in Africa. Father Francisco Paez acquired great influence in Abyssinia, and explored its highlands from 1600 to 1622. Fathers Mendez and Lobo traversed the deserts between the coast of the Red Sea and the mountains, became acquainted with the shores of Lake Tsana, and discovered the sources of the Abai or Blue Nile in 1624–1633.

East India Company.

But the attention of the Portuguese was mainly devoted to vain attempts to maintain their monopoly of the trade of India against the powerful rivalry of the English and Dutch. The English enterprises were persevering, continuous, and successful. James Lancaster made a voyage to the Indian Ocean from 1591 to 1594; and in 1599 the merchants and adventurers of London resolved to form a company, with the object of establishing a trade with the East Indies. On the 31st of December, 1599, Queen Elizabeth granted the charter of incorporation to the East India Company, and Sir James Lancaster, one of the directors, was appointed general of their first fleet. He was accompanied by John Davis, the great Arctic navigator, as pilot-major. This voyage was eminently successful. The ships touched at Achín in Sumatra and at Java, returning with full ladings of pepper in 1603. The second voyage was commanded by Sir Henry Middleton; but it was in the third voyage, under Keelinge and Hawkins, that the mainland of India was first reached in 1607. Captain Hawkins landed at Surat and travelled overland to Agra, passing some time at the court of the Great Mogul. In the voyage of Sir Edward Michelborne, John Davis of Arctic fame lost his life in a fight with a Japanese junk on December 27, 1605. The eighth voyage, led by Captain Saris, extended the operations of the company to Japan; and in 1613 the Japanese Government granted privileges to the Company; but the English retired in 1623, giving up their factory. The chief result of this early intercourse between England and Japan was the interesting series of letters written by William Adams from 1611 to 1617. Adams, however, though an Englishman, went to Japan in a Dutch ship. From the tenth voyage of the East India Company, commanded by Captain Best, who left England in 1612, dates the establishment of permanent English factories on the coast of India. It was Captain Best who secured a regular firman for trade from the Great Mogul. From that time a fleet was despatched every year, and the Company's operations greatly increased geographical knowledge of India and the Eastern Archipelago.

English in Persia.

The visits of Englishmen to Eastern countries, at this time, were not confined to the voyages of the Company. Journeys were also made by land, and, among others, Thomas Coryat, of Odcombe in Somersetshire, walked from France to India, and died in the Company's factory at Surat. In 1561 Mr. Anthony Jenkinson arrived in Persia with a letter from Queen Elizabeth to the shah. He travelled through Russia to Bokhara, and returned by the Caspian and Volga. In 1579 Christopher Burroughs built a ship at Nijni Novgorod and traded across the Caspian to Baku; and in 1598 Sir Anthony and Robert Shirley arrived in Persia, and Robert was afterwards sent by the shah to Europe as his ambassador. He was followed by a Spanish mission under Garcia de Silva, who wrote an interesting account of his travels; and to Sir Dormer Cotton's mission, in 1628, we are indebted for Sir Thomas Herbert's charming narrative. In like manner, Sir Thomas Roe's mission to India resulted not only in a large collection of valuable reports and letters of his own, but also in the detailed account of his chaplain Mr. Terry. But the most learned and intelligent traveller in the East, during the 17th century, was the German Kœmpfer, who accompanied an embassy to Persia in 1684, and was afterwards a surgeon in the service of the Dutch East India Company. He was in the Persian Gulf, India, and Java, and resided for more than two years in Japan, from 1690 to 1692. His *History of Japan* was published in England in 1727, Kœmpfer himself having died in 1716. From these various sources a considerable increase was made in the knowledge of India, Persia, and the further East.

Dutch enterprise.

The Dutch nation, as soon as it was emancipated from Spanish tyranny, displayed an amount of enterprise which, for a long time, was fully equal to that of England. The memorable Arctic voyages of Barents were quickly followed by the establishment of a Dutch East India Company; and Holland, ousting the Portuguese, not only established factories on the mainland of India and in Japan, but acquired a preponderating influence throughout the Eastern Archipelago. In 1583 Jan Hugen van Linschoten made a voyage to India with a Portuguese fleet, and his full and graphic descriptions of India, Africa, China, and the Eastern Archipelago must have been of no small use to his countrymen in the commencement of their distant voyages. The first of their Indian voyages was performed by ships which sailed from Holland in April, 1595, and rounded the Cape of Good Hope. A second large Dutch fleet sailed in 1598; and, so eager was the young republic to extend her commerce over the world that another fleet, consisting of five ships of Rotterdam, was sent in the same year by way of Magellan's Straits, under Jacob Mahu as admiral, with William Adams as pilot. Mahu died on the passage out, and was succeeded by Simon de Cordes, who was killed on the coast of Chili. In September, 1599, the fleet had entered the Pacific. The ships were then steered direct for Japan, and anchored off Bungo in April, 1600. In the very same year, 1598, a third expedition was despatched under Oliver van Noort, a native of Utrecht. The fleet left Holland in September, 1598, and entered the South Sea, through the Straits of Magellan, in February, 1600, after a tedious, and in truth unskilful, navigation of nearly a year and a half from the time of leaving Holland. After keeping along the west coast of America nearly as far as the line, Van Noort shaped a course for the Ladrone Islands, and arrived off Manila. In August, 1601, he anchored in front of Rotterdam, after an absence of three years, but the voyage contributed nothing to geography. The Dutch Company in 1614 again resolved to send a fleet to the Moluccas by the westward route, and Joris Spilbergen was appointed to the command as admiral, with a commission from the States-General. He was furnished with 4 ships of Amsterdam, 2 of Rotterdam, and 1 from Zeeland. On May 6, 1615, Spilbergen entered the Pacific Ocean, and touched at several places on the coast of Chili and Peru, defeating the Spanish fleet in a naval engagement off Chilca. After plundering Payta and making requisitions at Acapulco, the Dutch fleet crossed the Pacific and reached the Moluccas in March, 1616. At that time the Dutch Company had 37 sail of European shipping and 3000 troops in the East Indies.

Cape Horn rounded.

The Dutch now resolved to discover a passage into the Pacific to the south of Tierra del Fuego, the existence of which was ascertained by Sir Francis Drake. The vessels fitted out for this purpose were the "Eendracht," of 360 tons, commanded by Jacob le Maire, and the "Horn," of 110 tons, under Jan Schouten. They sailed from the Texel on June 14, 1615, and by the 20th of January, 1616, they were south of the entrance of Magellan's Straits. Passing through the strait of Le Maire they came to the southern extremity of Tierra del Fuego, which was named Cape Horn, in honor of the town of Horn in West Friesland, of which Schouten was a native. They passed the cape on the 31st of January, encountering the usual westerly winds. The great merit of this discovery of a second passage into the South Sea lies in the fact that it was not accidental or unforeseen, but was due to the sagacity of those who designed the voyage. On March 1 the Dutch fleet sighted the island of Juan Fernandez; and, having crossed the Pacific, the explorers sailed along the north coast of New Guinea, and arrived at the Moluccas on September 17, 1616. In 1623 the Dutch sent expeditions against Brazil and Peru, which, however, did little to advance geographical knowledge, except that the Brazilian invasion resulted in the valuable work of Nieuhof.

There were several early indications of the existence of the great Australian continent, which have been very

Exploration of Australia.

ably discussed by Mr. Major; and the Hollanders endeavored to obtain further knowledge concerning the country and its extent; but only its northern and western coasts had been visited before the time of Governor Van Diemen. Dirk Hartog had been on the west coast in latitude 26° 30′ S. in 1616. Pelsert struck on a reef called "Houtman's Abrolhos" on June 4, 1629. In 1697 the Dutch captain Vlamingh landed on the west coast of Australia in 31° 43′ S., and named the Swan River, where he saw some black swans. In 1642 the governor and council of Batavia fitted out two ships to prosecute the discovery of the south land, and entrusted the command to Captain Abel Jansen Tasman. This voyage proved to be the most important to geography that had been undertaken since the first circumnavigation of the globe. Tasman sailed from Batavia in the yacht "Heemskirk" on the 14th of August, 1642, and from Mauritius on the 8th of October. On November 24 high land was sighted in 42° 30′ S., which was named Van Diemen's Land, and, after landing there, sail was again made, and New Zealand (at first called Staten Land) was discovered on the 14th of December. Tasman communicated with the natives and anchored in what he called Murderer's Bay. From New Zealand it was resolved to steer eastward to longitude 220°, and then north. On this course the ships arrived at Tongatabu, one of the Friendly Islands of Cook; in April, 1643, they were off the north coast of New Guinea; and on June 15 Tasman returned to Batavia. In 1644 Tasman made a second voyage to effect a more full discovery of New Guinea.

French enterprise.

Champlain.

The French directed their enterprise more in the direction of North America than of the Indies. One of their most distinguished naval worthies was Samuel Champlain, a native of Brouage in Saintonge, whose friend and patron was Aymar de Chastes, governor of Dieppe, a devoted follower of Henry IV. Champlain after the close of the war with the League in Brittany, in which he served, made a remarkable journey through Mexico and the West India Islands from 1599 to 1602, and on his return he found that M. de Chastes was, undeterred by previous failures, resolved to undertake the establishment of a colony in Canada. Champlain was sent on a voyage of reconnaissance, and on his return he found that the Sieur de Chastes was dead. In 1603 the Sieur de Monts was named vice-admiral of the coasts of Acadia, and Champlain sailed with him from Dieppe. He was for some years engaged in surveying all the coasts of Acadia and Cape Breton, and in 1607 he returned to France with De Monts. In the following year another attempt was made. Champlain, with a colleague named Du Pont Gravé, sailed to the St. Lawrence, and on July 3, 1608, they first arrived at Quebec. In 1609 Champlain ascended the Iroquois to the lake which still bears his name. By 1611 a regular colony was established at Quebec; and in 1620 Champlain was installed as governor. He died towards the end of the year 1635. Champlain was an able navigator and a resolute explorer, and he made a very large addition to the knowledge of Canada and Acadia (Novia Scotia).

Halley.

The last expedition of the 17th century was purely scientific. In 1699 Edmund Halley, the astronomer-royal, in command of the "Paramour Pink," undertook a voyage to improve the knowledge of longitude, and of the variation of the compass. The results of his voyage were the construction of a variation chart, and proposals for finding the longitude by occultations of fixed stars.

Progress of navigation.

Cross-staff.

Finding longitude.

Variation of compass.

During the 17th century very considerable progress was made in the art of navigation, and in systematizing and delineating the vast mass of material that was accumulated by the ceaseless activity of explorers. The Dutch took the lead as map-makers. Mercator invented the useful projection which bears his name; and Ortelius, Hondius, and Hulsius compiled a series of valuable maps. In finding the latitude at sea, the astrolabe very generally gave place to the cross-staff, because the graduation of the latter was larger and more easily read off. The cross-staff was a very simple instrument, consisting of a graduated pole with cross pieces, called transversaries (of which there were four used according to the altitude), also graduated, which were fitted to work on it. The bearings of the sun were taken by compass, to ascertain when it was near the meridian; then the end of the long staff was placed close to the observer's eye, and the transversary moved until one end exactly touched the horizon, and the other the sun's centre. This was continued until the sun dipped, when the meridian altitude was obtained. The back-staff was an improvement on the cross-staff, invented by the great Arctic navigator John Davis. It was fitted with a reflector, and it was thus the first rough idea of the principle of the quadrant and sextant. The cross-staff was used for low altitudes, because both ends of the transversary could easily be seen at the same time, and the astrolabe for high altitudes. With the invention of these instruments came instructions for their use, and for working out observations. In England the first of these was *The Old Rutter of the Sea*, printed in 1490. Then followed the *Seaman's Secrets* of John Davis, and *A Regiment of the Sea, containing very necessary Matters with a perfect Sea Card*, by Thomas Hood, published in 1596. Hood also sold compasses constructed on Mr. Norman's principle, near the Minories. These manuals contained definitions, treatises on the use of the sea card and compass, tables of declination and rules for applying it, rules for dead reckonings and longitude, and instructions in the use of instruments. Latitude was obtained by observation, but longitude had usually to be reckoned on the chart from the meridian of Grand Canary, which in those days was used by all civilized countries. The differences of time between the eclipses of the moon at the place of the observer and the place for which it was calculated in the *ephemerides* for that day was another method in use of finding the difference of longitude. Mariners were also provided with tables giving the number of miles in a degree of longitude for every degree of latitude. Much attention was bestowed upon the phenomena of the variation and dip of the magnetic needle. Robert Norman, the hydrographer, discovered the dip or inclination of the needle in 1576, and in 1581 he observed the variation of the compass at London, and found it to be 11° 15′ E. In the same year his *Discourse of the Magnet or Loadstone* was published by Ballard. In 1580 Mr. Borough, comptroller of the navy, found the variation of the compass at Limehouse to be 11° 19′ E. It may be observed here that in 1657 there was no variation at London, and that it moved westerly until 1815, when it was 24° 27′ W. It is now returning eastwards.

By means of these rough instruments and calculations our Elizabethan navigators and their contemporaries succeeded in delineating the vast regions that were discovered. Thus the sum of human knowledge was augmented, while men's minds were enlarged, and the wealth and prosperity of nations were increased, through the provision of safe guides by which lands and seas could be traversed, and distant countries visited.

In the 18th century, to a far greater extent than had ever been the case before, geography began to be cultivated for its own sake, and expeditions were fitted out with the objects of discovery and of acquiring knowledge. The same objects also generally formed part of those enterprises which were avowedly undertaken for conquest, in the search of wealth, or from motives of religious zeal.

Board of Longitude.

Nautical Almanac.

Sextant.

The improvement of scientific apparatus naturally went hand in hand with the progress of discovery. The great desideratum was the means of finding the longitude; and it was the creation of a commission for the discovery of longitude in 1713 which, so far as England is concerned, gave the greatest stimulus to inventions connected with geographical research. To the Board of Longitude is due the conception of the *Nautical Almanac*, and the establishment of a surveying branch of the naval service. The *Nautical Almanac* first appeared in 1767, under the auspices of Dr. Maskelyne, the astronomer-royal, who, by furnishing tables of lunar distances, supplied another means of finding the longitude. The invention by Hadley, in 1731, of the quadrant for use at sea, which entirely superseded the astrolabe and cross-staff, was a still greater improvement; and it was soon followed by better instruments on the same principle—the sextants of Dollond and Troughton. The work of travellers on land also became more accurate in proportion as instruments and maps were improved. Early explorers by land were content with itineraries and maps which only indicated distances. The introduction of observations by compass bearings was an important improvement; and after the invention of Hadley's quadrant, these rough route surveys began to be checked and verified by astronomical observations.

Survey of China. The most remarkable example of the early application of these improvements is to be found in the survey of China by the Jesuit missionaries. They first prepared a map of the country round Peking, which was submitted to the emperor Kang-hi, and, being satisfied with the accuracy of the European method of surveying, he resolved to have a survey made of the whole empire on the same principles. This great work was commenced in July, 1708, and the completed maps were presented to the emperor in 1718. The records preserved in each city were examined, topographical information was diligently collected, and the Jesuit fathers checked their triangulation by meridian altitudes of the sun and pole star, and by a system of remeasurements. The result was a more accurate map of China than existed at that time, of any country in Europe. Kang-hi next ordered a similar map to be made of Tibet, the survey being executed by two lamas who were carefully trained as surveyors by the Jesuits at Peking. From these surveys were constructed the well-known maps which were forwarded to Duhalde, and from which D'Anville constructed his atlas.

Missions to Tibet. Several European missionaries had previously found their way from India to Tibet. Antonio Andrada, in 1624, was the first European to enter Tibet since the visit of Friar Odoric in 1325. The next journey was that of Fathers Grueber and Dorville about 1660, who succeeded in passing from China, through Tibet, into India. In 1715 Fathers Desideri and Freyre made their way from Agra, across the Himálayas, to Lassa, the capital of Tibet; and the Capuchin Friar Orazio della Penna resided at Lassa from 1735 until 1747. **Van de Putte.** But the most remarkable journey in this direction was performed by a Dutch traveller named Samuel Van de Putte. He is the only European who has ever completed the journey from India, through Lassa, to China, and returned to India by the same route. He left Holland in 1718, went by land through Persia to India, and eventually made his way to Lassa, where he resided for a long time. He went thence to China, returned to Lassa, and was in India in time to be an eye-witness of the sack of Delhi by Nadir Shah in 1737. In 1743 he left India, and died at Batavia on the 27th of September, 1745. The premature death of this illustrious traveller is the more to be lamented because his vast knowledge died with him. Two English missions sent by Warren Hastings to Tibet, one led by Mr. George Bogle in 1774, and the other by Captain Turner in 1783, completes the list of Tibetan explorers in the 18th century. **Persia.** From Persia much new information was supplied by Chardin, Tavernier, Hamilton, Thevenot, and Krusinski, and by English traders on the Caspian. In 1738 John Elton traded between Astrakhan and the Persian port of Enzelî on the Caspian, and undertook to build a fleet for Nadir Shah. Another English merchant, named Jonas Hanway, arrived at Astrabad from Russia, and travelled to the camp of Nadir at Kazvîn. One lasting and valuable result of Hanway's wanderings was a most charming book of travels. **India.** The extension of the dominions of the Company largely increased the knowledge of India. In 1700 Guillaume Delisle, the principal creator of the modern system of geography, published his map of the continents of the Old World; and his successor D'Anville produced his map of India in 1752. D'Anville's map contained all that was then known, but ten years afterwards Major Rennell commenced his surveying labors, which extended over a period from 1763 to 1782. His survey covered an area 900 miles long by 300 wide, from the eastern confines of Bengal to Agra, and from the Himálayas to Calpi. Rennell was indefatigable in collecting geographical information; his Bengal atlas appeared in 1781, his famous map of India in 1788, and the memoir in 1792. Surveys were also made along the Indian coasts, and the charts of Huddert, Ritchie, and M'Cluer were the forerunners of the more accurate and elaborate productions of the succeeding century.

Arabia. Arabia received very careful attention, in the 18th century, from the Danish scientific mission, which included Carsten Niebuhr among its members. Niebuhr landed at Loheia, on the coast of Yemen, in December, 1762, and went by land to Sana. All the other members of the mission died, and he proceeded from Mocha to Bombay. He then made a journey through Persia and Syria to Constantinople, returning to Copenhagen in 1767. His invaluable work, the *Description of Arabia*, was published in 1772, and was followed in 1774–78 by two volumes of travels in Asia. The great traveller survived until 1815, when he died at the age of eighty-two. **Bruce.** James Bruce of Kinnaird, the contemporary of Niebuhr, was equally devoted to Eastern travel. After studying Arabic and Geez for some years, he went out as consul to Algiers, and resided there from 1762 to 1765, exploring and sketching the Roman ruins in Algiers and Tunis. In 1765 he travelled by land from Tunis to Tripoli, and then took a passage for Candia, but was shipwrecked near Bengazi, and had to swim on shore. He eventually reached Candia, and, sailing thence to Sidon, travelled through Syria. In June. 1768, he landed at Alexandria in the dress of an Arab, and soon afterwards we hear of him at Jiddah, the port of Mecca, in the dress of a Turkish sailor. He had resolved to attempt the discovery of the source of the Nile; and in 1769 he landed at Massowah on the Abyssinian coast. He then penetrated to Axum and Gondar, and in November, 1770, he reached the source of the Abai, then supposed to be the main stream of the Nile. He thus attained the great object of his ambition. Returning by the desert into Egypt, Bruce reached England in 1774, and settled once more at his old home at Kinnaird after an absence of ten years. Urged by his old friend, Mr. Daines Barrington, the great traveller at length published his *Travels to Discover the Source of the Nile in the Years 1768–73* (5 vols. 4to) in 1790. Bruce, like many other conscientious and deserving explorers, was assailed by calumny and detraction. But every succeeding year has added to the high estimation in which his labors are held, and to the reverence with which his memory is cherished. He died at Kinnaird House, Stirlingshire, in 1794.

African Association. Before the death of Bruce an African Association was formed, in 1788, for collecting information respecting the interior of that continent, with Major Rennell and Sir Joseph Banks as leading members, and Bryan Edwards as secretary. The association first employed a Mr. Ledyard to cross Africa from east to west on the parallel of the Niger, and Mr. Lucas to cross the Sahara to Fezzan. Ledyard, who had previously made a most extraordinary journey into Siberia, died at Cairo in 1788. Lucas went from Tripoli to Mesurata, obtained some information respecting Fezzan, and returned in 1789. One of the chief problems the Association wished to solve was that of the existence and course of the river Niger, which Maxwell believed to be identical with the Congo. **Mungo Park.** Mungo Park, then an assistant surgeon of an Indiaman, volunteered his services, which were accepted by the Association, and in 1795 he arrived at the English factory of Pisania, 200 miles up the Gambia. Leaving this station in December he reached Ludamar, where a Moorish chief imprisoned him until the following July. He then crossed a mountainous tract to a Mandingo town called Kamalia. Quite destitute, and suffering from fever, he remained there for several months, but finally found his way back to Pisania, and returned to England. The interesting narrative of his adventures, with a geographical memoir by Rennell, was published in 1799. Five years afterwards he accepted an offer from the government to command an expedition into the interior of Africa, the plan being to cross from the Gambia to the Niger, and descend the latter river to the sea. Park left the factory of Pisania, on the Gambia, on the 4th of May, 1805, accompanied by Lieutenant Martyn and 35 soldiers, besides guides. All died but four during the rainy season, and the rest, including Mungo Park, perished in a rapid on the Niger, having been attacked from the shore by order of a chief who thought he had not received suitable presents. Park was only thirty-five at the time of his death. The details respecting the fate of the ill-fated explorer and his party were obtained from the guide.

Lacerda. While the English were at work in the direction of the Niger, the Portuguese were not unmindful of their old exploring fame. In 1798 Dr. Lacerda, an accomplished astronomer, was appointed to command a scientific expedition of discovery to the north of the Zambesi. He started in July, crossed the Muchenja Mountains, and reached the capital of the Cazembe, where he died of fever. Dr. Lacerda left a valuable record of his adventurous journey; but with Mungo Park and Lacerda the history of African exploration in the 18th century closes.

Arc of meridian measured. In South America scientific exploration was busily at work during this period. The great event of the century, as regards that continent, was the measurement of an arc of the meridian. The undertaking was proposed by the French Academy, and a commission left Paris in 1735, consisting of La Condamine, Bouguer, and Godin. Spain appointed two accomplished naval officers, the brothers Ulloa, as coadjutors. The operations were carried on during eight years on a plain to the south of Quito; and, in addition to his memoir on this memorable and most important measurement, La Condamine collected much valuable geographical information during a voyage down the Amazon. The arc measured was 3° 7′ 3″ in length; and the work consisted of two measured bases connected by a series of triangles, one north and the other south of the equator, on the meridian of Quito. Contemporaneously, in 1738, M. Maupertuis of St. Malo measured an arc of the meridian in Lapland. Another result of this expedition was the publication of a valuable work by the brothers Ulloa.

Buccaneers. The English and French governments despatched several expeditions of discovery into the Pacific and round the world during the 18th century. They were preceded by those wonderful and romantic voyages of the buccaneers, of such men as Woodes Rogers, Davis, Shelvocke, Clapperton, and Dampier, which can never fail to interest, while they are not without geographical value. The works of Dampier are especially valuable, and the narratives of William Funnell and Lionel Wafer furnished the best accounts then extant of the isthmus of Darien. Dampier's literary ability eventually secured for him a commission in the king's service; and he was sent on a voyage of discovery, during which he explored part of the coasts of Australia and New Guinea, and discovered the strait which bears his name between New Guinea and New Britain, returning in 1701. In 1721 Jacob Roggewein was despatched on a voyage of some importance across the Pacific by the Dutch West India Company, during which he discovered Easter Island on April 6, 1722.

The voyage of Lord Anson to the Pacific in 1740-44 was of a predatory character, and he lost more than half his men from scurvy; while it is not pleasant to reflect that at the very time when the French and Spaniards were measuring an arc of the meridian at Quito, the English under Anson were pillaging along the coast of the Pacific, and burning the town of Payta. But a romantic interest attaches to the wreck of the "Wager," one of Anson's fleet, on a desert island near Chiloe, for it bore fruit in the charming narrative of Byron, which will endure for all time. In 1764 Captain Byron himself was sent on a voyage of discovery round the world, which led immediately after his return to the despatch of another to complete his work, under the command of Captain Wallis.

Polynesian exploration. The expedition, consisting of the "Dolphin," commanded by Captain Wallis, and the "Swallow," under Captain Carteret, sailed in September, 1766, but the ships were separated on entering the Pacific from the Straits of Magellan. Wallis discovered Tahiti on June 19, 1767, of which island he gave a detailed account, and Sir Charles Saunders's Island; he returned to England on May 17, 1768. Carteret discovered the Charlotte and Gloucester Islands, and Pitcairn Island on July 2, 1767; revisited the Santa Cruz group, which was discovered by Mendaña and Quiros; and discovered the strait separating New Britain from New Ireland. He reached Spithead again on February 20, 1769. Wallis and Carteret were followed very closely by the French expedition of Bougainville, which sailed from Nantes in November, 1766. Bougainville had first to perform to him the unpleasant task of delivering up the Falkland Islands (Malouines), where he had encouraged the formation of a French settlement, to the Spaniards. He then entered the Pacific, and reached Tahiti on April 2, 1768. Passing through the New Hebrides group he touched at Batavia, and arrived at St. Malo after an absence of two years and four months.

Cook. The three voyages of Cook form an era in the history of geographical discovery. All his work was thoroughly and completely done. He systematically surveyed every land he discovered, collecting information touching every branch of inquiry, so that his labors form a very large addition to geographical knowledge. James Cook was born near Whitby, Yorkshire, in 1728, and had been marine surveyor of Newfoundland and Labrador from 1763 to 1767. In the latter year he commissioned the "Endeavor" and sailed for Tahiti, with the object of observing the transit of Venus, accompanied by Sir Joseph Banks and Dr. Solander, a pupil of Linnæus. The transit was observed at Tahiti on June 3, 1769. After exploring Tahiti and the Society group, Cook was six months surveying the two islands of New Zealand, and the coast of New South Wales from latitude 38° S. to the northern extremity. Passing through Torres Strait, he touched at Batavia, and arrived in England on June 12, 1771.

Cook's second voyage was mainly intended to explore the region round the Antarctic Circle; and it may be mentioned that meanwhile a French ship, commanded by M. Kerguelen, had sailed southwards in 1771, and discovered the island which bears his name. Captain Cook was provided with two vessels built at Whitby, the "Resolution," which he himself commanded, and the "Adventure," under Captain Furneaux, who had been with Wallis. After rounding the cape the two vessels reached a south latitude of 57° 15′. On March 26, 1773, Captain Cook arrived at New Zealand and proceeded to the Society Islands, whence he made another voyage southwards between the meridians of 170° E. and 106° 54′ W. On this occasion he was stopped by ice in 71° 10′ S. During the second voyage Cook visited Easter Island, discovered several islands of the New Hebrides and New Caledonia; and on his way home by Cape Horn, in March, 1774, he discovered the Sandwich Island group. Arrived at Spithead on July 30, 1774. The account of the second voyage was written by the young naturalist George Forster, whose subsequent work was so justly eulogized by Humboldt. The third voyage was intended to attempt the passage from the Pacific to the Atlantic by the north-east. The "Resolution" and "Discovery" sailed in 1776, and Cook again took the route by the Cape of Good Hope. In 1777 he was at the Friendly group, and on January 18, 1778, he discovered the Sandwich Islands. He then proceeded to the North American coast, and, after a stay of a month in Nootka Sound, he proceeded northwards, fixed the position of the western extremity of America, and surveyed Behring Strait. On August 17, 1778, he was stopped by the ice in 70° 41′ N., and named the farthest visible point on the American shore Icy Cape. He then visited the Asiatic shore and discovered Cape North, bearing up on August 29 when he was in the 180th degree of longitude. Returning to the Sandwich Islands, Captain Cook was murdered by the natives of Hawaii. On February 14, 1779, his second, Captain Clerke, took the command, and proceeding to Petropaulowski in the following summer, he again examined the edge of the ice, but only got to 70° 33′ N. The ships returned to England in October, 1780.

La Perouse. In 1785 the French Government fitted out a very carefully-prepared expedition of discovery at Brest, which was placed under the command of La Perouse, an accomplished and experienced officer. After touching at Concepcion in Chili, and at Easter Island, La Perouse proceeded to the Sandwich Islands, and thence to the coast of California, of which he has given a very interesting account. He then went across the Pacific to Macao, and in July, 1787, he proceeded to explore the Gulf of Tartary and the shores of Saghalien, remaining some time at Castries Bay, so named after the French minister of marine. Thence he went to the Kurile Islands and Kamchatka, and sailed from the far north down a meridian to the Navigator and Friendly Islands. He was in Botany Bay in January, 1788; and sailing thence, the explorer, his ship, and crew were never seen again. Their fate was long uncertain. In September, 1791, Captain D'Entrecasteaux sailed from Brest with two vessels, to seek for tidings. He visited the New Hebrides, Santa Cruz, New Caledonia, and Salomon Islands, and made careful though rough surveys of the Louisiade Archipelago, islands north of New Britain, and part of New Guinea. D'Entrecasteaux died on board his ship on July 20, 1793, without ascertaining the fate of La Perouse. It was Captain Peter Dillon who at length ascertained, in 1828, that the ships of La Perouse were wrecked on the island of Vanikoro during a hurricane.

Bligh. The work of Captain Cook bore fruit in many ways. His master, Captain Bligh, was sent in the "Bounty" to convey breadfruit plants from Tahiti to the West Indies. He reached Tahiti in October, 1788, and in April, 1789, a mutiny broke out, and he, with several officers and men, was thrust into an open boat in mid-ocean. During the remarkable voyage he then made to Timor, Captain Bligh passed amongst the northern islands of the New Hebrides, which he named the Banks Group, and made several running surveys. He reached England in March, 1790. The "Pandora," under Captain Edwards, was sent out in search of the "Bounty," and discovered the islands of Cherry and Mitre, east of the Santa Cruz group, but she was eventually lost on a reef in Torres Strait. In 1796–97 Captain Wilson in the missionary ship "Duff," discovered the Gambier and other islands, and rediscovered the islands known to and seen by Quiros, but since called the Duff Group. Another result of Captain Cook's work was the colonization of Australia. On January 18, 1788, Admiral Phillip and Captain Hunter arrived in Botany Bay in the "Supply" and "Sirius," followed by six transports, and established a colony at Port Jackson. Surveys were then undertaken in several directions. In 1795 and 1796 M. Flinders and G. Bass were engaged on exploring work in a small boat called the "Tom Thumb." In 1797 Bass, who had been a surgeon, made an expedition southwards, continued the work of Cook from Ram Head, and explored the strait which bears his name, and in 1798 he and Flinders were surveying the east coast of Van Diemen's Land. The planting of a colony at Port Jackson led to the despatch of an expedition to complete the exploration of the Australian coasts. The command was given to Captain Matthew Flinders. He was furnished with a vessel called the "Investigator," and sailed from England on July 18, 1801. Commencing from King George's Sound, Captain Flinders discovered and made a preliminary survey of all the south coast of Australia to Bass Strait, and the east coast from the barrier reef to Torres Strait, as well as the east coast of the Gulf of Carpentaria. Flinders met the French expedition under Baudin and Freycinet with the two ships "Géographe" and "Naturaliste," which was engaged upon the same work. He was taken prisoner by the French in 1804 and detained until 1810, so that his work did not appear before 1814.

Australian colonization.

Flinders.

Vancouver.

Yet another out-come of Captain Cook's work was the voyage of George Vancouver, who had served as a midshipman in Cook's second and third voyages. The Spaniards under Quadra had commenced a survey of north-western America and occupied Nootka Sound, which their Government eventually agreed to surrender. Captain Vancouver was sent out to receive the cession, and to survey the coast from Cape Mendocino northwards. He commanded the old "Discovery," and was at work during the seasons of 1792, 1793, and 1794, wintering at the Sandwich Islands. Returning home in 1795, he completed his narrative and very valuable series of charts, and died in 1798.

Hudson's Bay Company.

The 18th century saw the Arctic coast of North America reached at two points, as well as the first scientific attempt to reach the North Pole. The Hudson's Bay Company had been incorporated in 1670, and its servants soon extended their operations over a wide area to the north and west of Canada. In 1741 Captain Christopher Middleton was ordered to solve the question of a passage from Hudson's Bay to the westward. Leaving Fort Churchill in July, 1742, he stood northwards and discovered the Wager River and Repulse Bay, bearing up again on August 9. He was followed by Captain W. Moor in 1746, and Captain Coats in 1751, who examined the Wager Inlet up to the end. On November 6, 1769, Samuel Hearne was sent by the Hudson's Bay Company to discover the sea on the north side of America, but was obliged to return. On February 23, 1770, he set out again from Fort Prince of Wales; but, after great hardships, he was again forced to return to the fort. He started once more on December 7, 1771, and at length reached the Coppermine River, which he surveyed to its mouth, but his observations are very unreliable. With the same object of reaching the sea, Alexander Mackenzie, with a party of Canadians, set out from Fort Chepewyan on June 3, 1789, and descended a river which bears the explorer's name. His account of the journey is even more unsatisfactory than that of Hearne.

Polar exploration.

In February, 1773, the Royal Society submitted a proposal to the king for an expedition to try how far navigation was possible towards the Pole. The "Racehorse" and "Carcass" bombs were selected as best adapted for the service, and Captains Phipps and Lutwidge were appointed to command them. The expedition sailed on June 2, 1773, and sighted the coast of Spitzbergen on the 28th. Captain Phipps stood into every opening he could find in the ice, but was invariably stopped by a solid barrier. He examined a line extending over twenty degrees of longitude, and found no opening in the heavy polar pack in any direction. After a very careful and persevering examination of the ice, the expedition returned to England in September. The highest latitude reached was 80° 48′ N. But the most important Arctic work in the 18th century was performed by the Russians, for they succeeded in delineating the whole of the northern coast of Siberia. Some of this work, indeed, was done at a still earlier date. The Cossack Deschneff made an extraordinary voyage, in the summer of 1648, from the river Kolyma, through Behring Strait to Anadyr, a performance which has never since been equalled. Between 1738 and 1750 the mates Manin and Sterlegoff made their way in small sloops from the mouth of the Yenisei as far north as 75° 15′ N. The land from Taimyr to Cape Chelyuskin, the most northern extremity of Siberia, was mapped by the mate Chelyuskin, who discovered the extreme point in May, 1742. To the east of Cape Chelyuskin the Russians encountered greater difficulties. They built small vessels at Yakutsk on the Lena, 900 miles from its mouth, whence the first expedition was despatched under Lieutenant Prontschicheff in 1735. He sailed from the mouth of the Lena to the mouth of the Olonek, where he wintered, and on September 1, 1736, he got as far as 77° 29′ N., within five miles of Cape Chelyuskin, which is in 77° 34′ N. Both he and his young wife died of scurvy, and the vessel returned. A second expedition under Lieutenant Laptieff, started from the Lena in 1739, but encountered masses of drift ice in Chatanga bay, and with this ended the voyages to the westward of the Lena. Several attempts were also made to navigate the sea from the Lena to the Kolyma. In 1736 Lieutenant Laptieff sailed, but was stopped by the drift ice in August, and in 1739, during another trial, he reached the mouth of the Indigirka, where he wintered. In the season of 1740 he continued his voyage to beyond the Kolyma, wintering at Nijni Kolymsk. In 1725 Vitus Behring, a Dane in the Russian service, received his instructions from Peter the Great a few days before the czar's death. Two vessels were built for Behring at Okhotsk, and sailing in July, 1728, he ascertained the existence of the strait between Asia and America which bears his name. In September, 1740, Behring again sailed from Okhotsk, with Steller on board as naturalist. In June, 1741, Commodore Behring named the magnificent peak on the coast of North America Mount St. Elias, and explored the Aleutian Islands. In November the ship was wrecked on Behring Island; and the gallant Dane, worn out with scurvy, died there on the 8th of December, 1741. In March, 1770, a merchant named Liakhoff saw a large herd of reindeer coming from the north to the Siberian coast, which induced him to start in a sledge in the direction whence they came. Thus the New Siberian Islands were discovered, and for years afterwards the seekers for fossil ivory resorted to them. The Russian Captain Vassili Tchitschakoff in 1765 and 1766 made two persevering attempts to penetrate the ice north of Spitzbergen, and reached to 80° 30′ N., and Russian parties twice wintered at Bell Sound. But the result was the same as all others have obtained before and since; the Spitzbergen route is evidently not the way to the Pole.

Russians in Siberia.

Collections of voyages.

The 18th century saw great progress in the collection and arrangement of geographical material, and in the work of surveying and map-making. Collections of voyages and travels were brought together in the four quarto volumes of Astley (1745) and the two folios of Harris (1764); while Dr. Hawkesworth edited the Government voyages to the Pacific in 1773. Sir Joseph Banks was the great patron of geography in England, aided by the indefatigable labors of such critical geographers as Rennell, Dalrymple, and Barrington; while in France the great cartographer D'Anville introduced a habit of critical accuracy, and caused a complete revolution in the art of map-making.

Towards the close of the century it was recognized that geography served more extensive and important uses than

Surveys. **Classes of maps.**

had ever before been supposed. The route survey was sufficient for the traveller or soldier, while accurate charts guided the mariner across the ocean. But surveys are also the basis of statistics and of administration, and rigorous accuracy became necessary. Surveys on a trigonometrical basis, which have been proceeding in all the countries in Europe (except Turkey) and in India during the present, were commenced in the last century. In Great Britain the Ordnance Survey was begun in April, 1784, when General Roy measured a base line on Hounslow Heath. The triangulation of the British Isles was commenced in 1784 and completed in 1852. Maps based on trigonometrical surveys may eventually explain and illustrate the physical aspect of the whole globe, but at present they are necessarily confined to those nations which are in the front rank of civilization. Countries which are not so advanced are still obliged to be content with such maps as sufficed for all the world in the last century, before the results of trigonometrical surveys were available. These secondary maps are adapted for the requirements of the countries which use them, being based on positions fixed by astronomical observations, on cross bearings, and often on chained distances. The third class of maps includes the work of explorers of unknown or little known regions, and of geographers who delineate the features of such regions by compilation and by intelligent collation of the work of travellers. There are thus three grand divisions in the character and uses of maps. There are first those which aim at minute accuracy, and which are intended as documents for administrative purposes, and in pursuing exact statistical investigations. Secondly, there are maps which are based on less accurate surveys of countries less populous or less advanced in civilization; these are useful for political, geographical, and military purposes, but are not to be relied on to the same extent or in the same way as is the case with those based on trigonometrical surveys. Thirdly, there are the roughly compiled maps of little known regions, which are constantly in course of improvement, and which do the work of pioneers.

In treating here of the progress of geographical discovery in the present century, it is to those who prepare the last class of maps, to the pioneers—the discoverers—that we must mainly, though not exclusively, confine our attention. We propose to review the work of discoverers and explorers of the 19th century in two sections as regards time,—first during the first thirty, and secondly during the last forty-eight years. The Royal Geographical Society was founded in 1830, and forms a landmark. In each period we shall take first the work done in Asia, then Africa, then America, then Australia, then Polynesia, and finally the Arctic and Antarctic regions.

Work in India.

At the beginning of the century British rule in India was extended over the plains of the Ganges almost to the Sutlej, and the attention of explorers was drawn to the mighty mass of the Himálayas. Captain Herbert, in 1818, attempted to give a general view of the physical character of this great range, and Moorcroft reached the Mansarowa lake, and the upper courses of the Indus and Sutlej; while Mr. Manning, in 1811, was the only Englishman who ever visited Lassa, the capital of Tibet. The mission of Sir John Malcolm to Persia in 1808 led to much geographical work being achieved. On his staff was Macdonald Kinneir, who wrote a valuable memoir on the geography of Persia; while at the same time Lieutenant J. Macartney, under Mountstuart Elphinstone, was collecting materials for a map of Afghanistan. In 1810 Pottinger and Christie made an important journey through Baluchistan by different routes, Christie afterwards visiting Herat and Yezd; and in 1827 Mr. Stirling of the Bengal Civil Service crossed the Hazárah mountains.

Africa.

The close of the war in 1815 led to numerous efforts for the furtherance of geographical discovery, especially in Africa and the far north. In 1818 to 1820 Captain Lyon, R. N., and Mr. Ritchie landed at Tripoli, and penetrated as far as Mourzouk; and this led to the more important expedition of Major Denham and Captain Clapperton, R. N., which was despatched by the Government. They landed at Tripoli in 1823, and advanced into the interior as far as the east coast of Lake Tchad, of which they gave a most interesting account, obtaining latitudes by meridian altitudes and longitudes by lunar observations. Clapperton's furthest point was at Saccatoo, westward of the lake, and here he was forced to turn back. But in 1825 he was again employed to explore the interior of Africa, and this time he started from the Atlantic side with his faithful servant Richard Lander. Landing in the Bight of Benin, he succeeded in reaching Saccatoo from the west side, thus completing a route from Tripoli on the Mediterranean to the coast of Guinea. But at Saccatoo the gallant sailor succumbed at last, dying on the 13th of April, 1827. His faithful servant Lander returned to the coast; and in 1830 he and his brother were employed to explore the course of the Niger or Quorra. They embarked on the river near Boossa, passed through the Yorriba country, and came out at the mouth of the Nun.

The Admiralty also considered that a river of such magnitude as the Zaire or Congo ought to be explored. Captain Tuckey, R. N., was selected to conduct the Congo expedition, and received command of a steamer called the "Congo," with a crew of 49 officers and men. The expedition reached the mouth of the great river on July 5, 1816, and proceeded up to the foot of the falls of Yellala, the farthest point hitherto reached. Captain Tuckey, with 15 of his party, landed on the north shore on the 14th of August; and, after travelling for about 40 miles over a hilly country, he reached the head of the falls and the banks of the upper river. He had explored the river for a distance of 280 miles from the sea. But death overtook the commander of the expedition and several officers, and the "Congo" returned in command of the master, Mr. Fitzmaurice, after executing the survey from the foot of the falls to Embomma.

South America. **Humboldt.**

South America had produced two eminent physical geographers, namely, Caldas of Bogota and Unanue of Lima, before the scenery of the Orinoco and the Andes became familiar to Europe through the charming narratives of Humboldt. It was in 1799 that the great Prussian naturalist embarked at Coruña, and landed at Cumana on the coast of Venezuela. His observant eye and bright imagination, combined with habits of scientific thought, produced pictures of the physical aspects of the regions he explored which are quite unequalled. What he said of George Forster is even more true of himself: "He depicted in pleasing colors the changing stages of vegetation, the relations of climate and articles of food in their influence on the civilization of mankind. All that can give truth, individuality, and distinctiveness to the delineation of exotic nature is united in his work." The Orinoco and Cassiquiari, the falls of Tequendama, the mountains of Quindiu, Chimborazo, and Quito, Cajamarca, and the upper Amazon, and the varied scenery of Mexico, are imprinted on the imagination with life-like form and coloring by this great master of description. His service to geography was far greater than that of any mere discoverer. Humboldt left the New World in 1804.

Arctic discovery.

The greatest and most important enterprise, after the peace of 1815, was the renewal of Arctic exploration under the auspices of Sir John Barrow. To the great work of Scoresby, and to the careful observations of himself and his father, we are indebted for the most exhaustive account of the Spitzbergen seas, and of the ice which encumbers them, When the Government expeditions were undertaken, the volumes of Scoresby formed a storehouse of useful and well-digested information. The true object of modern Arctic enterprise has been the advancement of science, a noble and sufficient reason for incurring expenditure and facing dangers and hardships. In consequence of Sir John Barrow's representations, orders were given in 1818 for the preparation of four vessels for Arctic service, —two to attempt the passage from the Atlantic to the Pacific, and two to attempt an approach to the North Pole. But, as Sir John Barrow himself explained, the main objects were not the accomplishment of voyages by these routes, but the acquisition of useful knowledge. Sir John Ross, who commanded one of the two expeditions, circumnavigated Baffin's Bay on the track of that great navigator, and re-established his fame. Captain Buchan, who led the other, battled with the impenetrable pack to the north of Spitzbergen, like Phipps before him, and then returned. There can be no great success without continuity of effort and perseverance, and the early voyages of this century achieved lasting results, because those who sent them out were endowed with tenacity of purpose. No sooner had Ross returned than Parry was appointed to command two strongly built vessels, the "Hecla" and "Griper," and to proceed on the same service. On the 11th of May, 1819, Parry sailed, and on the 1st of August he entered the portals of Lancaster Sound, and commenced the discovery of a new region. He succeeded in sailing for 300 miles along the southern shores of the islands which now bear his name, among ice floes of moderate thickness, until he reached the edge of the impenetrable polar pack at the western extreme of Melville Island. He went as far as it will ever be possible for any vessel to go in this direction, and then wintered in a harbor of Melville Island. In 1820 he returned with a rich harvest of scientific observations, and of valuable information in all branches of inquiry. This first expedition was most successful. Parry's second voyage was into Hudson's Bay in search of a passage westward in that direction. He discovered a strait (that of "Fury and Hecla"), and passed two winters (1821–23) on the coast of Melville Peninsula. The third voyage (1824–25) was again up Baffin's Bay; but it was unsuccessful, and one of his vessels, the "Fury," was lost. Still every voyage, whether successful or not in its main object, brought back valuable results. Meanwhile the "Griper," commanded by Captain Clavering, had, in 1823, penetrated through the ice to the east coast of Greenland in 76° N., to enable Captain Sabine to take pendulum observations in that position. The Russian Captain Lutke had also surveyed the west coast of Novaya Zemlya from 1821 to 1824. Parry, after his return from the third voyage, proposed an attempt to reach the Pole by travelling over the ice during the summer, on the Spitzbergen meridians. He sailed on this service in the "Hecla" on the 3d of April, 1827, and, after placing her in a secure harbor in Spitzbergen, he began his bold and interesting attempt with two boats, fitted with runners for being dragged over the ice. But the whole mass of ice was drifting south faster than Parry's men, with all their efforts, could advance north. However, on July 23, 1827, he attained the latitude of 82° 45′ N., which continued to be the highest parallel ever reached by man until Captain Markham went beyond it in 1875. Parry returned to England in October. Another expedition of a private character left England in June, 1829, under the command of Sir John Ross, who was accompanied by his distinguished nephew James C. Ross. In August they reached Lancaster Sound, and then proceeded southwards down Regent's Inlet, wintering on the most northern peninsula of America, to which Ross gave the name of Boothia. Here they passed three winters, while, during the intervening summers, some exploring work was accomplished, and James Ross planted the Union Jack on the North Magnetic Pole on the 1st of June, 1831. At last they were forced to abandon their little vessel the "Victory," and make their way to the whalers in Baffin's Bay in open boats. They were picked up and arrived in England after an absence of four years.

Parry.

While these bold and perilous voyages were being conducted in the Arctic seas, a series of land journeys completed the delineation of the northern coast of America, which had just been touched at two points in the last century, by Hearne and Mackenzie. From 1819 to 1823 the gallant Sir John Franklin, with Dr. Richardson and George Back, were struggling to explore the Arctic coast eastward from the mouth of the Coppermine River. After great sufferings they embarked on the river on June 30, 1820, reaching the mouth on July 18, and exploring 550 miles of coast line to the eastward, as far as Point Turnagain. On the return journey across the barren lands, the party escaped death from starvation almost by a miracle. Undaunted by this terrible experience, Franklin, Richardson, and Back started on another expedition in 1825, this time by descending the Mackenzie River. Reaching its mouth on July 7, Franklin and Back discovered 374 miles of coast to the westward, as far as Return Reef; while Richardson explored the space between the mouths of the Mackenzie and Coppermine. In 1833 Back undertook a third journey with the object of succoring the Rosses, who had long been missing. He discovered and explored the Back or Great Fish River for 530 miles, and in July, 1834, reached its mouth in the Arctic Ocean. The gaps on the north coast, which were left by Franklin and Back, were subsequently filled in by servants of the Hudson's Bay Company. In 1837 Messrs. Simpson and Dease, in a boat, connected Return Reef with Cape Barrow. In 1839 the same explorers went from Cape Turnagain to the mouth of Back's River, and still further eastward to Castor and Pollux River. On August 26, 1839, Simpson built a cairn at Cape Herschel, on King William Island, separated by a strait ten miles wide from the mainland. Dr. Rae was sent in 1846 to winter in Repulse Bay, and in 1847 he travelled round the Gulf of Akkoolee and connected the work of Ross in Boothia with that of Parry during his second voyage. In 1854 he united the work of Ross with that of Simpson, and ascertained that Boothia was connected with the mainland of America by an isthmus. Thus the whole northern coast of America was explored and delineated without a break.

The Russians were engaged on daring Arctic exploration at the same time. In 1809 to 1812 a Russian officer named Hedenstrom surveyed the New Siberia Islands; and in 1821 Lieutenant Anjou made further investigations respecting the state of the ice to the northward. Baron Wrangell prosecuted similar researches from his headquarters at Nijni Kolymsk, near the mouth of the Kolyma. He made four sledge journeys over the Polar Sea from 1820 to 1823, exploring the coast from the Kolyma to Cape Chelagskoi, and making several attempts to advance northwards, but always encountering weak ice. Wrangell's interesting narrative is an important addition to Arctic literature.

Exploration of the Pacific.

The Russians, as well as the French, sent several voyages into the Pacific during the first half of the 19th century. In 1804 Admiral Krusenstern made a voyage round the world, and his pupil, Otto von Kotzebue, son of the dramatist, commanded the "Rurick" from 1815 to 1818 on a voyage of discovery. He discovered the great bay known as Kotzebue Sound, sounded in Behring Strait, and made careful observations of the currents. Wintering in California he returned to the Aleutian Islands in the following spring; and during the voyage homewards he discovered several new islands in the Pacific, especially Romanzoff and Krusenstern in the Dangerous Archipelago. During another Russian voyage, commanded by Billinghausen, Lazareff and other coral islands in the Dangerous Archipelago were discovered, and in 1828 Captain Lutke, in the "Seniavine," surveyed the Caroline group. Captain Freycinet, the officer who served with Baudin and edited his work, also examined the Caroline Islands in the "Uranie" in 1819, but his voyage was mainly in the interests of natural history. Duperry in 1822–23 did some surveying work on the coast of New Ireland. But the most important French voyage was that of Dumont D'Urville, who was sent out to seek for traces of La Perouse in 1828. He visited Tecopia and other islands in the "Astrolabe," and was nearly a month at Vanikoro collecting relics of the ill-fated expedition. The voyage of D'Urville contributed largely to the advancement of science, and resulted in the publication of a magnificent work in 1830.

The only English scientific voyage to the Pacific in this period was sent out mainly to co-operate with Parry in his third voyage, and Franklin in his second journey. It was commanded by Captain Beechey, who had been first lieutenant with Parry during his first Arctic voyage, and on May 19, 1825, he sailed from Spithead in H.M.S. "Blossom." After visiting Easter, Gambier, Pitcairn, and other islands, the "Blossom" arrived at Honolulu on May 20, 1826, and in July she was in Behring Strait, entering Kotzebue Sound on the 22d. Proceeding along the north coast of America, the ship's barge got as far as 156° 21′ W. to a low cape called Point Barrow, at the very time when Franklin and Back were at Return Reef. The accurate examination of the coast was made under circumstances which demanded great fortitude and perseverance, and reflects credit on the officers and crew. The "Blossom" returned to Honolulu in January, 1827, and arrived at Macao on the 12th of April. Captain Beechey next proceeded to survey the Loo Choo and Bonin Islands, and, after another visit to the far north, and the coasts of California and Mexico, he returned home by Cape Horn and arrived at Woolwich on October 12, 1828. His valuable and interesting narrative, in two volumes, was published in 1831. Mr. James Weddell, a master in the navy, made a voyage to the Antarctic Ocean in 1822–24, and went as far south as 74°.

Royal Geographical Society.

The Royal Geographical Society was founded in 1830, and forms a landmark in the history of discovery. The men who initiated the idea and gave it shape were Sir John Barrow, Sir John Cam Hobhouse, Sir Roderick Murchison, Mr.

Robert Brown (*Princeps Botanicorum*), and Mr. Bartle Frere. They formed the Foundation Committee. The first president was Lord Goderich, and the vice-presidents Sir John Barrow, Colonel Leake, Sir John Franklin, and Mr. Greenough. Through this organization explorers and students were encouraged and assisted, information was systematically collected and arranged, and the work of discovery was advanced. A similar society in Paris preceded that of London in point of time, and now every civilized country has established a Geographical Society.

Asia.

Our rapid review of the progress of discovery since the foundation of the Geographical Society will commence with the continent of Asia, where there were and still are vast and most interesting unexplored regions. In British India the Trigonometrical Survey has been proceeded with, and is now approaching completion. Himálayan peaks. During its progress the Himálayan peaks were measured, and in 1845 Sir Andrew Waugh fixed the height of the loftiest, which he named Mount Everest, at 29,002 feet above the sea. In 1831 Humboldt published his *Asie Centrale*, which, with the *Erdkunde von Asien* of Carl Ritter, gave new and clearer ideas of the orography of Central Asia. Many travellers explored the remoter parts of the Himálayan chain; while, in 1848, Dr. Hooker in Sikkim, and Dr. Thompson in Ladak, reached the summits of the passes leading to Tibet and Yarkand. Central Asia. Our relations with Afghanistan led to further exploration. In 1840 Lieutenants Abbott, Conolly, and Shakespear visited Khiva, and in 1841 Colonels Stoddart and Conolly were murdered at Bokhara, while Eldred Pottinger gallantly defended Herat. Sir Alexander Burnes had previously made his remarkable journey from Cabul to Bokhara and back through Persia, and in 1838 Lieutenant Wood of the Indian Navy discovered the source of the Oxus. Butakoff and other Russian officers, in 1848 and subsequent years, surveyed the sea of Aral, and Middendorf made extensive explorations and discoveries in Siberia. After the Afghan war it was long before any progress was made in the exploration of Central Asia, but through the opening of the treaty ports in China and the navigation of the Yangtsze a considerable increase was made in our knowledge of the Celestial Empire. In 1869 Mr. R. B. Shaw and Mr. Haywood reached the cities of Yarkand and Kashgar, and Mr. Shaw published a most graphic account of the physical aspects of Eastern Turkestan. In the previous year Mr. Ney Elias surveyed the Yellow River of China, and afterwards made a journey through a previously unknown portion of western Mongolia; and during 1866–68 the distinguished French geographer Lieutenant Garnier surveyed the course of the great Cambodian river. The Russians, meanwhile, in their advance into Central Asia, had enabled scientific travellers like Fedchenko and others to explore Khokand and the northern part of the Pamir, and the more adventurous Prjewalski made important journeys through Mongolia and to the frontiers of Tibet. Colonels Walker and Montgomerie, of the great Trigonometrical Survey of India, organized a system of training native explorers, who made journeys across the Pamir and to the upper waters of the Oxus, as well as through the previously unknown parts of Tibet. In the last mission of Sir Douglas Forsyth to Kashgar, Captain Trotter of the Trigonometrical Survey of India formed one of the staff. He did much valuable exploring work on the Pamir table-land, and verified the work of Lieutenant Wood at the source of the Oxus. In 1845 MM. Huc and Gabet travelled through Tibet; and in Western China the French missionaries have since done useful geographical work. English diplomatic officers have found their way from the south-western provinces of China into Burmah, and Baron Richthofen has made very extensive exploring journeys through the Chinese empire. The most important journey across Arabia in the present century was made by Mr. W. Gifford Palgrave in 1863.

Africa.

Geographical discoverers of the 19th century have had a great work to do in Africa. D'Anville and his successors cleared off all that was uncertain on the map, all that had come from the information given by Duarte Lopez to Pigafetta, and from Leo Africanus, and left a great blank. James Bruce and Mungo Park, Clapperton and Tuckey, merely touched the edges or penetrated in single lines across the vast unknown area. But they have been followed by many others, and now great progress has been made. In 1831 Monteiro and Gamitta were sent by the Portuguese Government, in the footsteps of La Cerda, to the capital of Cazembe; while, in 1849 and 1843–47, Ladislaus Magyar and Graça explored some of the southern affluents of the Congo. Abyssinia. Rüppell (1838), Harris (1843), and Dr. Beke (1840), Lefebvre and Dillon (1839–43), Ferret and Galinier (1847) improved the existing knowledge of Abyssinia, to which a further important contribution was made by the expeditionary field force sent in 1867–68 to enforce the release of English captives; and progress was made, under the auspices of the Egyptian Government, in exploring the White Nile above Khartoum. In 1849 the discoveries of Denham and Clapperton were followed up by Richardson, Overweg, and Barth, who, like their predecessors, went from Tripoli to Mourzouk, the capital of Fezzan. The two first died in Africa, but Dr. Barth returned home with a rich harvest of results. He reached Kouka the capital of Bornou, on Lake Tchad, and in 1851 he visited the south side of that lake, and advanced some distance to the eastward. In 1852 he was at Saccatoo, where Clapperton died, whence he crossed the Niger and eventually reached Timbuctoo. After a stay of some months Dr. Barth left Timbuctoo in March, 1854, and got back to Tripoli in the end of 1855, being the sole survivor of his party. Dr. Vogel, in 1853–57, followed up the discoveries in the direction of Lake Tchad, and fell a victim to science; and the researches of Dr. Baikie in 1854 supplemented the work of the Landers in the lower part of the course of the Niger. Dr. Baikie also explored 250 miles of the river Chadda or Benue.

On the eastern coast of Africa, the missionaries Rebmann and Krapf ascertained the existence of the snowy peaks of Kenia and Kilimanjaro near the equator, and collected reports touching the equatorial lakes in the interior. Burton. This led to the expedition of Captain Burton in 1857, who, accompanied by Captain Speke, landed opposite to Zanzibar, and, advancing westward, discovered Lake Tanganyika. Captain Burton's admirable description of the region between the coast and the great lake he had discovered is one of the most valuable contributions to African descriptive geography. Speke. His companion, Captain Speke, made an excursion northwards to the southern coast of a lake which he judged to be a main source of the Nile. In this belief he again set out in 1860 to attempt the achievement of a journey from Bagamoyo, opposite Zanzibar, to the Nile. This great enterprise was crowned with success. Speke traced out the western shore, and visited the northern outlet of the Victoria Nyanza, the main reservoir of the White Nile. He then marched northwards to Gondokoro and descended the Nile. He had heard of a second great Nile reservoir, which Sir Samuel Baker discovered in 1864, and named the Albert Nyanza. The Bahr el Ghazal and other western feeders of the Nile were visited by Consul Petherick, and explored in 1868–71 by Dr. Schweinfurth, whose work ranks with that of Burton as a record of African discovery.

Livingstone.

The travels of Dr. Livingstone in Southern Africa also added considerably to our knowledge of the geography of that continent. In 1848 he started from Cape Colony, visited Lake Ngami in 1849, and eventually reached the Portuguese town of St. Paul Loanda in 1855. Thence he marched across the continent, discovering the great falls and a considerable part of the course of the Zambesi. In his second expedition he proceeded up the Zambesi and its tributary the Shire, and discovered the Lake Nyassa. On his third and last expedition he landed on the east coast at the mouth of the Rovuma, and made his way thence to Lake Nyassa. The great traveller then followed in the footsteps of Dr. Lacerda and Monteiro to the Cazembe's capital, and thence to Lake Tanganyika. From Ujiji, on that lake, he made his way westward to the river Lualaba (the upper course of the Congo), and returning in a destitute condition to Ujiji, he was there succored by Mr. Stanley. Finally he once more started, and died in the midst of his discoveries among the remoter sources of the Congo. Cameron. Lieutenant Cameron's expedition in 1873 had for its main object the succor of Livingstone, but the news of the great traveller's death was received at Unyanyembe. Cameron then continued his march by a new route to Ujiji, and completed the survey of the southern half of Lake Tanganyika, discovering the Lukuga outlet. Thence he advanced westward across the Manyuema country to Livingstone's furthest point at Nyangwe, crossed the Lualaba, and traversed the whole width of the African continent, reaching St. Paul Loanda on the west coast. **Stanley.** Mr. Stanley followed in 1874. He circumnavigated and fixed the outline of the Victoria Nyanza, followed Cameron across Lake Tanganyika to Nyangwe, and then descended the great River Congo, discovering its course, and connecting the work of Livingstone with that of Tuckey. Mr. Young has since completed the survey of Lake Nyassa; Nachtigal has supplemented the work of Barth and Vogel in the Tchad region; while Duveyrier and other French explorers have examined the region of Sahara. In the far south the Limpopo basin, and the country intervening between the Limpopo and Zambesi, have been made known to us by St. Vincent Erskine and Elton, Carl Mauch and Baines. Thus the extent of the unknown parts of Africa has been rapidly curtailed, while our knowledge has been widened during the last half century.

American surveys. On the American continent scientific progress has been made in the United States and the dominion of Canada, where, within the last half century, boundary commissions and surveys have fixed positions and described previously unknown regions of great extent. **South America.** In South America there are vast unexplored regions to the eastward of the Andes, and in the basins of the great rivers. Sir Robert Schomburgk did much valuable work in Guiana, and explored the delta of the Orinoco in 1841; while Spix and Martius, Poeppig and Castelnau, Maw and Smyth, Herndon and Gibbon, Spruce and Bates, Wallace and Chandless, and others, explored the basin of the Amazon. The labors of Pissis in Chili, of Raimondi and Werthermann in Peru, of Codazzi in Colombia and Venezuela, and of Morales and others in the Argentine Republic, have been most valuable to geographical science. In Patagonia, Fitz Roy and King explored the Santa Cruz river, Cox and Morales have since added to our knowledge, and Commander Musters, R. N., was the first traveller who traversed the whole of Patagonia from south to north, 960 miles of latitude, of which 780 were previously unknown to Europeans.

Australia. The difficulty of exploring the interior of the Australian continent was caused by the scarcity of water, and the immense distances it was necessary to cross without supplies of any kind. Hence the work of exploration has required and called forth high and noble qualities in a degree quite equal to any that have been recorded in any other part of the world. The names of Sturt and Leichhardt, of Eyre and Grey, of Macdouall Stewart and Burke, of Gregory, of Forrest and Warburton, will be handed down as those of intrepid and courageous explorers who laid open the secrets of the interior of Australia.

Pacific. The Pacific Ocean was explored by numerous expeditions during the 18th and early part of the 19th centuries. Still much remained to be done in the way of verification and more complete survey. From 1826 to 1836 Captain Fitzroy, with the naturalist Darwin, surveyed Magellan's Strait and the west coast of South America; and further important surveys in the Pacific were afterwards executed by Captain Wilkes of the United States Navy, and by Belcher, Kellett, and Denham.

Arctic and Antarctic work. But the great geographical work of the present century must be the extension of discovery in the Arctic and Antarctic regions. Progress has been made in both directions, and in both much remains to be done. It is this polar work which calls forth the highest qualities of an explorer; it is here that the greatest difficulties must be overcome; and it is here that the most valuable scientific results are to be obtained.

Between the years 1830 and 1843 much was done in the Antarctic regions. In 1830–32 Mr. John Biscoe, R. N., made a voyage in a brig belonging to Messrs. Enderby, and discovered "Enderby Land" and "Graham Land" in 67° S.; and from 1837 to 1840 Dumont d'Urville discovered "La Terre Adèle" and "Coté Clarie," going as far south as 66° 30′. Auckland Island was discovered by Bristow in 1806. In 1839 Balleny, in another vessel belonging to Messrs. Enderby, discovered the Balleny Islands in 66° 44′ S., and Sabrina Island in 65° 10′ S. The Antarctic expedition of Sir James Ross sailed from England **Ross.** in 1839. In 1840 Sir James explored Kerguelen Island, and wintered at Hobart Town. He then visited the Auckland Islands, and crossing the Antarctic Circle, reached the great icy barrier, and discovered Victoria Land, with its lofty volcanoes, in January, 1841. He gained the latitude of 78° 4′ S. in 187° E., and established the continuity of the southern continent from 70° to 79° S. In 1841 Ross again wintered at Van Diemen's Land, and in January, 1842, crossed the Antarctic Circle in 156° 28′ W. He was once more stopped by the great icy barrier in 78° 10′ S., after having penetrated through ice floes of more than 1000 miles in width. Extraordinary dangers were encountered in the ice, many valuable observations were taken, and in 1842 the expedition wintered at the Falkland Islands. In the following season another exploring voyage was made beyond the Antarctic Circle, and in September, 1843, this most important expedition returned to England.

Franklin. On the return of Sir James Ross attention was once more turned to the Arctic regions; and in the spring of 1845 Sir John Franklin's Arctic expedition, consisting of the "Erebus" and "Terror," sailed from Woolwich. His instructions were to make the North-West Passage, but the main object of the expedition was the advancement of science, and to secure it the most accomplished officers in the navy were appointed, as well as the eminent naturalist, Dr. Goodsir. It is now known that, in the first and second seasons, the expedition was very successful. In 1845 Sir John Franklin made a remarkable run up Wellington Channel to 77° N.; in 1846, proceeding south, he had almost achieved the North-West Passage when his ships were permanently beset to the north of King William Island in 70° 5′ N. and 98° 23′ W. Here the veteran explorer died on June 11, 1847; and all his companions perished in the attempt to reach one of the Hudson's Bay Company's settlements in the summer of 1848. Those among them who reached Cape Herschel, and it is certain that some did reach that point, undoubtedly discovered the North-West Passage.

The expeditions which were sent out in search of Sir John Franklin's ships did much important geographical work; but their principal use was the establishment, through their means, of the true method of extensive Arctic exploration. The grand object of the officers and men employed on this service was the relief of their missing countrymen, and their utmost efforts were devoted to the examination of the largest possible extent of coast-line. Hence the discovery of the modern system of Arctic sledge travelling, the only efficient means of exploring the icy regions around the North Pole. In 1848–49 Sir James Ross discovered the western side of North Somerset, and Sir Leopold M'Clintock served his first apprenticeship in the ice under that veteran explorer. Austin's expedition sailed in 1850, and wintered nearly in the centre of the region discovered by Parry during his first voyage. It was then that M'Clintock developed and put in practice the system of Arctic sledge-travelling which has since achieved such grand results; and Captain Ommanney, M'Clintock, and his colleagues, Sherard Osborn, Frederick Mecham, Robert Aldrich, and Vesey Hamilton, made what were then unparalleled journeys in various directions. In December, 1849, also, Captains Collinson and M'Clure went out to conduct further search by way of Behring Strait. The former made the most remarkable voyage on record along the north coast of America, while M'Clure took his ship between the west coast of Banks Island and the tremendous polar pack, until he was within sight of the position attained by Parry in his first voyage from Baffin's Bay. Here M'Clure's ship was finally iced up in the Bay of God's Mercy. On the return of Austin's expedition, the same ships were again sent out under Captains Belcher and Kellett by Baffin's Bay; and M'Clintock, Osborn, Mecham, and Hamilton, who were once more in the front rank of searchers, surpassed even their former efforts. Mecham discovered a record left by M'Clure on Melville Island which revealed his position, and thus he and his officers and crew, by marching from their abandoned ship to the "Resolute" and returning to England with the expedition of Belcher and Kellett, were enabled to make the North-West Passage partly by ship and partly sledging over the ice. They all returned in 1854. But the concluding search was made by Sir Leopold M'Clintock in the "Fox" from 1857 to 1859, when he found the record on King William Island, and thus discovered the fate of Franklin. These search expeditions added immensely to our knowledge of the Arctic regions, and established the true method of exploration. Sea voyages in the summer season are useful for reconnaissances, but efficient polar work can only be achieved by wintering at a point beyond any previously reached, and sending out extended sledge parties in the spring.

Spitzbergen explored.

After the return of M'Clintock, England neglected the great work of Arctic exploration for fifteen years; but a deep interest was taken in the discovery of the unknown polar regions by other nations, and numerous efforts to explore them were made in the interval. In 1853–55 Dr. Kane, with the American brig "Advance," wintered just within the entrance of Smith Sound, and sent an exploring party for some distance up the east side of the channel; and in 1860–61 Dr. Hayes wintered near the same spot, and made a sledge journey up the west side. Ten years afterwards Captain Hall, accompanied by Dr. Bessels, a German scientific explorer, sailed in the "Polaris" in August, 1871, and succeeded in making his way up the channels leading north from Smith Sound for 250 miles, wintering in 81° 38′ N. Captain Hall unfortunately died in the autumn of 1871, and his comrades returned after suffering great hardships. The "Polaris" was abandoned, but she had attained the highest latitude ever reached by any vessel up to that date. In the direction of Spitzbergen and Novaya Zemlya the Norwegian walrus hunters made many daring voyages. They circumnavigated both those masses of Arctic land, and yearly frequented the hitherto closed Sea of Kara. The Swedes, under the lead of the accomplished and indefatigable Nordenskiöld, have made voyage after voyage to Spitzbergen, and afterwards to the north-east. The first Swedish expedition to Spitzbergen was in 1857, the second in 1861, the third in 1864, the fourth in 1868, consisting of the steamer "Sophia," which reached the highest latitude ever attained by a vessel trying the Spitzbergen route, namely, 81° 42′ N. In 1872 a fifth expedition started, and Nordenskiöld then passed his first winter in the Arctic regions, and gained experience of sledge-travelling in the spring, exploring a large area of North-East Land. Experience also proved that the Spitzbergen route was not one by which large results could be secured, although the scientific researches of the Swedes in Spitzbergen itself were most valuable. In 1875 therefore Professor Nordenskiöld made his first attempt towards the north-east, reaching the mouth of the Yenisei; and in 1876 he made an equally successful voyage in the same direction. The Germans also entered the field of Arctic enterprise. In 1868 Captain Koldewey made a summer voyage to Spitzbergen, and in 1869–70 he went in the "Germania" to the east coast of Greenland, accompanied by Lieutenant Payer, wintered at the Pendulum Island, discovered by Clavering in 1823, whence they made a sledge journey to the northward as far as 77°, and explored a deep fjord in about 73° 15′ N. during the navigable season. English yachtsmen, notably Lamont and Leigh Smith, were also in the field; and the latter made important corrections of the charts of North-East Land. But by far the most important and successful voyage in this period was that of Lieutenants Weyprecht and Payer in the Austrian steamer "Tegethoff." Sailing in 1872, they were beset in the ice to the north of Novaya Zemlya during the winter of 1872–73, and were drifted northwards until, on August 31, 1873, they sighted a previously unknown country. It proved to be very extensive, and was named Franz Josef Land. In March, 1874, Lieutenant Payer started on an extended sledge journey, in the equipment of which he closely followed M'Clintock's system. He discovered a great extent of coast-line, and attained a latitude of 82° 5′ N. at Cape Fligely. The Austrian explorers were eventually obliged to abandon the "Tegethoff," reaching Norway in September, 1874; but their expedition was a great success, and they added an extensive region to the map of the known world.

Austrian expedition.

English Arctic expedition.

In England the very important branch of geographical research relating to the Arctic regions was neglected by the Government during this interval of fifteen years, while Americans, Swedes, Norwegians, Germans, Austrians, and English yachtsmen were making praiseworthy efforts with more or less success. The resumption of English Arctic research on an adequate scale is due to the exertions and arguments of Admiral Sherard Osborn from 1865 until 1875. He set forth the valuable results to be obtained, and the means of success. Basing his arguments on long experience, he showed that it was necessary for success that an expedition should follow a coast-line, that it should pass beyond any point previously reached and there winter, and that the work should be completed by extended sledge parties in the spring. At length an expedition was fitted out on these principles, the Smith Sound route was selected, and in May, 1875, the "Alert" and "Discovery" sailed from Portsmouth under the command of Captain Nares. As regards the ice navigation the success of the expedition was complete. Captain Nares, in the face of unparalleled difficulties, brought the ships to a point farther north than any vessel of any nation had ever reached before, wintered the "Alert" in 82° 27′ N., and, in the face of still greater difficulties, brought both vessels safely home again. The extended sledge-travelling called forth an amount of heroic devotion to duty, and of resolute perseverance in spite of greater obstacles than had ever been encountered before, which add a proud page to the history of English naval enterprise. The exploring parties were led by Commander Markham and Lieutenants Aldrich and Beaumont. Advancing over the great frozen Polar Sea, Markham reached 83° 20′ 26″ N., the highest latitude ever attained by any human being. He thus won the blue ribbon of Arctic discovery. Aldrich discovered 200 miles of coast to the westward, while Beaumont added to our knowledge of the north coast of Greenland. The results of the Arctic expedition of 1875–76 were the creation of a young generation of experienced Arctic officers, the discovery of 300 miles of new coast-line and of a large section of the Polar Ocean, the attainment of the highest latitude ever reached by man, a year's magnetic and meteorological observations at two stations both further north than any before taken, tidal observations, the examination of the geology of a vast region and the discovery of a fossil forest in 82° N., and large natural history collections representing the fauna and flora of a new region.

Nares.

Markham's highest latitude.

Dutch Arctic work.

Swedish Arctic expedition.

The return of this memorable expedition again incited our neighbors to further efforts. In the summer of 1878 the Dutch entered the field, and the schooner "William Barents," under Lieutenants de Bruyne and Koolemans Beynen, made a useful reconnaissance of the Barent's Sea; while Professor Nordenskiöld left Sweden in July, 1878, in the well-equipped steamer "Vega," to achieve the North-East Passage. In August he rounded Cape Chelyuskin, the most northern point of the Old World, and reached the mouth of the Lena. But much work remains to be done in the polar regions, in order to complete the connection between Aldrich's furthest in 1876 and M'Clintock's in 1854, to complete the discovery of the north side of Greenland, to explore the northern bounds of Franz Josef Land, and to discover lands north of Siberia.

Physical geography of the sea.

There is one great branch of physical geography which has only been effectively studied within the last thirty years, namely, the physical geography of the sea. Matthew Fontaine Maury, by his wind and current charts, by his trade wind, storm, rain, and whale charts, and above all by his charming work *The Physical Geography of the Sea*, gave the first impulse to this study. It was Captain Maury who organized the first deep-sea soundings in the North Atlantic, which up to that time was deemed to be unfathomable; and when his work was published, the illustrious Humboldt declared Maury to be the founder of a new and important science—the meteorology of the sea. He first took charge of the Washington Observatory in 1842; he resigned that post under a deep sense of duty in April, 1861, after a career of great usefulness; and he ended a noble and well-spent life in 1872. The investigations into the physical geography of the sea, which were combined into a system by Maury, have since been ably and zealously continued by others, among whom the names of Dr. Carpenter, Sir Wyville Thomson, and Professor Mohn of Christiania are pre-eminent. The voyage of the "Challenger" from 1873–1876, under Captains Nares and Thomson, with Sir Wyville Thomson as chief of the scientific staff, was organized with the object of examining and mapping the bottom of the ocean, of describing the fauna of the great depths, of ascertaining the temperatures at various depths, and of solving questions relating to oceanic circulation. The area thus explored in the Atlantic, Antarctic, Pacific, and Indian Oceans is of vast extent, and the researches, ably and zealously conducted, have resulted in an important addition to geographical knowledge.

In this rapid sketch of the history of geographical discovery, the labors of numerous explorers during many generations have been enumerated; but its perusal will show that, notwithstanding all this work, there is much remaining to be done. Vast areas round both poles, and in the interior of Asia, Africa, South America, and New Guinea, are still unknown, even more extensive regions have only been partially explored, and millions of square miles remain to be surveyed, before the work of geographers is complete. (C. R. M.)

II. MATHEMATICAL GEOGRAPHY.

All our knowledge of the planet on which we live, whether obtained from the explorations of travellers, the voyages of navigators, or the discoveries of astronomy in modern times, goes to confirm the doctrine held and taught by philosophers in a remote antiquity that the earth is spherical. What is spherical, however, is not the actual surface of the earth, but rather that of the sea produced in imagination to pass through the continents. That the surface of the sea is convex any one may—at a seaside station where there is a high cliff—convince himself, by noting with a telescope at the top of the cliff the exact appearance of a ship in, or slightly beyond, the horizon, and then, immediately after, repeating at the foot of the cliff the same observation on the same ship. By a more precise observation of the sea horizon from a known altitude one may even calculate the radius of the earth.

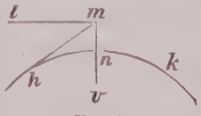

FIG. 1.

Let *m* (fig. 1) be a point on the top of a mountain; *hnk* a portion of the earth's surface; *mnv* a line drawn from *m* towards the centre of the earth; *mh* a tangent from *m* to the spherical surface; and *ml* a horizontal line through *m*, that is *ml* is perpendicular to *mv*. Then by the mere measure of the angle *lmh*, or the depression of the sea horizon, one can, knowing *mn*, calculate very simply the radius of the earth. Let the height $mn = h$, the angle $lmh = \delta$, and the radius of the earth $= r$; then since the angle subtended at the earth's centre by *hn* is δ, it is clear that $(h+r) \cos\delta = r$, which gives r in terms of h and δ, known quantities. In fact, since h and δ are both small, $r = \frac{1}{2}h \div \sin^2\frac{1}{2}\delta$. But here we have assumed that the ray of light proceeding from h to m takes a rectilinear course; this is not true, however, for the path is curved, its concavity being turned towards the earth—a consequence of terrestial refraction. From the laws of terrestrial refraction, which have been very minutely studied, we know that the formula last written down should be $r = {\cdot}422h \div \sin^2\frac{1}{2}\delta$. Now to take an actual case—the depression of the sea horizon at the top of Ben Nevis is 64′ 48″ (this is the mean of several observations, taken with special precautions for the express purpose of this experimental calculation), and the height of the hill is 4406 feet, or ·8345 of a mile. The formula gives at once $r = 3965$ miles, which is remarkably near the truth. But this method is not capable of precision on account of the variableness of terrestrial refraction. In connection with the appearance of the sea horizon from a height the following formulæ are useful:—h being the height in feet, δ the depression or *dip* of the horizon in minutes, s the distance of the horizon in miles, then

$$\delta = \left(1 - \frac{1}{40}\right)\sqrt{h}; \qquad s = \frac{4}{3}\sqrt{h}.$$

Thus, for instance, to a spectator on the top of Snowdon, which is 3590 feet in height, the distance of the sea horizon is about 80 miles.

The first great fact in the description of the earth being that it is spherical (or at any rate so nearly so that, were a perfect model of it constructed, no one could, by unaided vision, discover that it is not spherical), the next points to be noted are,—secondly, that the earth rotates uniformly round an axis passing through its centre, and fixed, or very nearly fixed as to direction, in space; and thirdly, that its figure is not spherical but spheroidal, the surface being that found by the revolution of an ellipse round its minor axis, the axis of figure corresponding with the axis of diurnal rotation. The spheroidal figure is a necessary consequence of the rotation. The rotation of the earth once in 24 hours, although made evident by the rising and setting of the heavenly bodies, is rendered perhaps more distinctly visible by Foucault's pendulum experiment. Let a heavy ball be suspended by a fine thread, free from tension, from a fixed point. Let it be drawn aside from the position of equilibrium and then dropped so that it commences to oscillate in a vertical plane passing through the point of suspension. Then a careful observation of the pendulum will show that its plane of oscillation is not fixed, but has a uniform rotation in a direction opposite to that of the earth's rotation. Suppose, for instance, that the pendulum were suspended at the north pole and that it were set oscillating in a plane passing through any one fixed star, then it will continue to oscillate in that same plane notwithstanding the earth's rotation. Consequently, to the observer there the plane of the pendulum's oscillation will appear to rotate through 360° in 24 hours. At the equator, since there is no component of rotation there, the pendulum would continue to move in one and the same plane. At intermediate stations the rate of rotation is easily calculated; and observations confirm the calculations, and have made the earth's rotation actually visible.

The poles of the earth are the points in which the axis of rotation, or of figure, meet the surface; and the equator is the circle in which the surface is intersected by a plane through the earth's centre, perpendicular to the axis of rotation. Every point of the equator is therefore equidistant from the poles.

To determine the position of a point in space three coordinates or measurements are necessary; they may be three lines, or two lines and one angle, or two angles and one line. Thus, to define the precise position of a point on the earth's surface, we express it by latitude, longitude, and altitude; the first two are angular measures, the third a linear magnitude, namely the height above the surface of the sea.

The line in which the surface of the earth is intersected by a plane through the axis of rotation is called a meridian, and all meridians are evidently similar curves. A line perpendicular to the surface at any point is called a vertical line; it corresponds with the direction of gravity there; being produced outwards, that is, away from the earth's centre, it meets the heavens in the *zenith;* and produced downwards it intersects the axis of revolution; it would of course pass through the earth's centre were it a sphere; as it is, it passes *near* the earth's centre.

The angle between the meridian planes of two stations as A and B is called the difference of longitude of A and B, or the longitude of B with reference to A. In British maps the longitudes of all places are expressed with reference to the Royal Observatory of Greenwich.

The latitude of any point is the angle made by the vertical line there with the plane of the equator, or the colatitude is the angle between the vertical line and the axis of rotation. The surface of the earth being one of revolution, any intersecting plane parallel to the equator cuts it in a circle. If we imagine the vertical lines drawn at any two points, as P and Q, in such a circle it is evident from the symmetry of the surface that these verticals make the same angle with the equator; in other words, the latitudes of all points on this circle are equal. Such circles are called parallels; they intersect meridians at right angles.

If we suppose that at any point Q of the surface the meridian, or a small bit of it, is actually traced on the surface, and also a portion of the parallel through the same point, then these lines, crossing at right angles in Q, mark there the directions which we call north and south, east and west—the meridian lying north and south, the parallel east and west. Planes containing the vertical line at Q are vertical planes there. A vertical plane is defined by its azimuth, which is the angle it makes with the meridian plane; the azimuth at Q of any object (or point) celestial or terrestrial is the angle which the vertical plane passing through the object makes with the meridian. The south meridian is generally taken as the zero of azimuth. The plane touching the surface at Q is the visible horizon there —a plane parallel to this through the centre of the earth being called the rational horizon. The altitude at Q of a heavenly body, as a star, is the angle which the line drawn from Q to the star makes with the plane of the horizon—the zenith distance of the same star being the angle between its direction and the vertical at Q.

By a degree of the meridian is meant this: if E, F are points on the same meridian such that the directions of their verticals make with each other an angle of one degree—a ninetieth part of a right angle—then the distance between E and F measured along the meridian is a degree of the meridian. As the radius of curvature of an ellipse is variable, increasing from the extremity of the major axis to the extremity of the minor axis, so on the earth's surface a degree of the meridian is found by geodetic measurement to increase from the equator to the poles.

The actual length of a degree of the meridian at the equator is 362746·4 feet; at either pole it is 366479·8 feet. The length of one degree of the equatorial circle is 365231·1 feet.

With regard to the figure of the earth as a whole, the polar radius is 3949·79 miles, and the radius of the equator 3963·30 miles; the difference of these, called the ellipticity, is $\frac{1}{293}$ of the mean radius. A spheroid with these semiaxes is equivalent in volume to a sphere having a radius of 3958·79 miles. Without referring further here to the spheroidal figure, we shall now, having given the precise dimensions, regard the earth as a sphere whose radius is 3959 miles. On such a sphere one degree is 69·09 miles. From the definitions given above it appears that the radius of the parallel which corresponds to all points whose latitude is ϕ is $3959 \cos \phi$; and that one degree of this circle, *i. e.*, one degree of longitude in the latitude ϕ, is $69·09 \cos \phi$ expressed in miles.

In the representation of the spherical earth (fig. 2) P is the pole, QQ the equator, E, F any two points on the surface, PE*e*, PF*f* the meridians of those points intersecting the equator in *e* and *f*. Join EF by a great circle; then in the spherical triangle PEF the angle at P is the difference of longitude of E and F, PE is the co-latitude of E, and PF the co-latitude of F, the latitudes being *e*E and *f*F respectively. The angle at E being that contained between the meridian there and a vertical plane passing through F, is the azimuth of F (measured in this case from the north), while the angle at F is the azimuth of E. If, then, there be given the latitudes and longitudes of two places, to find their distance apart, and their relative bearings, it becomes necessary to calculate a spherical triangle (PEF) in which two sides and the included angle are given—the calculation bringing out the third side, which is the required distance, with the adjacent azimuthal angles.

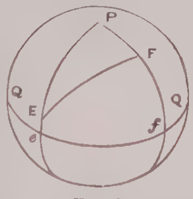

Fig. 2.

The latitudes and longitudes of places on the earth's surface are determined by observations of the stars, of the sun, and of the moon. As the earth rotates, the zenith of any place (not being on the equator) traces out among the stars a small circle having for centre that point in which the axis of rotation meets the heavens. If there were a star at this last point it would be apparently motionless, having always the same altitude and azimuth. The pole star, though very conveniently near the north pole of the heavens, and without perceptible motion to the unaided eye, is in reality moving in a very small circle. The zenith of a point on the equator traces out in the heavens a great circle, namely, the celestial equator.

As the positions of points on the earth are defined with reference to the equator and a certain fixed meridian, so the positions of stars are defined by their angular distance from the celestial equator, called in this case declination, and by their right ascension, which corresponds to terrestrial longitude. Stars which are on the same meridian plane (extended to the heavens) have the same right ascension. Right ascension is expressed in time from 0^h to 24^h. A sidereal clock, going truly, indicates 24^h for every revolution of the earth: at every observatory, the sidereal clock there shows, at each moment, the right ascension of the stars which at that moment are on the meridian. Thus the right ascension of the zenith is the sidereal time.

In the left hand circle of the diagram (fig. 3) two concentric small circles are drawn such that the sum of their radii is a right angle or 90°. Let the inner circle be that traced among the stars by the zenith of any given place, say Q, then the outer circle encloses all those stars which are circumpolar at Q, that is, whose entire course is performed above that horizon; for clearly the zenith distance of none of these can exceed 90° at Q. Or if the outer circle be that described by the zenith of Q, then the inner circle encloses all those stars which are circumpolar at Q. The second circle in the diagram shows the diurnal paths of stars with reference to the horizon.

If we consider in the first circle the changes of distance between any one star and the zenith of Q as the latter traces out its path in the heavens, we see that the distance becomes alternately a maximum and a minimum every twelve hours, namely, when the meridian of Q passes through the star. This is called the star's culmination or meridian transit. It will be clear from an inspection of the figure that, if for instance the star culminate to the south of the zenith, the star's declination plus its zenith distance at culmination is equal to the latitude of the zenith, that is, of Q. A corresponding rule is easily made for a northern transit. Thus the simplest manner of determining the latitude is to measure the zenith distance of a known star at its meridian transit.

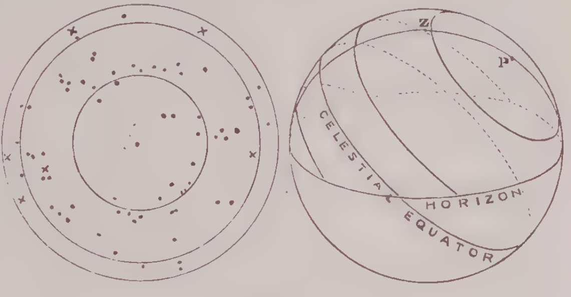

Fig. 3.

The position of the zenith at any moment may be determined by simultaneous observation of the zenith distance of two known stars. For these distances clearly determine a point in the heavens (two points rather, which however need not be confounded) whose declination and right ascension can be computed by spherical trigonometry. Thus, at the same time, are obtained both the time and the latitude. For the success of this method, which is suitable for travellers exploring an unknown country, it is desirable that the stars should differ in azimuth by about a right angle.

If the path of the zenith, that is, the latitude, be known, then clearly a single observation of the zenith distance of a known star, which should be towards the east or west, not towards the north or south, will fix the place or right ascension of the zenith, that is, the sidereal time, at the moment of observation. Here the pole, the zenith, and the star are the angular points of a spherical triangle, of which the three sides are known: the angle at the pole, being computed, is the difference of right ascension of the star and the zenith. Thus the sidereal time is found.

The determination of the difference of longitude of the two stations AB on the earth's surface requires that the true time be kept at each. All that is necessary is a comparison of these times at any instant. For instance, the time at B may, by the transport of chronometers, be brought to A, and thus the difference of the local times be ascertained, or the indications of the clock at A may be conducted by electro-telegraphy to B. The difference of the local times at A and B is the time a star takes to pass from the meridian of the one to that of the other; and this is the difference of longitude which may be converted into angle at the rate of 360° to 24^h.

But the traveller in unknown lands, who seeks to fix astronomically his position, has no telegraph to count on, and his expectations for longitude depend chiefly on observations of the moon. In the *Nautical Almanac* are published the angular distances of the moon from certain stars in its path for every three hours of Greenwich time. Therefore, by actually observing the distance of the moon from one of these stars, one can infer the corresponding Greenwich time at the moment of observation. The comparison of this with the local time gives the longitude.

Observations on the sun have shown that it traces out amongst the stars in the course of a year a great circle, inclined to the equator at an angle of 23½°; at midsummer it attains a maximum northern declination of 23½°, and at midwinter a maximum southern declination of the same amount. Hence it is inferred that the earth moves round the sun in a plane, completing one orbital revolution yearly, the axis of the earth's diurnal rotation being inclined to this plane at an angle of 66½°. Upon this angle of inclination depend the seasons, and in great measure the climates of the different portions of the earth's surface.

It is usual to draw on globes and in maps a circle or parallel at the distance of 23½° from the equator on either side; of these circles the northern is called the Tropic of Cancer, the southern is the Tropic of Capricorn. A circle drawn with a radius of 23½° from the North Pole as centre is the Arctic Circle; a similar and equal circle round the South Pole is the Antarctic Circle.

When the sun is in the equator—which it crosses from north to south in September, and from south to north in March—it is in the horizon of either pole. When the sun has northern declination, the North Pole is in constant daylight and the South Pole in darkness. When the sun has southern declination the North Pole on the contrary is in constant darkness while the South Pole is illuminated by sunshine. At midsummer in the northern hemisphere the whole region within the Arctic Circle is in constant daylight, and that within the Antarctic Circle is in darkness; at midwinter this state of things is exactly reversed. The portion of the globe lying between the Tropic of Cancer and the Arctic Circle is called the North Temperate Zone; that between the Tropic of Capricorn and the Antarctic Circle is the South Temperate Zone. In the former the sun is always to the south of the zenith; in the latter it is always to the north.

In the Torrid Zone, which lies between the Tropics, the sun, at any given place, passes the meridian to the north of the zenith for part of the year, and to the south for the remainder.

When the sun is to the north of the equator the days are longer than the nights in the northern hemisphere, while in the southern hemisphere the nights are longer than the days; when the sun has southern declination this condition is reversed. As the sun increases his north declination from 0° to 23½°, not only do the days increase in length in the northern hemisphere, but the rays of the sun—in the Temperate and Arctic regions—impinge more perpendicularly on the surface; hence the warmth of summer. Even in summer the rays of the sun in the Arctic regions strike the surface very obliquely; this, combined with the protracted season of darkness, produces excessive cold. Summer in the northern hemisphere is thus contemporaneous with winter in the southern; while winter in the northern hemisphere is simultaneous with summer in the southern.

The length of the day at any place at any season of the year is easily ascertained from the following considerations. Let *ns* (fig. 4) be the axis of rotation, *eq* the equator orthographically projected on a meridian plane, *ab* the parallel of the given place; draw the diameter *fg* making the angle *nog* equal to the sun's declination, which we suppose to be north, then the hemisphere *gnaef* is in sunshine, while the hemisphere *gbqsf* is in darkness. As the earth rotates, a point which is at *a* at midday is carried from *a* towards *b*, which it reaches at midnight; *h* is reached at 6 o'clock P. M., and *k* at sunset. Now if ϕ be the latitude of the place and δ the sun's declination $hk = \sin \phi \tan \delta$; this in the parallel whose radius is $\cos \phi$ corresponds to an angle whose sine is $\tan \phi \tan \delta$. Call this angle η; the time taken to rotate through it is $\frac{1}{15}\eta$; hence the length of the daylight is $12^h + \frac{2}{15}\eta$, and the length of night $12^h - \frac{2}{15}\eta$.

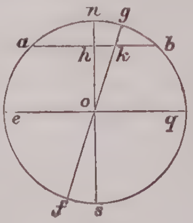

FIG. 4.

Now η vanishes when either ϕ or δ is zero; that is, at the equator the nights and days are equal in length throughout the year; and again when the sun is in the equator, that is, at the equinox, the nights and days are equal in all latitudes. When the sun's declination is equal to the co-latitude, η is a right angle, and the sun does not actually set; this can only happen at places within the polar circle. The longest day at Gibraltar is $14^h\ 27^m$, at Falmouth $16^h\ 11^m$, and in Shetland $18^h\ 14^m$; while in Iceland it is 20^h on the south coast and 24^h on the north. At Washington the longest day is $14^h\ 44^m$, and at Quebec $15^h\ 40^m$.

All this, however, is on the supposition that day ends with sunset; but the length of apparent day is increased by atmospheric refraction and reflection. When the disk of the setting sun first seems to touch the horizon it is in reality wholly below it and is only seen by refraction. After the sun has wholly set at any given place his light still continues to illuminate the upper portion of the atmosphere there, so that, instead of ending abruptly, daylight gradually fades away until the sun is 18° below the horizon.

In a diagram (fig. 5) similar to the last draw *mi* parallel to *gf*, and at a distance from it equal to the sine of 18°; then *gbf* being the hemisphere unenlightened by the direct rays of the sun, *gmif* will represent the twilight zone. A point in the latitude of *a* describing the parallel *ab* loses sight of the sun at *k*, and is in twilight until it reaches the small circle *mi*, when the sun's zenith distance is 108°. The duration of twilight corresponds then to the portion *kl* of *ab*, the angle rotated through being

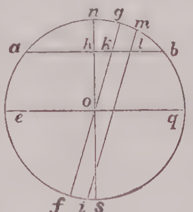

FIG. 5.

$$\sin^{-1}(hl : hb) - \sin^{-1}(hk : hb);$$

this converted into time gives the duration of twilight. Here

$$hk = \sin \phi \tan \delta; \quad kl = \sin 18^\circ \sec \delta.$$

At any given latitude the twilight is shortest when the great circle passing through *k* and *l* passes also through the sun. Expressed algebraically, if τ be the duration of the shortest twilight in angular measure and δ the sun's declination at the time, then

$$-\sin \delta = \sin \phi \tan 9^\circ$$
$$\sin \tfrac{1}{2}\tau = \sec \phi \sin 9^\circ.$$

Suppose in the last diagram the sun to be at his greatest northern declination, then $ng = 23\tfrac{1}{2}^\circ$, $gm = 18^\circ$, and $mq = 48\tfrac{1}{2}^\circ$. Hence a place whose latitude is 48½° N. has, at midsummer, twilight lasting from sunset to midnight and continuing from midnight to sunrise, that is, for a few days there is no absolute darkness. A little further south this twilight is interrupted by a short period of darkness. Since $is = 23\tfrac{1}{2}^\circ - 18^\circ = 5\tfrac{1}{2}^\circ$, we see from the diagram that the South Pole is at this time in total darkness, which extends to all places within 5½° of it. When the sun's declination is 9° south, the North Pole is in the centre of the twilight belt; thus all places whose latitude is greater than 81° then move in continual twilight, alternating between clearness and dimness, never attaining either daylight or total darkness. The actual period during which either pole is in total darkness is about two and a half months.

At the equator, the shortest twilight occurs at the equinox, when it is $1^h\ 12^m$; the longest when the sun is in the tropics, being $1^h\ 18^m$. At London, in latitude 51½°, twilight continues all night from May 22 to July 21; it is shortest about three weeks after the autumnal and three weeks before the vernal equinox, when its duration is $1^h\ 50^m$. At Washington the shortest twilight (being $1^h\ 33^m$) occurs on the 6th of March and 7th October; at Quebec the shortest is $1^h\ 46^m$, falling on the 3d March and 10th October.

At page 183, fig. 19 is a perspective representation of the earth—of more than a hemisphere, in fact—namely, the segment *mgnafi* in fig. 5. It exhibits all those regions of the earth which at Greenwich apparent noon at midsummer are in sunshine *and* twilight. It is very remarkable how Asia and America, but especially the former, just escape going into darkness.

Construction of Maps.

In the construction of maps, one has to consider how a portion of spherical surface, or a configuration traced on a sphere, can be represented on a plane. If the area to be represented bear a very small ratio to the whole surface of the sphere, the matter is easy: thus, for instance, there is no difficulty in making a map of a parish, for in such cases the curvature of the surface does not make itself evident. If the district is larger and reaches the size of a county, as Yorkshire for instance, then the curvature begins to be sensible, and one requires to consider how it is to be dealt with. The sphere not being a developable surface cannot be opened out into a plane like the cone or cylinder, consequently in a plane representation of configurations on a sphere it is impossible to retain the desired proportions of lines or areas or equality of angles. But though one cannot fulfil all the requirements of the case, we may fulfil some by sacrificing others; that is to say, we may, for instance, have in the representation exact similarity to all very small portions of the original, but at the expense of the areas, which will be quite misrepresented. Or we may retain equality of areas if we give up the idea of similarity. It is therefore usual, excepting in special cases, to steer a middle course, and, by making compromises, endeavor to obtain a representation which shall not offend the eye.

A globe gives a perfect representation of the surface of the earth; but practically, the necessary limits to its size make it impossible to represent in this manner the details of countries. A globe of the ordinary dimensions serves scarcely any other purpose than to convey a clear conception of the earth's surface as a whole, exhibiting the figure, extent, position, and general features of the continents and islands, with the intervening oceans and seas; and for this purpose it is indeed absolutely essential and cannot be replaced by any kind of map.

The construction of a map virtually resolves itself into the drawing of two sets of lines, one set to represent meridians, the other to represent parallels. These being drawn, the filling in of the outlines of countries presents no difficulty. The first and most natural idea that occurs to one as to the manner of drawing the circles of latitude and longitude is to draw them according to the laws of perspective. But, as Lagrange has remarked, one may regard geographical maps from a more general point of view as representations of the surface of the globe, for which purpose we have but to draw meridians and parallels according to any given law; then any place we have to fix must take that position with reference to these lines that it has on the sphere with reference to the circles of latitude and longitude. Let the law which connects latitude and longitude, ϕ and ω, with the rectangular co-ordinates x and y in the representation be such that $dx = m\,d\phi + n\,d\omega$, and $dy = m'd\phi + n'd\omega$. In fig. 6 let the lines intersecting in the parallelogram PQRS be the representations of the meridians rp, sq and parallels rs, pq intersecting in the indefinitely small rectangle $pqrs$ on the surface of the sphere. The co-ordinates of P being x and y, while those of p are ϕ and ω, the co-ordinates of the other points will stand thus:

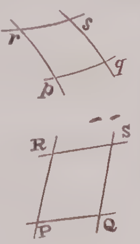

FIG. 6.

q . . .	ϕ	$\omega + d\omega$
r . . .	$\phi + d\phi$	ω
s . . .	$\phi + d\phi$	$\omega + d\omega$
Q . . .	$x + n\,d\omega$	$y + n'd\omega$
R . . .	$x + m\,d\phi$	$y + m'd\phi$
S . . .	$x + m\,d\phi + n\,d\omega$	$y + m'd\phi + n'd\omega$.

Thus we easily see that $\mathrm{PR} = (m^2+m'^2)^{\frac12}d\phi$; and $\mathrm{PQ} = (n^2+n'^2)^{\frac12}d\omega$: also the area of the parallelogram PQRS is equal to $(m'n - mn')d\phi d\omega$. If 90° ± ψ are the angles of the parallelogram, then

$$\tan\psi = \frac{mn + m'n'}{m'n - mn'}.$$

If the lines of latitude and of longitude intersect at right angles, then $mn + m'n' = 0$. Since the length of pr is $= d\phi$ its representation PR is too great in the proportion of $(m^2+m'^2)^{\frac12} : 1$; and pq being in length $\cos\phi d\omega$, its representation PQ is too great in the ratio of $(n^2+n'^2)^{\frac12} : \cos\phi$. Hence the condition that the rectangle PQRS is similar to the rectangle $pqrs$ is $(m^2+m'^2)\cos^2\phi = n^2+n'^2$, together with $mn + m'n' = 0$; or, which is the same, the condition of similarity is expressed by

$$-n' = m\cos\phi\,; \quad n = m'\cos\phi.$$

Since the area of the rectangle $pqrs$ is $\cos\phi d\phi d\omega$, the exaggeration of area in the representation will be expressed by $m'n - mn' : \cos\phi$. Thus when the nature of the lines representing the circles of latitude and longitude is defined we can at once calculate the error or exaggeration of scale at any part of the map, whether measured in the direction of a meridian or of a parallel; and also the misrepresentation of angles.

The lines representing in a map the meridians and parallels on the sphere are constructed either on the principles of true perspective or by artificial systems of developments. The perspective drawings are indeed included as a particular case of development in which, with reference to a certain point selected as the centre of the portion of spherical surface to be represented, all the other points are represented in their true azimuths,—the rectilinear distances from the centre of the drawing being a certain function of the corresponding true distances on the spherical surface. For simplicity we shall first apply this method to the projection or development of parallels and meridians when the pole is the centre. According to what has been said above, the meridians are now straight lines diverging from the pole, dividing the 360° into equal angles; and the parallels are represented by circles having the pole as centre, the radius of the parallel whose co-latitude is u being ρ, a certain function of u. The particular function selected determines the nature of the development.

Let Ppq, Prs (fig. 7) be two contiguous meridians crossed by parallels rp, sq, and O$p'q'$, O$r's'$ the straight lines representing these meridians. If the angle at P is $d\mu$, this also is the value of the angle at O. Let the co-latitude

$$\mathrm{P}p = u,\ \mathrm{P}q = u + du\,;\ \mathrm{O}p' = \rho,\ \mathrm{O}q' = \rho + d\rho,$$

the circular arcs $p'r'$, $q's'$ representing the parallels pr, qs. If the radius of the sphere be unity,

$$p'q' = d\rho\,;\ p'r' = \rho d\mu,$$
$$pq = du\,;\ pr = \sin u d\mu.$$

Put

$$\sigma = \frac{d\rho}{du}\,;\ \sigma' = \frac{\rho}{\sin u},$$

then $p'q' = \sigma pq$ and $p'r' = \sigma' pr$. That is to say, σ, σ' may be regarded as the relative scales, at co-latitude u, of the representation. σ applying to meridional measurements, σ' to measurements perpendicular to the meridian. A small square situated in co-latitude u, having one side in the direction of the meridian—the length of its side being i—is represented by a rectangle whose sides are $i\sigma$ and $i\sigma'$; its area consequently is $i^2\sigma\sigma'$.

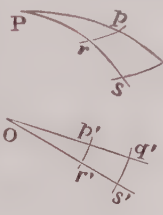

Fig. 7.

If it were possible to make a perfect representation, then we should have $\sigma = 1$, $\sigma' = 1$ throughout. This, however, is impossible. We may make $\sigma = 1$ throughout by taking $\rho = u$. This is known as the *Equidistant Projection*, a very simple and effective method of representation.

Or we may make $\sigma' = 1$ throughout. This gives $\rho = \sin u$, a perspective projection, namely, the *Orthographic*. Or we may require that areas be strictly represented in the development. This will be effected by making $\sigma\sigma' = 1$, or $\rho d\rho = \sin u du$, the integral of which is $\rho = 2\sin\frac12 u$, which is the *Equivalent Projection* of Lambert, sometimes referred to as *Lorgna's Projection.* In this system there is misrepresentation of form, but no misrepresentation of areas. Or we may require a projection in which all small parts are to be represented in their true forms. For instance, a small square on the spherical surface is to be represented as a small square in the development. This condition will be attained by making $\sigma = \sigma'$, or $\frac{d\rho}{\rho} = \frac{du}{\sin u}$, the integral of which is, c being an arbitrary constant, $\rho = c\tan\frac12 u$. This, again, is a perspective projection, namely, the *Stereographic.* In this, though all small parts of the surface are represented in their correct shapes, yet, the scale varying from one part of the map to another, the *whole* is not a similar representation of the original. The scale, $\sigma = \frac12 c\sec^2\frac12 u$, at any point, applies to all directions round that point.

These two last projections are, as it were, at the extremes of the scale; each, perfect in its own way, is in other respects very objectionable. We may avoid both extremes by the following considerations. Although we cannot make $\sigma = 1$ and $\sigma' = 1$, so as to have a perfect picture of the spherical surface, yet considering $\sigma - 1$ and $\sigma' - 1$ as the local errors of the representation, we may make $(\sigma-1)^2 + (\sigma'-1)^2$ a minimum over the whole surface to be represented. To effect this we must multiply this expression by the element of surface to which it applies, viz., $\sin u\,du\,d\mu$, and then integrate from the centre to the (circular) limits of the map. Let β be the spherical radius of the segment to be represented, then the total misrepresentation is to be taken as

$$\int_0^\beta \left\{ \left(\frac{d\rho}{du} - 1\right)^2 + \left(\frac{\rho}{\sin u} - 1\right)^2 \right\} \sin u du,$$

which is to be made a minimum. Putting $\rho = u + y$, and giving to y only a variation subject to the condition $\delta y = 0$ when $u = 0$, the equations of solution—using the ordinary notation of the calculus of variations—are

$$\mathrm{N} - \frac{d(\mathrm{P})}{du} = 0; \ \mathrm{P}_\beta = 0,$$

P_β being the value of $2p \sin u$ when $u = \beta$. This gives

$$\sin^2 u \frac{d^2y}{du^2} + \sin u \cos u \frac{dy}{du} - y = u - \sin u,$$

$$\left(\frac{dy}{du}\right)_\beta = 0.$$

This method of development is due to Sir George Airy, whose original paper—the investigation is different in form from the above—will be found in the *Philosophical Magazine* for December, 1861. The solution of the differential equation leads to this result—

$$\rho = 2 \cot \frac{u}{2} \log_e \sec \frac{u}{2} + \mathrm{C} \tan \frac{u}{2},$$

$$\mathrm{C} = 2 \cot^2 \frac{\beta}{2} \log_e \sec \frac{\beta}{2}.$$

The limiting radius of the map is $\mathrm{R} = 2\mathrm{C} \tan \frac{1}{2}\beta$. In this system, called by the Astronomer-Royal the "*Projection by balance of errors,*" the total misrepresentation is an absolute minimum.

Returning to the general case where ρ is any function of u, let us consider the local misrepresentation of direction. Take any indefinitely small line, length $= i$, making an angle α with the meridian in co-latitude u. Its projections on a meridian and parallel are $i \cos \alpha$, $i \sin \alpha$, which in the map are represented by $i\sigma \cos \alpha$, $i\sigma' \sin \alpha$. If then α' be the angle in the map corresponding to α,

$$\tan \alpha' = \frac{\sigma'}{\sigma} \tan \alpha.$$

Put

$$\frac{\sigma'}{\sigma} = \frac{\rho du}{\sin u d\rho} = \Sigma,$$

and the error $\alpha' - \alpha$ of representation $= \varepsilon$, then

$$\tan \epsilon = \frac{(\Sigma - 1) \tan \alpha}{1 + \Sigma \tan^2 \alpha}.$$

Put $\Sigma = \cot^2 \zeta$, then ε is a maximum when $\alpha = \zeta$, and the corresponding value of ε is

$$\epsilon = \frac{\pi}{2} - 2\zeta.$$

For simplicity of explanation we have supposed this method of development so applied as to have the pole in the centre. There is, however, no necessity for this, and any point on the surface of the sphere may be taken as the centre. All that is necessary is to calculate by spherical trigonometry the azimuth and distance, with reference to the assumed centre, of all the points of intersection of meridians and parallels within the space which is to be represented in a plane. Then the azimuth is represented unaltered, and any spherical distance u is represented by ρ. Thus we get all the points of intersection transferred to the representation, and it remains merely to draw continuous lines through these points, which lines will be the meridians and parallels in the representation.

The exaggeration in such systems, it is important to remember, whether of linear scale, area, or angle, is the same for a given distance from the centre, whatever be the azimuth; that is, the exaggeration is a function of the distance from the centre only.

We shall now examine and exemplify some of the most important systems of projection and development, commencing with

Perspective Projections.

In perspective drawings of the sphere, the plane on which the representation is actually made may generally be any plane perpendicular to the line joining the centre of the sphere and the point of vision. If V be the point of vision, P any point on the spherical surface, then p, the point in which the straight line VP intersects the plane of the representation, is the projection of P.

In the orthographic projection, the point of vision is at an infinite distance and the rays consequently parallel; in this case the plane of the drawing may be supposed to pass through the centre of the sphere. Let the circle (fig. 8) represent the plane of the equator on which we propose to make an orthographic representation of meridians and parallels. The centre of this circle is clearly the projection of the pole, and the parallels are projected into circles having the pole for a common centre. The diameters aa', bb', being at right angles, let the semicircle bab' be divided into the required number of equal parts; the diameters drawn through these points are the projections of meridians. The distances of c, of d, and of e from the diameter aa' are the radii of the successive circles representing the parallels. It is clear that, when the points of division are very close, the parallels will be very much crowded towards the outside of the map; so much so, that this projection is not much used.

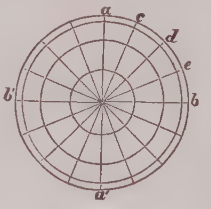

Fig. 8.

For an orthographic projection of the globe on a meridian plane, let $qnrs$ (fig. 9) be the meridian, ns the axis of rotation, then qr is the projection of the equator. The parallels will be represented by straight lines passing through the points of equal division; these lines are, like the equator, perpendicular to ns. The meridians will in this case be ellipses described on ns as a common major axis, the distances of c, of d, and of e from ns being the minor semiaxes.

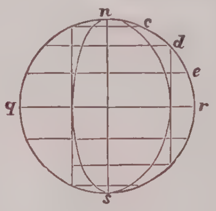

Fig. 9.

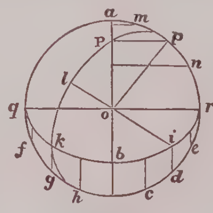

Fig. 10.

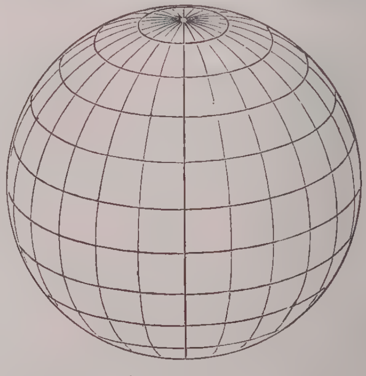

Fig. 11.—Orthographic Projection.

Let us next construct an orthographic projection of the sphere on the horizon of any place. Set off the angle aop (fig. 10) from the radius oa, equal to the latitude. Drop the perpendicular pP on oa, then P is the projection of the pole. On ao produced take $ob = p$P, then ob is the minor semiaxis of the ellipse representing the equator, its major axis being qr at right angles to ao. The points in which the meridians meet this elliptic equator are determined by lines drawn parallel to aob through the points of equal subdivision $cdefgh$. Take two points, as d and g, which are 90° apart, and let ik be their projections on the equator; then i is the pole of the meridian which passes through k. This meridian is of course an ellipse, and is described with reference to i exactly as the equator was described with reference to P. Produce io to l, and make lo equal to half the shortest chord that can be drawn through i; then lo is the semiaxis of the elliptic meridian, and the major axis is the diameter perpendicular to iol.

For the parallels: let it be required to describe the parallel whose co-latitude is u; take $pm = pn = u$, and let $m'n'$ be the projections of m and n on oPa; then $m'n'$ is the minor axis of the ellipse representing the parallel. Its centre is of course midway between m' and n', and the greater axis is equal to mn. Thus the construction is obvious. When pm is less than pa, the whole of the ellipse is to be drawn. When pm is greater than pa, the ellipse touches the circle in two points; these points divide the ellipse into two parts, one of which, being on the other side of the meridian plane aqr, is invisible.

Stereographic Projection.—In this case the point of vision is on the surface, and the projection is made on the plane of the great circle whose pole is V. Let kplV (fig. 12) be a great circle through the point of vision, and ors the trace of the plane of projection. Let c be the centre of a small circle whose radius is $cp = cl$; the straight line pl represents this small circle in orthographic projection.

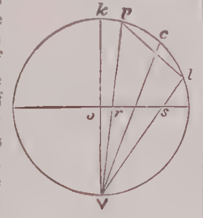

FIG. 12.

We have first to show that the stereographic projection of the small circle pl is itself a circle; that is to say, a straight line through V, moving along the circumference of pl, traces a circle on the plane of projection ors. This line generates an oblique cone standing on a circular base, its axis being cV (since the angle pVc = angle cVl); this cone is divided symmetrically by the plane of the great circle kpl, and also by the plane which passes through the axis Vc, perpendicular to the plane kpl. Now Vr·Vp, being = Vo sec kVp·Vk cos kVp = Vo·Vk, is equal to Vs·Vl; therefore the triangles Vrs, Vlp are similar, and it follows that the section of the cone by the plane rs is similar to the section by the plane pl. But the latter is a circle, hence also the projection is a circle; and since the representation of every infinitely small circle on the surface is itself a circle, it follows that in this projection the representation of small parts is (as we have before shown) strictly similar. Another inference is that the angle in which two lines on the sphere intersect is represented by the same angle in the projection. This may otherwise be proved by means of fig. 13, where Vok is the diameter of the sphere passing through the point of vision, fgh the plane of projection, kt a great circle, passing of course through V, and ouv the line of intersection of these two planes. A tangent plane to the surface at t cuts the plane of projection in the line rvs perpendicular to ov; tv is a tangent to the circle kt at t, tr and ts are any two tangents to the surface at t. Now the angle vtu (u being the projection of t) is 90° − otV = 90° − oVt = ouV = tuv, therefore tv is equal to uv, and since tvs and uvs are right angles, it follows that the angles vts and vus are equal. Hence the angle rts also is equal to its projection rus; that is, any angle formed by two intersecting lines on the surface is truly represented in the stereographic projection.

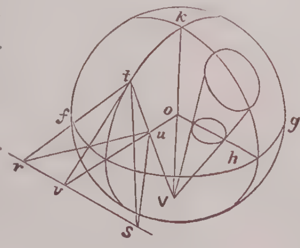

FIG. 13.

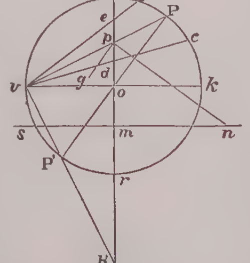

FIG. 14.

We have seen that the projection of any circle of the sphere is itself a circle. But in the case in which the circle to be projected passes through V, the projection becomes, for a great circle, a line through the centre of the sphere; otherwise, a line anywhere. It follows that meridians and parallels are represented in a projection on the horizon of any place by two systems of orthogonally cutting circles, one system passing through two fixed points, namely, the poles; and the projected meridians as they pass through the poles show the proper differences of longitude.

To construct a stereographic projection of the sphere on the horizon of a given place. Draw the circle $vlkr$ (fig. 14) with the diameters kv, lr at right angles; the latter is to represent the central meridian. Take koP equal to the co-latitude of the given place, say u; draw the diameter PoP′, and vP, vP′ cutting lr in pp': these are the projections of the poles, through which all the circles representing meridians have to pass. All their centres then will be in a line smn which crosses pp' at right angles through its middle point m. Now to describe the meridian whose west longitude is ω, draw pn making the angle $opn = 90° - \omega$, then n is the centre of the required circle, whose direction as it passes through p will make an angle $opg = \omega$ with pp'. The lengths of the several lines are

$$op = \tan\tfrac{1}{2}u\,; \quad op^1 = \cot\tfrac{1}{2}u\,;$$
$$om = \cot u\,; \quad mn = \operatorname{cosec} u \cot\omega.$$

Again for the parallels take Pb = Pc equal to the co-latitude, say c, of the parallel to be projected; join vb, vc cutting lr in e, d. Then ed is the diameter of the circle which is the required projection; its centre is of course the middle point of ed, and the lengths of the lines are

$$od = \tan\tfrac{1}{2}(u - c)\,; \quad oe = \tan\tfrac{1}{2}(u + c).$$

The line sn itself is the projection of a parallel, namely, that of which the co-latitude $c = 180° - u$, a parallel which passes through the point of vision.

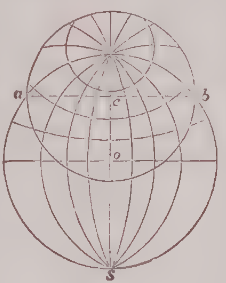

FIG. 15.

A very interesting connection, noted by Professor Cayley, exists between the stereographic projection of the sphere on a meridian plane (*i. e.*, when a point on the equator occupies the centre of the drawing) and the projection on the horizon of any place whatever. The very same circles that represent parallels and meridians in the one case represent them in the other case also. In fig. 15, abs being a projection in which an equatorial point is in the centre, draw any chord ab perpendicular to the centre meridian cos, and on ab as diameter describe a circle, when the property referred to will be observed. This smaller circle is now the stereographic projection of the sphere on the horizon of some place whose co-latitude we may call u. The radius of the first circle being unity, let $ac = \sin x$, then by what has been proved above $co = \sin x \cot u = \cos x$; therefore $u = x$, and $ac = \sin u$. Although the meridian circles dividing the 360° at the pole into equal angles must be actually the same in both systems, yet a parallel circle whose co-latitude is c in the direct projection abs belongs in the oblique system to some other co-latitude as c'. To determine the connection between c and c', consider the point t (not marked), in which one of the parallel circles crosses the line soc. In the direct system, p being the pole,

$$pt = 1 - \tan\tfrac{1}{2}(90° - c) = \frac{2}{1 + \cot\frac{1}{2}c}$$

and in the oblique,

$$pt = ac\left(\tan\tfrac{1}{2}u - \tan\tfrac{1}{2}(u - c')\right)$$

which, replacing ac by its value $\sin u$, becomes

$$\frac{2\sin\frac{1}{2}u\sin\frac{1}{2}c'}{\cos\frac{1}{2}(u - c')} = \frac{2}{1 + \cot\frac{1}{2}u\cot\frac{1}{2}c'},$$

therefore $\tan\frac{1}{2}c = \tan\frac{1}{2}c' \tan\frac{1}{2}u$ is the required relation.

Notwithstanding the facility of construction, the stereographic projection is not much used in map-making. But it may be made very useful as a means of graphical interpolation for drawing other projections in which points are represented in their true azimuths, but with an arbitrary law of distance, as $\rho = f(u)$. We may thus avoid the calculation of all the distances and azimuths (with reference to the selected centre point) of the intersections of meridians and parallels. Construct a stereographic projection of the globe on the horizon of the given place; then on this projection draw concentric circles (according to the stereographic law) representing the loci of points whose distances from the centre are consecutively 5°, 10°, 15°, 20°, etc., up to the required limit, and a system of radial lines at intervals of 5°. Then to construct any other projection—commence by drawing concentric circles, of which the radii are previously calculated by the law $\rho = f(u)$, for the successive values of u, 5°, 10°, 15°, 20°, etc., up to the limits as before, and a system of radial lines at intervals of 5°. This being completed, it remains to transfer the points of intersection from the stereographic to the new projection by graphic interpolation.

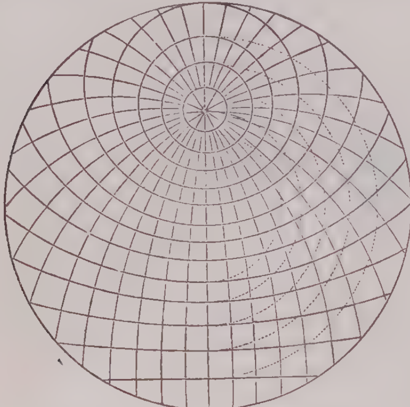

Fig. 16.—Stereographic Projection.

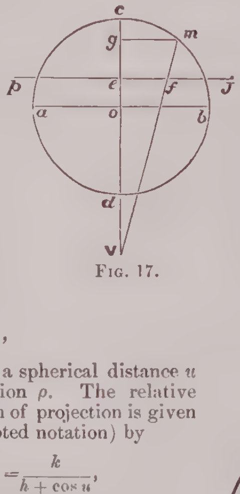

Fig. 17.

We now come to the general case in which the point of vision has any position outside the sphere. Let *abcd* (fig. 17) be the great circle section of the sphere by a plane passing through *c*, the central point of the portion of surface to be represented, and V the point of vision. Let *pj* perpendicular to V*c* be the plane of representation, join *m*V cutting *pj* in *f*, then *f* is the projection of any point *m* in the circle *abc*, and *ef* is the representation of *cm*. Let the angle $com = u$, $Ve = k$, $Vo = h$, $ef = \rho$; then, since $ef : eV = mg : gV$,

$$\rho = \frac{k \sin u}{h + \cos u},$$

which gives the law connecting a spherical distance u with its rectilinear representation ρ. The relative scale at any point in this system of projection is given (keeping to our previously adopted notation) by

$$\sigma = k \frac{1 + h \cos u}{(h + \cos u)^2}; \quad \sigma' = \frac{k}{h + \cos u},$$

the former applying to measurements made in a direction which passes through the centre of the map, the latter to the transverse direction. The product $\sigma\sigma'$ gives the exaggeration of areas. With respect to the alteration of angles we have

$$\Sigma = \frac{h + \cos u}{1 + h \cos u},$$

and the greatest alteration of angle is

$$= \sin^{-1}\left(\frac{h-1}{h+1} \tan^2 \frac{u}{2}\right).$$

This vanishes when $h = 1$, that is, if the projection be stereographic; or for $u = 0$, that is, at the centre of the map. At a distance of 90° from the centre, the greatest alteration is $90° - 2 \cot^{-1} \sqrt{h}$. (See *Philosoph. Mag.*, April, 1862.)

The constants h and k can be determined, so that the total misrepresentation, viz.,

$$M = \int_0^\beta \{(\sigma - 1)^2 + (\sigma' - 1)^2\} \sin u du,$$

shall be a minimum, β being the greatest value of u, or the spherical radius of the map. On substituting the expressions for σ and σ' the integration is effected without difficulty. Put

$$\lambda = \frac{1 - \cos \beta}{h + \cos \beta}; \quad \nu = (h - 1)\lambda,$$
$$H = \nu - (h + 1) \log_e (\lambda + 1),$$
$$H' = \frac{\lambda}{h + 1} (2 - \nu + \tfrac{1}{3}\nu^2).$$

Then the value of M is

$$M = 4 \sin^2 \tfrac{1}{2}\beta + 2kH + k^2H'.$$

When this is a minimum,

$$\frac{dM}{dh} = 0; \quad \frac{dM}{dk} = 0.$$

$$\therefore kH' + H = 0; \quad 2\frac{dH}{dh} + k\frac{dH'}{dh} = 0.$$

Therefore $M = 4 \sin^2 \frac{1}{2}\beta - \frac{H^2}{H'}$, and h must be determined so as to make $H^2 : H'$ a maximum. In any particular case this maximum can only be ascertained by trial, that is to say, $\log H^2 - \log H'$ must be calculated for certain equidistant values of h, and then the particular value of h which corresponds to the required maximum can be obtained by interpolation. Thus we find that if it be required to make the best possible perspective representation of a hemisphere, the values of h and k are $h = 1{\cdot}47$ and $k = 2{\cdot}034$; so that in this case

$$\rho = \frac{2{\cdot}034 \sin u}{1{\cdot}47 + \cos u}.$$

For a map of Africa or South America, the limiting radius β we may take as 40°; then in this case

$$\rho = \frac{2{\cdot}543 \sin u}{1{\cdot}625 + \cos u}.$$

For Asia, $\beta = 54$, and the distance h of the point of sight in this case is 1·61. Fig. 18 is a map of Asia having the meridians and parallels laid down on this system.

Figure 19 is a perspective representation of more than a hemisphere, the radius β being 108°, and the distance h of the point of vision, 1·40.

The co-ordinates xy of any point in this perspective may be expressed in terms of the latitude and longitude of the corresponding point on the sphere in the following manner. The co-ordinates originating at the centre, take the central meridian for the axis of y and a line perpendicular to it for the axis of x. Let the latitude of the point G, which is to occupy the centre of the map, be γ; if ϕ, ω be the latitude and longitude of any point P (the longitude being reckoned from the meridian of G), u the distance PG, and μ the

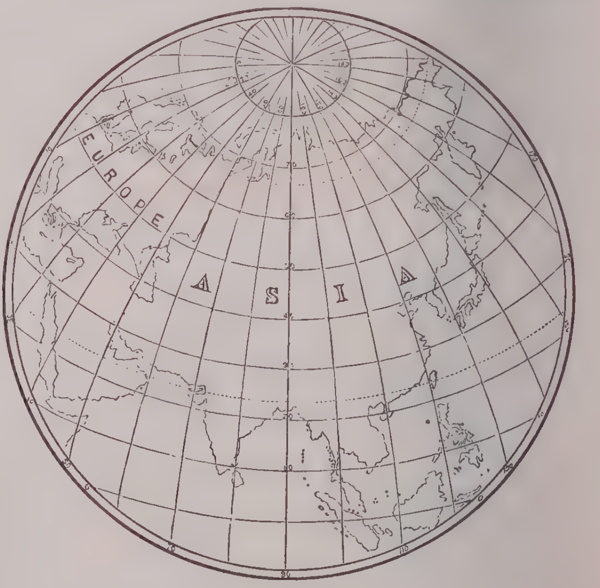

Fig. 18.

azimuth of P at G, then the spherical triangle whose sides are $90° - \gamma$, $90° - \phi$, and u gives these relations—

$$\begin{aligned}
\sin u \sin \mu &= \cos \phi \sin \omega, \\
\sin u \cos \mu &= \cos \gamma \sin \phi - \sin \gamma \cos \phi \cos \omega, \\
\cos u &= \sin \gamma \sin \phi + \cos \gamma \cos \phi \cos \omega.
\end{aligned}$$

Now $x = \rho \sin \mu$, $y = \rho \cos \mu$, that is,

$$\frac{x}{k} = \frac{\cos \phi \sin \omega}{h + \sin \gamma \sin \phi + \cos \gamma \cos \phi \cos \omega},$$

$$\frac{y}{k} = \frac{\cos \gamma \sin \phi - \sin \gamma \cos \phi \cos \omega}{h + \sin \gamma \sin \phi + \cos \gamma \cos \phi \cos \omega},$$

by which x and y can be computed for any point of the sphere. If from these equations we eliminate ω, we get the equation to the parallel whose latitude is ϕ; it is an ellipse whose centre is in the central meridian, and its greater axis perpendicular to the same. The radius of curvature of this ellipse at its intersection with the centre meridian is

$$\frac{k \cos \phi}{h \sin \gamma + \sin \phi}.$$

The elimination of ϕ between x and y gives the equation of the meridian whose longitude is ω, which also is an ellipse whose centre and axes may be determined.

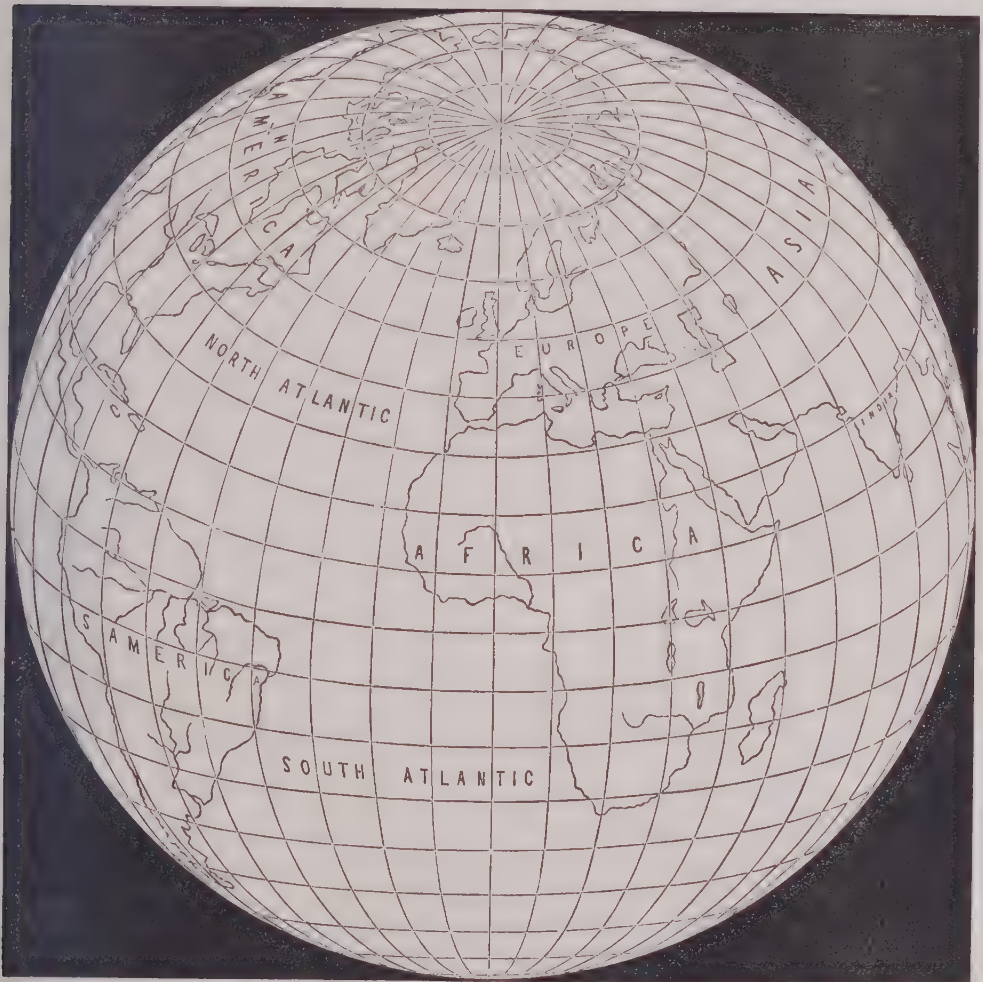

Fig. 19.—Twilight Projection.

ϕ	Values of x and y.				
	$\omega = 0°$	$\omega = 10°$	$\omega = 20°$	$\omega = 30°$	$\omega = 40°$
0°	$x =$ 0·00 $y =$ 0·00	9·69 0·00	19·43 0·00	29·25 0·00	39·17 0·00
10°	$x =$ 0·00 $y =$ 9·69	9·60 9·75	19·24 9·92	28·95 10·21	38·76 10·63
20°	$x =$ 0·00 $y =$ 19·43	9·32 19·54	18·67 19·87	28·07 20·43	37·53 21·25
30°	$x =$ 0·00 $y =$ 29·25	8·84 29·40	17·70 29·87	26·56 30·67	35·44 31·83
40°	$x =$ 0·00 $y =$ 39·17	8·15 39·36	16·28 39·94	24·39 40·93	32·44 42·34

The preceding table contains the computed co-ordinates for a map of Africa, which is included between latitudes 40° north and 40° south, and 40° of longitude east and west of a central meridian.

Conical Development.

The conical development is adapted to the construction of maps of tracts of country of no great extent in latitude but any extent in the direction of a parallel. Selecting the mean parallel, or that which most nearly divides the area to be represented, we have to consider the cone which touches the sphere along that parallel. In fig. 20, which is an orthographic projection of the sphere on a meridian plane, let Pp be the parallel of contact with the cone. ON being the axis of revolution, the tangents at P and p will intersect ON

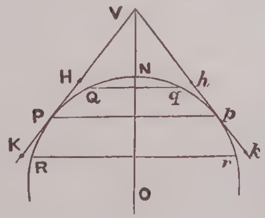

Fig. 20.

produced in V. Let Qq be a parallel to the north of Pp, Rr another parallel the same distance to the south, that is, PQ = PR. Take on the tangent PV two points H, K such that PH = PK, each being made equal to the arc PQ. It is clear, then, that the surface generated by HK is very nearly coincident with the surface generated by RQ when the figure rotates round ON through any angle, great or small. The approximation of the surfaces will, however, be very close only if QR is very small. Suppose, now, that the paths of H and K, as described in the revolution round ON, are actually marked on the surface of the cone, as well as the line of contact with the sphere. And further, mark the surface of the cone by the intersections with it of the meridian planes through OV at the required equal intervals. Then let the cone be cut along a generating line and opened out into a plane, and we shall have a representation as in fig. 21 of the spherical surface contained between the latitudes of Q and R. The parallels here are represented by concentric circles, the meridians by lines drawn through the common centre of the circles at equal angular intervals. Taking the radius of the sphere as unity, and ϕ being the latitude of P, we see that VP = cot ϕ, and if ω be the difference of longitude between two meridians, the corresponding length of the arc Pp is $\omega \cos \phi$. The angle between these meridians themselves is $\omega \sin \phi$.

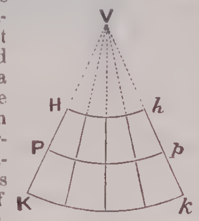

FIG. 21.

Suppose, now, we require to construct a map on this principle for a tract of country extending from latitude $\phi - m$ to $\phi + m$, and covering a breadth of longitude of $2n$, m and n being expressed in degrees. In fig. 21 let HKkh be the quadrilateral formed by the extreme lines, so that HK = $hk = 2m$; then the angle HVh is $2n \sin \phi$ expressed in degrees. Now, taking the length of a degree as the unit, VP = 57·296 cot ϕ, and VH = 57·296 cot $\phi - m$. It may be convenient in the first instance to calculate the chords Hh, Kk, and thus construct the rectilinear quadrilateral HKkh. The lengths of these chords are

$$\begin{aligned} \mathrm{H}h &= 2(57{\cdot}296 \cot \phi - m) \sin (n \sin \phi), \\ \mathrm{K}k &= 2(57{\cdot}296 \cot \phi + m) \sin (n \sin \phi), \end{aligned}$$

and the distance between them is $2m \cos (n \sin \phi)$. The inclined sides of this trapezoid will then meet in a point at V, whose distance from P and p must correspond with the calculated length of VP. Now with this centre V describe the circular arcs representing the parallels through H, K, P. Also if the parallels are to be drawn at every degree of latitude, divide HK into $2m$ equal parts, and through each point of division describe a circular arc from the centre V. Then divide Pp into $2n$ equal parts, and draw the meridian lines through each of these points of division and the centre V.

If the centre V be inconveniently far off, it may be necessary to construct the centre parallel by points, that is, by calculating the co-ordinates of the various points of division. For this purpose, draw through the intersection of the centre meridian and centre parallel a line perpendicular to the meridian and therefore touching the parallel. Let the co-ordinate x be measured from the centre along this line, and y perpendicular to it. Then the co-ordinates of a point whose longitude measured from the centre meridian is ω are

$$\begin{aligned} x &= \cot \phi \sin (\omega \sin \phi), \\ y &= 2\cot \phi \sin^2 \tfrac{1}{2}(\omega \sin \phi) = x \tan \tfrac{1}{2}(\omega \sin \phi), \end{aligned}$$

the radius of the sphere being the unit; if a degree be the unit, these must be multiplied by 57·296.

The great defect of this projection is the exaggeration of the lengths of parallels towards either the northern or southern limits of the map. Various have been the devices to remedy this defect, and amongst these the following is a system very much adopted. Having subdivided the central meridian and drawn through the points of division the parallels precisely as described above, then the true lengths of degrees are set off along *each* parallel; the meridians, which in this case become curved lines, are drawn through the corresponding points of the parallels (fig. 22).

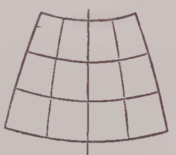

FIG. 22.

This system is that which was adopted in 1803 by the "Dépôt de la Guerre" for the map of France, and is there known by the title "*Projection de Bonne.*" It is that on which the Ordnance Survey map of Scotland on the scale of one inch to a mile is constructed, and it is frequently met with in ordinary atlases. It is ill-adapted for countries having great extent in longitude, as the intersections of the meridians and parallels become very oblique—as will be seen on examining the map of Asia in most atlases. If ϕ_0 be taken as the latitude of the centre parallel, and co-ordinates be measured from the intersection of this parallel with the central meridian, as in the case of the conical projection, then, if ρ be the radius of the parallel of latitude ϕ, we have $\rho = \cot \phi_0 + \phi_0 - \phi$. Also, if S be a point on this parallel whose co-ordinates are x, y, so that VS $= \rho$, and θ be the angle VS makes with the central meridian, then $\rho\theta = \omega \cos \phi$; and

$$x = \rho \sin \theta, \quad y = \cot \phi_0 - \rho \cos \theta.$$

Now, if we form the differential coefficients of x and y with respect to ϕ and ω, the latitude and longitude of S, we get

$$\begin{aligned} m'n - mn' &= \cos \phi, \\ mn + m'n' &= \frac{\omega}{\rho} \cos \phi (\cos \phi - \rho \sin \phi); \end{aligned}$$

the first of which equations proves that the areas are truly represented. Moreover, if $90° \pm \psi$ be the angles of intersections of meridians and parallels,

$$\tan \psi = \theta - \omega \sin \phi,$$

which indeed might have been more easily obtained. In the case of Asia, the middle latitude $\phi_0 = 40°$, and the extreme northern latitude is 70°. Also the map extends 90° of longitude from the central meridian; hence, at the north-west and north-east corners of the map the angles of intersection of meridians and parallels are $90° \pm 33°{\cdot}54'$. But for comparatively small tracts of country, as France or Scotland, this projection is very suitable.

Another modification of the conical projection consists in taking, not a tangent cone, but a cone which, having its vertex in the axis of revolution produced, intersects the sphere in two parallels,—these parallels being approximately midway between the centre parallel of the country and the extreme parallels. By this means part of the error is thrown on the centre parallel which is no longer represented by its true length, but is made too small, while the parallels forming the intersections of the cone are truly represented in length.

The exact position of these particular parallels may be determined so as to give, upon the whole, the least amount of exaggeration for the entire map. This idea of a cutting cone seems to have originated[1] with the celebrated Gerard Mercator, who in 1554 made a map of Europe on this principle, selecting for the parallels of intersection those of 40° and 60°. The same system was adopted in 1745 by Delisle for the construction of a map of Russia. Euler in the *Acta Acad. Imp. Petrop.*, 1778, has discussed this projection and determined the conditions under which the errors at the northern extremity, at the centre, and at the southern extremity of a map so constructed shall be severally equal. Let c, c' be the co-latitudes of the extreme northern and southern parallels, γ, γ' those of two intermediate parallels, which are to be truly represented in the projection. Let OC′, Om' (fig. 23) be two consecutive meridians, as represented in the developed cone; the difference of longitude being ω, let the angle at O be $h\omega$. The degrees along the meridian being represented by their proper lengths, CC′ $= c' - c$; and P corresponding to the pole, let OP $= z$, then OC $= z + c$; and so for G, G′, C′. The true lengths of G′n' and Gn, namely, $\omega \sin \gamma'$ and $\omega \sin \gamma$, are equal to the represented lengths, namely, $h\omega\,(z + \gamma')$ and $h\omega\,(z + \gamma)$ respectively, whence γ and γ' are known when h and z are known. Comparing now the represented with the true lengths of parallel at the extremities and at the centre, if e be the common error that is to be allowed, then

$$\begin{aligned} e &= h\omega(z + c) - \omega \sin c, \\ e &= - h\omega(z + \tfrac{1}{2}c + \tfrac{1}{2}c') + \omega \sin \tfrac{1}{2}(c + c'), \\ e &= h\omega(z + c') - \omega \sin c'. \end{aligned}$$

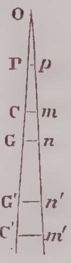

FIG. 23.

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[1] See page 178 of *Traité des Projections des Cartes Géographiques*, by A. Germain, Paris, an admirable and exhaustive essay. See also the work entitled *Coup d'œil historique sur la Projection des Cartes de Géographie*, by M. d'Avezac, Paris, 1863.

The difference of the first and third gives h, and then subtracting the second from the mean of the first and third, we get

$$z + \tfrac{1}{2}(c + c') = \tfrac{1}{4}(c' - c) \cot \tfrac{1}{4}(c' - c) \tan \tfrac{1}{2}(c' + c).$$

Thus z being known, the common centre of the circles representing the parallels is given. The value of h is given by the equation $h(c' - c) = \sin c' - \sin c$, and γ and γ' can be easily computed. But there is no necessity for doing this as we may construct the angles at O, which representing a difference of longitude ω are in reality equal to $h\omega$.

For instance, to construct a map of Asia on this system, having divided the central meridian into equal spaces for degrees z must be calculated. Here we have $c = 20°$, $c' = 80°$, whence $z + 50° = 15° \tan 50° \cot 15° = 66°{\cdot}7$. Hence in this case the centre of the circles is 16°·7 beyond the north pole; also $h = {\cdot}6138$, so that a difference of longitude of 5° is represented at O by an angle of 3° 4′ 9″. The degrees of longitude in the parallel of 70° are in this map represented too large in the ratio of 1·150 : 1; those in the mid-latitude of 40° are too small in the ratio of 0·933 : 1; and those in 10° latitude are too large in the ratio of 1·05 to 1.

Gauss's Projection

may be considered as another variation of the conical system of development. Meridians are represented by lines drawn through a point, and a difference of longitude ω is represented by an angle $h\omega$, as in the preceding case. The parallels of latitude are circular arcs, all having as centre the point of divergence of the meridian lines, and the law of their formation is such that the representations of all small parts of the surface shall be precisely similar to the parts so represented. Let u be the co-latitude of a parallel, and ρ, a function of u, the radius of the circle representing this parallel. Consider the infinitely small space on the sphere contained by two consecutive meridians the difference of longitude of which is $d\mu$, and two consecutive parallels whose co-latitudes are u and $u + du$. The sides of this rectangle (fig. 24) are $pq = du$, $pr = \sin u d\mu$, whereas in the representation $p'q'r's'$, $p'q' = d\rho$, $p'r' = \rho h d\mu$, the angle at O being $= h d\mu$. Now, as the representation is to be similar to the original,

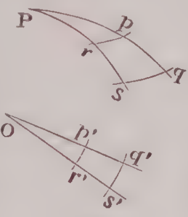

FIG. 24.

$$\frac{p'q'}{p'r'} = \frac{d\rho}{h\rho d\mu} = \frac{pq}{pr} = \frac{du}{\sin u d\mu},$$

whence $\dfrac{d\rho}{\rho} = h \dfrac{du}{\sin u}$, and integrating,

$$\rho = k\left(\tan \frac{u}{2}\right)^h,$$

where the constant h is to be determined according to the requirements of each individual case. This investigation was first made in 1772 by the German mathematician J. H. Lambert,[1] but in 1825 it was again brought forward by Gauss in an essay written in answer to a prize question proposed by the Royal Society of Sciences at Copenhagen. A translation of this essay is to be found in the *Philosophical Magazine* for 1828 (see page 112), where Lambert's projection comes out as a particular solution of the general problem. Again, in a general investigation of the problem of "similar representation," Sir John Herschel, in the 30th volume of the *Journal of the Royal Geographical Society* (1860), deduced as a particular case this same projection. A large map of Russia was constructed and published on this system by the Geographical Society of St. Petersburg in 1862.

The relative scale in this development is—

$$\frac{d\rho}{du} = \frac{hk}{a} \cdot \frac{\left(\tan \frac{u}{2}\right)^h}{\sin u},$$

where a is the radius of the sphere. It is a minimum when $u = \cos^{-1} h$. This minimum should occur in the vicinity of the central parallel of the map; if u_0 be the co-latitude of this parallel, we may put

$$\rho = k\left(\tan \frac{u}{2}\right)^{\cos u_0}.$$

Or if we agree that the scale of the representation shall be the *same* at the extreme co-latitudes c, c', then

$$h = \frac{\log \sin c' - \log \sin c}{\log \tan \frac{1}{2}c' - \log \tan \frac{1}{2}c}.$$

To construct a map of North America extending from 10° latitude to 70°, we may take $h = \frac{2}{3}$, and k such as shall make the difference of radii of the extreme parallels $= 60$, namely $k = 104{\cdot}315$. The scales of the representation at the northern and southern limits are 1·116 and 1·096 respectively. The radii of the parallels are these—

70° . . .	32·801	30° . . .	72·328
60° . . .	43·356	20° . . .	82·255
50° . . .	53·177	10° . . .	92·801
40° . . .	62·728	0° . . .	104·315

Having drawn a line representing the central meridian, and selected a point on it as the centre of the concentric circles, let arcs be described with the above radii as parallels. For meridians, in this system a difference of longitude of 10° is represented by an angle of two-thirds that amount, or 6° 40′. The chord of this angle on the parallel of 10°, whose radius is 92·801, is easily found to be 10·792. Now stepping this quantity with a pair of compasses along the parallel, we have merely to draw lines through each of the points so found and the common centre of circles. The points of division of the parallel may be checked by taking the chord of 20°, or rather of 13° 20′, which is 21·547. The map of North America so found (fig. 25) shows small portions of country in strictly correct forms; but the areas are slightly too great at the extreme latitudes and too small in the centre. At any part of the map a degree of latitude may be used as the true scale in any direction.

The value $h = \frac{1}{3}$, as suggested by Sir John Herschel, is admirably suited for a map of the world. The representation is fan-shaped, with remarkably little distortion (fig. 26).

It follows from what has been said above that the condition that the scale is true at the equator is $hk = a$, which determines k when h is given. The radius of the parallel whose co-latitude is u being ρ, let r be the distance of that

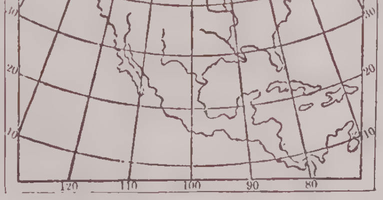

FIG. 25.

parallel from the equator; then, keeping to the condition that the scale is true at the equator,

$$\rho = \frac{a}{h} \tan^h \frac{u}{2},$$

$$r = \frac{a}{h}\left(1 - \tan^h \frac{u}{2}\right).$$

When h is very small, the angles between the meridian lines in the representation are very small; and proceeding to the limit, when h is zero the meridians are parallel, that is, the vertex of the cone has removed to infinity. And at the limit when h is zero we have

$$r = a \log_e \cot \frac{u}{2},$$

which is the characteristic equation of

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[1] *Beiträge zum Gebrauche der Mathematik und deren Anwendung*, vol. iii. p. 55. Berlin, 1772.

Mercator's Projection.

From the manner in which we have arrived at this projection it is clear that it retains the characteristic property of Gauss's projection,—namely, similarity of representation of small parts of the surface. In Mercator's chart the equator is represented by a straight line, which is crossed at right angles by a system of parallel and equidistant straight lines representing the meridians. The parallels are straight lines parallel to the equator, and the distance of the parallel of latitude ϕ from the equator is, as we have seen above, $r = a \log_e \tan(45° + \frac{1}{2}\phi)$. In the vicinity of the equator, or indeed within 30° of latitude of the equator, the representation is very accurate, but as we proceed northwards or southwards the exaggeration of area becomes larger, and eventually excessive,—the poles being at infinity. This distance of the parallels may be expressed in the form $r = a\,(\sin\phi + \frac{1}{3}\sin^3\phi + \frac{1}{5}\sin^5\phi + \ldots)$, showing that near the equator r is nearly proportional to the latitude. As a consequence of the similar representation of small parts, a curve drawn on the sphere cutting all meridians at the same angle—the loxodromic curve—is projected into a straight line, and it is this property which renders Mercator's chart so valuable to seamen. For instance: join by a straight line on the chart Land's End and Bermuda, and measure the angle of intersection of this line with the meridian. We get thus the bearing which a ship has to retain during its course between these ports. This is not great-circle sailing, and the ship so navigated does not take the shortest path. The projection of a great circle (being neither a meridian nor the equator) is a curve which cannot be represented by a simple algebraic equation.

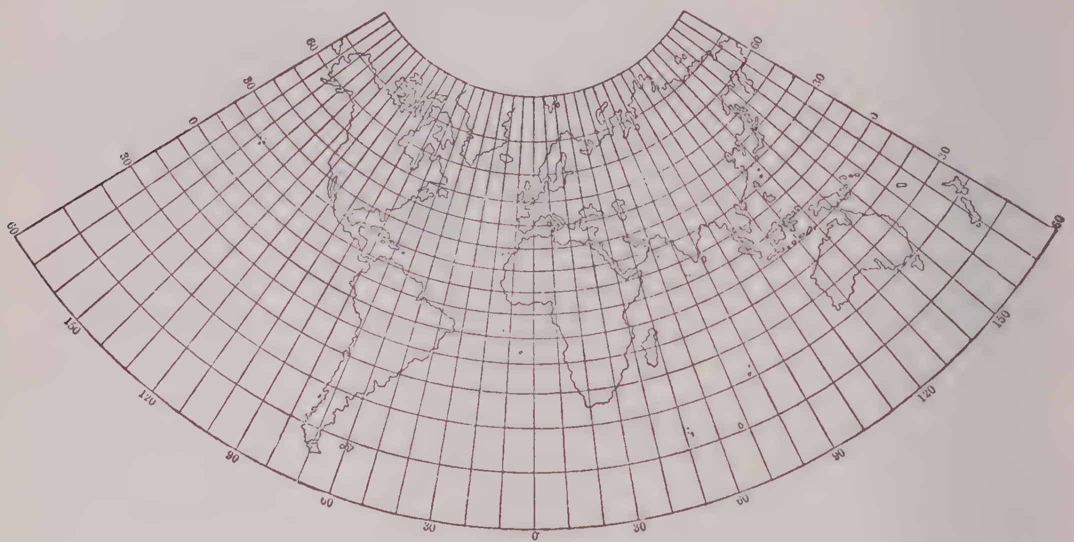

Fig. 26.—Fan-shaped Map of the World.

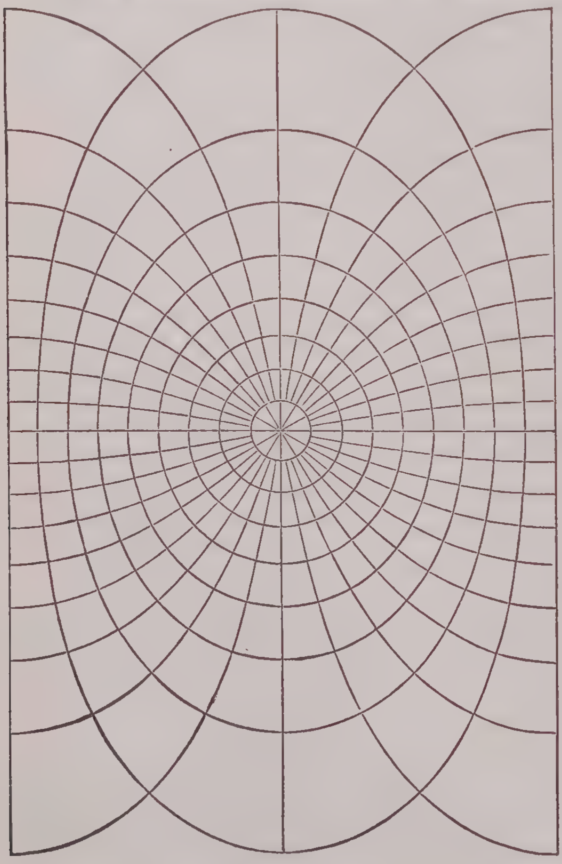

Fig 27.

If we apply Mercator's system of projection *along a meridian*, as proposed by Lambert, we have the representation of all possible great circles. The diagram (fig. 27) gives the projection. The two vertical bounding lines are the equator—crossed at right angles by the initial meridian passing through one of the poles. From the form of the representations of parallels round the pole it is clear that the distortion up to a distance of 30° or 40° from the initial meridian is not at all great. The representation extends to infinity upwards and downwards, and the left and right halves are interchangeable; if interchanged the representation is on a meridian extending from pole to pole.

The meridian Mercator drawn as described in the last paragraph—with the meridians and parallels rather close—may be made to serve the important purpose of enabling one to trace on the ordinary Mercator's chart the track of a great circle joining any two places, and of indicating at the same time the distance of the two places. For this purpose the two charts must be on the same scale, one of them being on tracing paper or tracing linen. The transparent chart being placed over the other, the equator in the ordinary chart must coincide with the initial meridian in the meridian Mercator. Retaining this relative position, let the upper chart be moved until the two points (the projection of the great circle joining which is required) on the ordinary Mercator are found to lie on a great circle of the meridian Mercator.

The curvatures of the meridians and parallels in the meridian Mercator are expressed by very simple formulæ. Let x, y be the co-ordinates, measured from the pole along and perpendicular to the initial meridian, of any point S of the representation,—x corresponding to an arc of the sphere $= x$, and y to an arc η which is on the sphere the distance of S from the initial meridian. Then if x', y' be the centre of curvature of the parallel at S, x'', y'' the centre of curvature of the meridian at S,

$$x' = x - \tan x\,, \quad x'' = x + \frac{1}{\tan x}\,,$$

$$y' = y - \sin\eta\,, \quad y'' = y - \frac{1}{\sin\eta}\,.$$

The corresponding radii of curvature are $\sin\beta \div \cos x$, where β is the spherical radius of the small circle, and $1 \div \sin x \sin\gamma$, where γ is the longitude of the great circle, counted from the initial meridian.

Polyconic Development.

Imagine a hollow globe formed of a mere surface of paper, to be cut by a system of parallel planes along equidistant parallels of latitude; let also one meridian be cut through, from north pole to south pole, 180°. In this state let the whole be opened out into a plane from the meridian exactly opposite to the one cut through, and the previously spherical surface is converted into a number of strips of paper, each of which is part of a circular belt, with the exception of the equator, which will be straight. All points which lay on the parallel whose co-latitude is u now lie on an arc of a circle whose radius is $\tan u$ and length $2\pi\sin u$; moreover, the centres of these arcs lie in the same straight line, which is the central meridian produced. The parallels being now defined, we must define meridians. These may be formed by laying off on each parallel the degrees of longitude according to their true lengths, which is the system adopted in the maps of the United States Coast Survey. Or we may take for meridians that system of lines which cuts the parallels at right angles, forming the rectangular polyconic system.

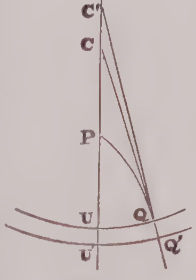

FIG. 28.

In this case, let P (fig. 28) be the north pole, CPU the central meridian, U, U′ points in that meridian whose co-latitudes are u and $u + du$, so that $UU' = du$. Make $PU = u$, $UC = \tan u$, $U'C' = \tan(u + du)$; and with CC′, as centres describe the arcs UQ, U′Q′, which represent the parallels of co-latitude u and $u + du$. Let PQQ′ be part of a meridian curve cutting the parallels at right angles. Join CQ, C′Q′; these being perpendicular to the circles will be tangents to the curve. Let $UCQ = 2\phi$, $UC'Q' = 2(\phi + d\phi)$, then the small angle CQC′, or the angle between the tangents at QQ′, will $= 2d\phi$. Now

$$CC' = C'U' - CU - UU' = \tan(u + du) - \tan u - du = \tan^2 u\, du\,;$$

and in the triangle CC′Q the perpendicular from C on C′Q′ is equal to either side of the equation

$$\tan^2 u\, du \sin 2\phi = -\tan u\, d\phi.$$

$$-\tan u\, du = \frac{2d\phi}{\sin 2\phi}\,,$$

which is the differential equation of the meridian: the integral is $\tan\phi = \omega\cos u$, where ω, a constant, determines a particular meridian curve. The distance of Q from the central meridian, $\tan u \sin 2\phi$, is equal to

$$\frac{2\tan u \tan\phi}{1 + \tan^2\phi} = \frac{2\omega\sin u}{1 + \omega^2\cos^2 u}\,.$$

At the equator this becomes simply 2ω. Let any equatorial point whose actual longitude is 2ω be represented by a point on the developed equator at the distance 2ω from the central meridian, then we have the following very simple construction (due to Mr. O'Farrel of the Ordnance Survey-Office). Let P (fig. 29) be the pole, U any point in the central meridian, QUQ′ the represented parallel whose radius $CU = \tan u$. Draw SUS′ perpendicular to the meridian through U; then to determine the point Q, whose longitude is, say, 3°, lay off US equal to half the true length of the arc of parallel on the sphere, *i. e.*, 1° 30′ to radius $\sin u$, and with the centre S and radius SU describe a circular arc, which will intersect the parallel in the required point Q. For if we suppose 2ω to be the longitude of the required point Q, US is by construction $= \omega \sin u$, and the angle subtended by SU at C is

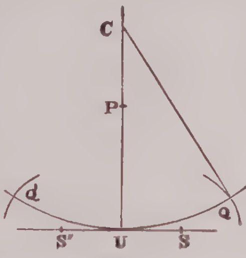

FIG. 29.

$$\tan^{-1}\left(\frac{\omega\sin u}{\tan u}\right) = \tan^{-1}(\omega\cos u) = \phi,$$

and therefore $UCQ = 2\phi$, as it should be. The advantages of this method are that with a remarkably simple and convenient mode of construction we have a map in which the parallels and meridians intersect at right angles.

The following table contains the lengths of the radii for describing parallels, and also the lengths of degrees of longitude for every 5° of latitude,—the radius of the sphere being 57·296:—

Lat.	Radius for Parallel.	Degree of Longitude.	Lat.	Radius for Parallel.	Degree of Longitude.
0°	∞	1·0000	45°	57·30	·7071
5	654·89	·9962	50	48·08	·6428
10	324·94	·9848	55	40·12	·5736
15	213·83	·9659	60	33·08	·5000
20	157·42	·9397	65	26·72	·4226
25	122·87	·9063	70	20·85	·3420
30	99·24	·8660	75	15·35	·2588
35	81·83	·8191	80	10·10	·1736
40	68·28	·7660	85	5·01	·0872

With regard to the distortion involved in this system of development, consider a small square described on the surface of the sphere, its sides being parallel to and perpendicular to the meridian. Let u and 2ω define its position, and let i be the length of its side. If we differentiate the equation $\tan\phi = \omega\cos u$, u being constant, $\sec^2\phi\, d\phi = \cos u\, d\omega$. But the representation of $2d\omega$ is $2\tan u\, d\phi$, which is equal to $\sin u \cos^2\phi\, d.2\omega$; hence that side of the square which is parallel to the equator is represented by $i\cos^2\phi$. And similarly the meridional side is represented by

$$i\cos^2\phi(1 + \omega^2 + \omega^2\sin^2 u).$$

Therefore the square is represented by a rectangle whose sides are in the proportion of

$$1 : 1 + \omega^2 + \omega^2\sin^2 u,$$

and its area is increased in the proportion of

$$1 + \omega^2 + \omega^2\sin^2 u : (1 + \omega^2\cos^2 u)^2.$$

Fig. 30 is a representation on this system of the continents of Europe and Africa, for which it is well suited. For Asia this system would not do, as in the northern latitudes, say along the parallel of 70°, the representation is much cramped.

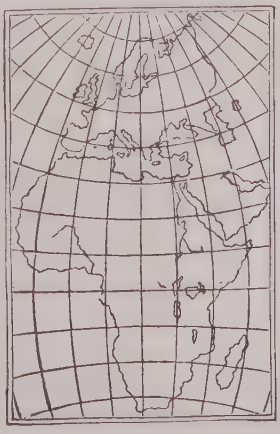

FIG. 30.

With regard to the distortion in the map of Africa as thus constructed, consider a small square in latitude 40° and in 40° longitude east or west of the central meridian, the square being so placed as to be transformed into a rectangle. The sides, originally unity, become 0·95 and 1·13, and the area 1·08, the diagonals intersecting at 90° ± 9° 56′. In the perspective projection a square of unit side occupying the same position, when transformed to a rectangle, has its sides 1·02 and 1·15, its area 1·17, and its diagonals intersect at 90° ± 7° 6′. The latter projection is therefore the best in point of "similarity," but the former represents areas best. This applies, however, only to a particular part of the map; along the equator towards 30° or 40° longitude, the polyconic is certainly inferior, while along the meridian it is better than the perspective—except, of course, near the centre. Upon the whole, the more even distribution of distortion gives the advantage to the perspective system. The system of lines ordinarily used for the map of Africa is objectionable, and has scarcely the excuse of facility of construction, since the perspective co-ordinates given above are so easily computed.

Ordnance Survey Maps.

The method of development used in the Ordnance Survey maps of England on the scale of one inch to a mile, as also in the county maps of England, Scotland, and Ireland, on the 6-inch scale, is this. A central meridian having been selected, let a perpendicular arc be drawn from any trigonometrical station p to the meridian, meeting it in q. S being a point of reference selected in the central meridian, make $\mathrm{S}q = y$, $pq = x$. Then in the development, a straight line drawn to represent the central meridian is the axis of y, and a line at right angles to this is the axis of x. The point whose co-ordinates are $x = pq$, $y = \mathrm{S}q$ is the representation of p. Supposing the earth spherical, if ϕ, ω be the latitude and longitude of p, then ω being small, that is, only a few degrees,

$$\begin{aligned} dx &= \quad - x \tan\phi d\phi + \cos\phi(1 - \tfrac{1}{2}x^2 \tan^2\phi)d\omega, \\ dy &= (1 + \tfrac{1}{2}x^2 - \tfrac{1}{2}x^2 \tan^2\phi)d\phi \quad + \quad x \sin\phi \, d\omega, \end{aligned}$$

from which the distortion can be computed. It principally consists in the exaggeration of the scale in a north-and-south direction at the extreme longitudes, where $\sigma = \sec x$.

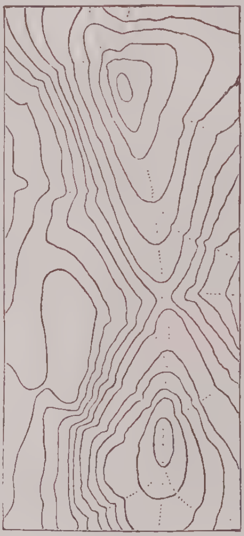

FIG. 31.

Contours.

In maps of a large scale, it is usual to show the relief of the ground by contour lines, which are the intersections with the actual surface of a system of equidistant horizontal planes. Contours indicate not only the height of the ground but its slope. Fig. 31 shows a piece of contoured country, including two summits and a "col" between them.

The dotted lines, which, however, are not shown in maps, are lines of greatest slope, cutting contours at right angles. At each summit, supposing the contours there to be ellipses (Dupin's indicatrices), there is an infinity of steepest lines having a common tangent there. At the col, where the indicatrix is an hyperbola, there are two steepest lines intersecting at right angles, of which one is the "watershed" joining the summits. (A. R. C.)

III. PHYSICAL GEOGRAPHY.

This term in its ordinary acceptation means a description of the physical features of the earth. It includes an account of the phenomena of the atmosphere; of the composition, distribution, and movements of the sea; of the forms of the land, with its water circulation, earthquakes, and volcanoes; of the distribution of plant and animal life. Its object, however, is not to present a mere bald enumeration of facts, but to group the facts together in such a way as to bring before the mind a luminous picture of the whole structure and working of the earth as a habitable planet. Physical geography is not so much a science or branch of science as a collection of the data ascertained, and probable conclusions arrived at, by different sciences, in so far as these bear upon its own subject. Accordingly, it culls from all departments of inquiry whatever helps to give additional distinctness and vividness to that broad conception of the daily economy of the globe which it is its aim to form and develop.

So vast a subject, if treated in its entirety, would demand a very large allotment of space for its adequate discussion. Some of its branches have, during the last few years, received so much development that in the present edition of this work it has been considered more expedient to make them the subject of special articles; and here, therefore, to avoid the repetition which a general article on physical geography would involve, there will be given, instead of a formal essay, a mere outline or synopsis of the branches of knowledge embraced in the subject, with references to the other parts of the work where detailed information may be looked for. In the first three parts of the article GEOLOGY a large section of what is usually included under physical geography will be found.

1. *The Earth in its Cosmical Relations.*—From astronomy we learn the shape and size of the earth, its motions of rotation round its axis and of revolution in an elliptical orbit round the sun, the origin of day and night, and of the seasons. Speculating on the original condition of the whole solar system, we may regard it as having been in the condition of a nebula, gradually contracting, condensing, and leaving behind successive rings, which on disruption and reaggregation formed planets. Hence the primitive condition of our globe as a separate mass must have been gaseous or fluid. Since that time the earth has been cooling and contracting, but still retains a high residual temperature in its interior. This original condition, and the internal heat of the earth, must be constantly kept in view as an explanation of many of the features of its outer surface. See GEOLOGY, part i.; ASTRONOMY, chapter i.; GEOGRAPHY (MATHEMATICAL); GEODESY.

2. *The Atmosphere or Gaseous Envelope of the Earth.*—The solid planet is covered by two envelopes, one of gas, which completely surrounds it, and one of water, which occupies about three-fourths of its surface. In studying the atmosphere we have to consider its height, its composition, its temperature, its moisture, and its pressure (see ATMOSPHERE, METEOROLOGY). Its height must be at least 40 or 50 miles. This deep gaseous ocean consists of a mixture of the two gases, oxygen (21 parts by weight) and nitrogen (79 parts), with a minute proportion of carbonic acid (·004) and of aqueous vapor. The physical geographer takes note of the manifold importance of oxygen, not only in supporting animal life, but in the general oxidation of the earth's outer crust. He recognizes the atmospheric carbonic acid as the source of the carbon built up into the structure of plants. He cannot contemplate without ever-increasing wonder and delight the coming and going of the water-vapor in the air, as it rises incessantly from every sea and land, and after condensation into visible form courses over the land as rain, brooks, rivers, and glaciers (see GEOLOGY, part iii.). The consideration of the temperature of the atmosphere elicits the facts that temperature falls as we rise above the sea-level, and as we recede from the equator to the poles, and that it is profoundly affected by the relative positions of sea and land. The want of strict dependence upon latitude in this distribution of temperature is strikingly brought out by the contrast between the mean temperature of Labrador and Ireland on the same parallels (see CLIMATE, ISOTHERMS). In dealing with the moisture of the air we have to consider the phenomena of evaporation and condensation, the formation of dew, clouds, rain, snow, and hail, the distribution of rain, the position of the snow-line, the occurrence of deserts, etc. (see METEOROLOGY). The study of the pressure of the atmosphere, which appears to vary with variations in temperature and amount of vapor, brings before us the cause of the constant aerial movements. The law has now been well established that air always flows out from tracts where the barometric pressure is high into those where it is low. A knowledge of the distribution of pressure over the globe furnishes the key to the great movements of the atmospheric circulation. The trade winds, for example, blow constantly from a belt of high pressure towards the equator, where the pressure remains low. Periodic winds, like the monsoons and land and sea breezes, shift with the changes in atmospheric pressure. Thus Asia during winter is a vast region of high pressure; the winds round its margin therefore flow out towards the sea. In summer, on the other hand, it becomes a region of low pressure, and the winds consequently blow inland from the sea. Sudden and violent atmospheric movements, such as tempests and hurricanes, are illustrations of the same law, the force of the wind being always proportional to the shortness of the space between great extremes of pressure (see ATMOSPHERE).

3. *The Ocean or Water-Envelope of the Earth*, from the point of view of physical geography, presents for consideration the form of the basins in which it is contained, the shape and nature of their bottom, their submarine ridges and islands, the density and composition of the water, the distribution of marine temperature, the ice of the sea, and the movements of the ocean due to cosmical causes as in the tides, to the effects of winds as in surface drifts, currents, and waves, and to differences of temperature. The largest additions in recent years to our knowledge of the earth have been made in the ocean, notably by the different expeditions and cruises equipped for the purpose by the British Government. The climates of the sea have been systematically determined, and the extraordinary fact has been brought to light that the great mass of the ocean water is cold, or below 40° Fahr. Even in the equatorial parts of the ATLANTIC and PACIFIC OCEANS (*q. v.*), though the upper layers of water partake in the heat of the intertropical latitudes, a temperature of 40° is found within 300 fathoms of the surface, while at the bottom, at depths of 2500 or 3000 fathoms, the temperature (32°·4 to 33° Fahr.) is very little above that of the freezing-point of fresh water. It has been proved that the bottom temperature of every ocean in free communication with the poles has a temperature little different from that of the water in polar latitudes. Between Scotland and the Faroe Islands a sounding was obtained giving even a temperature of 29°·6, or 2·4 degrees below the freezing-point of fresh water, and very little above that of salt water. These observations warrant the conclusion that a vast system of circulation takes place in the ocean. The cold heavy polar water creeps slowly towards the equator under the upper lighter water, which moves away towards the poles.

4. *The Land.*—We have to consider the distribution of the land over the face of the globe, the grouping of the continents, the forms and trend of the great terrestrial ridges, the relation of coast-line to superficial area, the contours of the land, as mountains, table-lands, valleys, and plains, the relation of the continents to each other as regards general mass (see GEOLOGY, part ii.; AFRICA, AMERICA, ASIA, EUROPE). Over this framework of land there is a ceaseless circulation of water. The vapor raised by the sun's heat from every ocean and surface of water on the land, after being condensed into clouds and rain, falls in large measure upon the land, and courses over its surface from mountain to shore in brooks and rivers, which again have their own distinguishing phenomena, such as the formation of terraces, deltas, etc. Part of the water performs an underground circulation and returns to the surface in springs. Another portion falls as snow upon the mountains and descends into valleys in the form of glaciers. In this ceaseless flow of water from the summits to the sea we must recognize one of the great agencies by which the present contour of the land has been moulded (see GEOLOGY, part iii., section ii.).

The physical geographer collects, moreover, data which show the reaction of the earth's interior upon its surface—proofs from bores and mines of a progressive increase of temperature downwards, the evidence of hot springs, and of earthquakes and volcanoes. He finds proofs of oscillations in the level of the land, some regions having been raised and others depressed within the times of human history. From the geologist he learns that such instability has characterized the outer crust of the planet from very ancient times, and that indeed it is to the results of terrestrial movements that we owe the existence of mountain ranges and even the dry land itself (see GEOLOGY, part iii., section i., and part vii.). He perceives that the present area of land on the earth's surface is the result of the balance of two antagonistic processes—the destruction caused by superficial agents on every portion of land exposed to their influence, and the periodic elevation, by subterranean action, of the land so wasted, or of new land from beneath the sea.

5. *Distribution of Animal and Vegetable Life.*—It is usual to include in treatises on physical geography an outline of the distribution of plants and animals, with an account of the great regions or provinces into which zoologists and botanists have divided the continents. The question naturally arises why the distribution should be as it is. Two answers obviously suggest themselves—1st, climate, and 2d, the power possessed by plants and animals of diffusing themselves. Yet climate only explains a part of this problem, and it is evident that migration cannot possibly account for the diffusion of innumerable organisms. There is a large residuum of unexplained phenomena on which much light is thrown by geological inquiry. Thus, for example, the presence of living Arctic forms of vegetation on the mountains of central Europe can be connected with the occurrence of the remains of Arctic animals in the superficial deposits of that region, and with other facts which make it clear that at no very distant date an Arctic climate prevailed over most of Europe, that at that time a northern vegetation spread southwards and covered the plains and heights of Europe even as far south as the Alps and Pyrenees, and that as the climate gradually ameliorated the northern vegetation was extirpated from the low grounds by the advance of plants better suited to the milder temperature, but continued to maintain its ground amid the congenial frosts and snows of the mountains, where to this day it still flourishes (see DISTRIBUTION). (A. GE.)

GEOLOGY is the science which investigates the history of the earth. Its object is to trace the progress of our planet from the earliest beginnings of its separate existence, through its various stages of growth, down to the present condition of things. It seeks to determine the manner in which the evolution of the earth's great surface features has been effected. It unravels the complicated processes by which each continent has been built up. It follows, even into detail, the varied sculpture of mountain and valley, crag and ravine. Nor does it confine itself merely to changes in the inorganic world. Geology shows that the present races of plants and animals are the descendants of other and very different races which once peopled the earth. It teaches that there has been a progress of the inhabitants, as well as one of the globe on which they dwelt; that each successive period in the earth's history, since the introduction of living things, has been marked by characteristic types of the animal and vegetable kingdoms; and that, however imperfectly they have been preserved or may be deciphered, materials exist for a history of life upon the planet. The geographical distribution of existing faunas and floras is often made clear and intelligible by geological evidence; and in the same way light is thrown upon some of the remoter phases in the history of man himself. A subject so comprehensive as this must require a wide and varied basis of evidence. It is one of the characteristics of geology to gather evidence from sources which at first sight seem far removed from its scope, and to seek aid from almost every other leading branch of science. Thus, in dealing with the earliest conditions of the planet, the geologist must fully avail himself of the labors of the astronomer. Whatever is ascertainable by telescope, spectroscope, or chemical analysis, regarding the constitution of other heavenly bodies, has a geological bearing. The experiments of the physicist, undertaken to determine conditions of matter and of energy, may sometimes be taken as the starting-points of geological investigation. The work of the chemical laboratory forms the foundation of a vast and increasing mass of geological inquiry. To the botanist, the zoologist, even to the unscientific, if observant, traveller by land or sea, the geologist turns for information and assistance.

But while thus culling freely from the dominions of othe sciences, geology claims as its peculiar territory the rocky framework of the globe. In the materials composing that framework, their composition and arrangement, the processes of their formation, the changes which they have undergone, and the terrestrial revolutions to which they bear witness, lie the main data of geological history. It is the task of the geologist to group these elements in such a way that they may be made to yield up their evidence as to the march of events in the evolution of the planet. He finds that they have in large measure arranged themselves in chronological sequence,—the oldest lying at the bottom and the newest at the top. Relics of an ancient sea-floor are overlaid by traces of a vanished land-surface; these are in turn covered by the deposits of a former lake, above which once more appear proofs of the return of the sea. Among these rocky records lie the lavas and ashes of long-extinct volcanoes. The ripple left upon the shore, the cracks formed by the sun's heat upon the muddy bottom of a dried-up pool, the very imprint of the drops of a passing rain-shower, have all been accurately preserved, and yield their evidence as to geographical conditions widely different from those which exist where such markings are now found.

But it is mainly by the remains of plants and animals imbedded in the rocks that the geologist is guided in unravelling the chronological succession of geological changes. He has found that a certain order of appearance characterizes these organic remains, that each great group of rocks is marked by its own special types of life, and that these types can be recognized, and the rocks in which they occur can be correlated even in distant countries, and where no other means of comparison would be possible. At one moment he has to deal with the bones of some large mammal scattered through a deposit of superficial gravel, at another time with the minute foraminifers and ostracods of an upraised sea-bottom. Corals and crinoids crowded and crushed into a massive limestone where they lived and died, ferns and terrestrial plants matted together into a bed of coal where they originally grew, the scattered shells of a submarine sand-bank, the snails and lizards which lived and died within a hollow tree, the insects which have been imprisoned within the exuding resin of old forests, the footprints of birds and quadrupeds, the trails of worms left upon former shores—these, and innumerable other pieces of evidence, enable the geologist to realize in some measure what the faunas and floras of successive periods have been, and what geographical changes the site of every land has undergone.

It is evident that to deal successfully with these varied materials, a considerable acquaintance with different branches of science is needful. Especially necessary is a tolerably wide knowledge of the processes now at work in changing the surface of the earth, and of at least those forms of plant and animal life whose remains are apt to be preserved in geological deposits, or which in their structure and habitat enable us to realize what their forerunners were. It has often been insisted upon that the present is the key to the past; and in a wide sense this assertion is eminently true. Only in proportion as we understand the present, where everything is open on all sides to the fullest investigation, can we expect to decipher the past, where so much is obscure, imperfectly preserved, or not preserved at all. A study of the existing economy of nature ought thus to be the foundation of the geologist's training.

While, however, the present condition of things is thus employed, we must obviously be on our guard against the danger of unconsciously assuming that the phase of nature's operations which we now witness has been the same in all past time, that geological changes have taken place in former ages in the manner and on the scale which we behold to-day, and that at the present time all the great geological processes, which have produced changes in the past eras of the earth's history, are still existent and active. Of course we may assume this uniformity of action, and use the assumption as a working hypothesis. But it ought not to be allowed any firmer footing, nor on any account be suffered to blind us to the obvious truth that the few centuries wherein man has been observing nature form much too brief an interval, by which to measure the intensity of geological action in all past time. For aught we can tell the present is an era of quietude and slow change, compared with some of the eras which have preceded it. Nor can we be sure that, when we have explored every geological process now in progress, we have exhausted all the causes of change which, even in comparatively recent times, have been at work.

In dealing with the Geological Record, as the accessible solid part of the globe is called, we cannot too vividly realize that at the best it forms but an imperfect chronicle. Geological history cannot be compiled from a full and continuous series of documents. From the very nature of its origin the record is necessarily fragmentary, and it has been further mutilated and obscured by the revolutions of successive ages. And even where the chronicle of events is continuous, it is of very unequal value in different places. In one case, for example, it may present us with an unbroken succession of deposits many thousands of feet in thickness, from which, however, only a few meagre facts as to geological history can be gleaned. In another instance it brings before us, within the compass of a few yards, the evidence of a most varied and complicated series of changes in physical geography, as well as an abundant and interesting suit of organic remains. These and other characteristics of the geological record will become more apparent and intelligible as we proceed in the study of the science.

In the systematic treatment of the subject the following arrangement will here be followed:—

1. *The Cosmical Aspects of Geology.*—Under this head we may consider the evidence supplied by astronomy and physics regarding the form and motions of the earth, the composition of the sun and planets, and the probable history of the solar system.

2. *Geognosy: an Inquiry into the Materials of the Earth's Substance.*—In this division we deal with the parts of the earth, its envelopes of air and water, its solid crust, and the probable condition of its interior. Especially, we have to study the more important minerals of the crust, and the chief rocks of which that crust is built up. In this way we lay a foundation of knowledge regarding the nature of the materials constituting the mass of the globe, and may next proceed to investigate the processes by which these materials are produced and altered.

3. *Dynamical Geology* embraces an investigation of the various agencies whereby the rocks of the earth's crust are formed and metamorphosed, and by which changes are effected upon the distribution of sea and land, and upon the forms of terrestrial surfaces. Such an inquiry necessitates a careful study of the existing geological economy of nature, and forms a fitting introduction to the investigation of the geological changes of former periods. This and the previous section include most of what is embraced under Physical Geography; and for the reason stated under that heading the subject will here be treated more in detail than is usual in geological treatises.

4. *Structural Geology, or the Architecture of the Earth.*—We now advance to consider how the various materials composing the crust of the earth have been arranged. We learn that some have been formed in beds or strata on the floor of the sea, that others have been built up by the slow aggregation of organic forms, that others have been poured out in a molten condition or in showers of loose dust from subterranean sources. We further find that, though originally laid down in almost horizontal beds, the rocks have subsequently been crumpled, contorted, and dislocated, that they have been incessantly worn down, and have often been depressed and buried beneath later accumulations.

5. *Palæontological Geology.*—This branch of the subject deals with the organic forms which are found preserved in the crust of the earth. It includes such questions as the relations between extinct and living types, the laws which appear to have governed the distribution of life in time and in space, the relative importance of different genera of animals in geological inquiry, the nature and use of the evidence from organic remains regarding former conditions of physical geography. This subject will be more properly discussed in the article PALÆONTOLOGY, and will therefore be only cursorily treated in the following pages.

6. *Stratigraphical Geology.*—This section might be called geological history. It works out the chronological succession of the great formations of the earth's crust, and endeavors to trace the sequence of events of which they contain the record. More particularly it determines the order of succession of the various plants and animals which in past time have peopled the earth, and thus ascertains what has been the grand march of life upon the planet.

7. *Physiographical Geology*, starting from the basis of fact laid down by stratigraphical geology regarding former geographical changes, embraces an inquiry into the origin and history of the features of the earth's surface—continental ridges and ocean basins, plains, valleys, and mountains. It explains the causes on which local differences of scenery depend, and shows under what very different circumstances, and at what widely separated intervals, the hills and mountains, even of a single country, have been produced.

PART I.—COSMICAL ASPECTS OF GEOLOGY.

Before geology had attained to the position of an inductive science, it was customary to begin all investigations into the history of the earth by propounding or adopting some more or less fanciful hypothesis in explanation of the origin of our planet, or even of the universe. Such preliminary notions were looked upon as essential to a right understanding of the manner in which the materials of the globe had been put together. To the illustrious James Hutton (1785) geologists are indebted for strenuously upholding the doctrine that it is no part of the province of geology to discuss the origin of things. He taught them that in the materials from which geological evidence is to be compiled there can be found "no traces of a beginning, no prospect of an end." In England, mainly to the influence of the school which he founded, and to the subsequent rise of the Geological Society (1807), which resolved to collect facts instead of fighting over hypotheses, is due the disappearance of the crude and unscientific cosmologies by which the writings of the earlier geologists were distinguished.

But there can now be little doubt that in the reaction against those visionary and often grotesque speculations, geologists were carried too far in an opposite direction. In allowing themselves to believe that geology had nothing to do with questions of cosmogony, they gradually grew up in the conviction that such questions could never be other than mere speculation, interesting or amusing as a theme for the employment of the fancy, but hardly coming within the domain of sober and inductive science. Nor would they soon have been awakened out of this belief by anything in their own science. It is still true that in the data with which they are accustomed to deal, as comprising the sum of geological evidence, there can be found no trace of a beginning. The oldest rocks which have been discovered on any part of the globe have probably been derived from other rocks older than themselves. Geology by itself has not yet revealed, and is little likely ever to reveal, a trace of the first solid crust of our globe. If then geological history is to be compiled from direct evidence furnished by the rocks of the earth, it cannot begin at the beginning of things, but must be content to date its first chapter from the earliest period of which any record has been preserved among the rocks.

Nevertheless, though geology in its usual restricted sense has been, and must ever be, unable to reveal the earliest history of our planet, it no longer ignores, as mere speculation, what is attempted in this subject by its sister sciences. Astronomy, physics, and chemistry have in late years all contributed to cast much light on the earlier stages of the earth's existence, previous to the beginning of what is commonly regarded as geological history. But whatever extends our knowledge of the former conditions of our globe may be legitimately claimed as part of the domain of geology. If this branch of inquiry therefore is to continue worthy of its name as the science of the earth, it must take cognizance of these recent contributions from other sciences. It must no longer be content to begin its annals with the records of the oldest rocks, but must endeavor to grope its way through the ages which preceded the formation of any rocks. Thanks to the results achieved with the telescope, the spectroscope, and the chemical laboratory, the story of these earliest ages of our earth is every year becoming more definite and intelligible.

Relations of the Earth in the Solar System.

Before entering upon the study of the structure and history of the earth, we may with advantage consider the general relations of our planet to the solar system, especially in view of its origin and history. It is now regarded as in the highest degree probable that all the members of that system have had a common origin. The investigations of recent years have revived and given a new form and meaning to the well-known nebular hypothesis, in which Laplace sketched the progress of the system from the state of an original nebula to its existing condition of a central incandescent sun with surrounding cool planetary bodies. He supposed that the nebula, originally diffused at least as far as the furthest member of the system, began to condense towards the centre, and that in so doing it threw off or left behind successive rings which on disruption and further condensation assumed the form of planets, sometimes with a further formation of rings, which in the case of Saturn remain, though in other planets they have broken up and united into satellites.

According to this view we should expect that the matter composing the various members of the solar system should be everywhere nearly the same. The fact of condensation round centres, however, indicates at least differences of density throughout the nebula. Mr. Lockyer has, indeed, suggested that the materials composing the nebula arranged themselves according to their respective densities, the lightest occupying the exterior and the heaviest the interior of the mass. And if we compare the densities of the various planets, they certainly seem to support this suggestion. These densities are shown in the following table, that of the earth being taken as the unit:—

Density of the Sun	0·25
" Mercury	1·12
" Venus	1·03
" Earth	1·00
" Mars	0·70
" Jupiter	0.24
" Saturn	0·13
" Uranus	0·17
" Neptune	0·16

There is not indeed a strict progression in the diminution of density, but the fact remains that, while the planets near the sun are about twice as heavy as they would be if they consisted of such a substance as granite, towards the outer limits of the system they are composed of matter as light as cork. Again, in some cases, a similar relation has been observed between the densities of the satellites and their primaries. The moon, for example, has a density little more than half that of the earth. The first satellite of Jupiter is less dense, though the other three are found to be more dense than the planet. Further, in the condition of the earth itself, a very light gaseous atmosphere forms the outer portion, beneath which lies a heavier layer of water, while within these two envelopes the materials forming the solid substance of the planet are so arranged that the outer layer or crust has only about half the density of the whole globe. Mr. Lockyer finds in the sun itself evidence of the same tendency towards a stratified arrangement in accordance with relative densities as will be immediately further alluded to.

There seems therefore to be much probability in the hypothesis that, in the gradual condensation of the original nebula, each successive mass left behind represented the density of its parent layer, and consisted of progressively heavier matter. The remoter planets, with their low density and vast absorbing atmospheres, may be supposed to consist of metalloids like the outer parts of the sun's atmoshere, while the interior planets are no doubt mainly metallic. The rupture of each planetary ring would, it is conceived, raise the temperature of the resultant nebulous planet to such a height as to allow the vapors to rearrange themselves by degrees in successive layers, or rather shells, according to density. And when the planet gave off a satellite, that body would, it might be expected, have the composition and density of the outer layers of its primary.[1]

For many years the only evidence available as to the actual composition of other heavenly bodies than our own earth was furnished by the *aerolites*, *meteorites*, or falling stars, which from time to time have entered our atmosphere from planetary space, and have descended upon the surface of the globe. Subjected to chemical analysis these foreign bodies show considerable diversities of composition; but in no case have they yet yielded a trace of any element not already recognized among terrestrial materials. Upwards of twenty of our elements have been detected in aerolites, sometimes in the free state, sometimes combined with each other. More than half of them are metals, including iron, nickel, manganese, calcium, sodium, and potassium. There occur also carbon, silicon, phosphorus, sulphur, oxygen, nitrogen, and hydrogen. In some of their combinations these elements, as found in the meteoric stones, differ from their mode of occurrence in the accessible parts of the earth. Iron, for example, occurs as native metal, alloyed with a variable proportion (6 to 10 per cent.) of metallic nickel. But in other respects they closely resemble some of the familiar materials of the earth's rocky crust. Thus we have such minerals as pyrite, apatite, olivine, augite, hornblende, and labradorite. No more reliable proof could be desired that some at least of the other members of the solar system are formed of the same materials as compose the earth.

But in recent years a far more precise and generally applicable method of research into the composition of the heavenly bodies has been found in the spectroscope. By means of this instrument, the light emitted from self-luminous bodies can be analyzed in such a way as to show what elements are present in their intensely hot luminous vapor. When the light of a burning metal is examined with a properly-arranged prism, it is seen to give a dark band or *spectrum* which is traversed by certain vertical bright lines. This is termed a *radiation-spectrum*. Each element appears to have its own characteristic arrangement of lines, which retain the same relative position, intensity, and colors. Moreover, gases and the vapors of solid bodies are found to intercept those rays of light which they themselves emit. The spectrum of burning sodium, for example, shows two bright yellow lines. If therefore white light from some other source passes through the vapor of sodium, these two bright lines become dark lines, that portion of the light being exactly cut off which would have been given out by the sodium itself. This is called an *absorption-spectrum*.

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[1] Mr. Lockyer communicated some of his views to Professor Prestwich, who gave them in his interesting *Inaugural Lecture* at Oxford, in 1875. He has further stated them in his Manchester Lectures, *Why the Earth's Chemistry is as it is.*

By this method of examination it has been ascertained that many of the elements of which our earth is composed exist in the state of incandescent vapor in the atmosphere of the sun. Among these are some of our most familiar metals—iron, zinc, copper, nickel, with sodium, magnesium, barium, calcium, and vast quantities of free hydrogen. Moreover, as Mr. Lockyer has pointed out, these elements appear to succeed each other in relation to their respective densities. Thus the coronal atmosphere which, as seen in total eclipses, extends to so prodigious a distance beyond the orb of the sun, consists mainly of sub-incandescent hydrogen and another element which may be new. Beneath this external vaporous envelope lies the chromosphere where the vapors of incandescent hydrogen, calcium, and magnesium can be detected. Further inward the spot-zone shows the presence of sodium, titanium, etc.; while still lower, a layer (the *reversing* layer) of intensely hot vapors, lying probably next to the inner brilliant photosphere gives spectroscopic evidence of the existence of incandescent iron, manganese, cobalt, nickel, copper, and other well-known terrestrial metals.[1]

The spectroscope has likewise been successfully applied by Mr. Huggins and others to the observation of the fixed stars and nebulæ, with the result of establishing a similarity of elements between our own system and other bodies in sidereal space. In the radiation spectra of nebulæ Mr. Huggins finds the hydrogen lines very prominent; and he conceives that they may be glowing masses of that element. Sir William Thomson and Professor Tait have suggested, on the other hand, that they are more probably clouds of stones in rapid motion, perhaps in an atmosphere of hydrogen. Among the fixed stars absorption spectra have been recognized, pointing to a structure resembling that of our sun, viz., a solid or liquid incandescent nucleus, surrounded with an atmosphere of glowing vapor.[2] According to Mr. Lockyer, those stars or nebulæ which have the highest temperature have the simplest spectra, and in proportion as they cool their materials become more and more differentiated into what we call elements. He remarks that the most brilliant or hottest stars show in their spectra only the lines of gases, as hydrogen. Cooler stars, like our sun, give indications of the presence, in addition, of the more stable metals—magnesium, sodium, calcium, iron. A still lower temperature he regards as marked by the appearance of the other metals, metalloids, and compounds, so that the older a star or planet is the more will it lose free hydrogen, till, when it comes to the condition of our earth, all its free hydrogen will have disappeared.[3] According to this view the atoms of all the elements existed originally in the nebula dissociated from each other by reason of the intense heat. As the nebula gravitated towards its nucleus and cooled, the atoms came together, and the elements appeared in a certain order, beginning with hydrogen, and passing on through the metals and metalloids into compounds such as we find on our globe. The sun would thus be a star considerably advanced in the process of differentiation or association of its atoms. It contains, so far as we know, no metalloids or compounds, while stars like Sirius show the presence only of hydrogen, with but a feeble proportion of metallic vapors; and on the other hand, the red stars indicate by their spectra that their metallic vapors have entered into combination, whence it is inferred that their temperature is lower than that of our sun.

Further confirmation of these views as to the order of planetary evolution is furnished by the form and structure of the earth. Reference has already been made to the fact that the outer crust of our planet possesses only about half the density of the whole mass. It consists largely of metalloids—oxygen, silicon, carbon, sulphur, chlorine. On the other hand, lavas and mineral veins, which are believed to have been supplied from some considerable depth, contain abundance of metallic ingredients.

The form of the globe likewise points to a former fluid condition. As the result of computations from ten measured arcs of the meridian made by different observers between the latitudes of Sweden and the Cape of Good Hope, Bessel obtained the following data for the dimensions of the earth:—

Equatorial diameter.........	41,847,192	feet, or	7925·604	miles.
Polar diameter..................	41,707,314	"	7899·114	"
Amount of polar flattening,	139,768	"	26·471	"

The equatorial circumference is thus a little less than 25,000 miles, and the difference between the polar and equatorial diameters (nearly 26½ miles) amounts to about $\frac{1}{300}$th of the equatorial diameter.[4] More recently, however, it has been shown that the oblate spheroid indicated by these measurements is not a symmetrical body, the equatorial circumference being an ellipse instead of a circle. The diameter of which the vertices touch the surface of the globe in longtitudes 14° 23′ E. and 194° 23′ E. of Greenwich is nearly two miles longer than that at right angles to it.[5]

In obedience to the influence of rotation on its axis, our planet would tend to assume exactly such a flattening at the poles as it has been proved to possess. This was discovered and demonstrated by Newton, and the amount of the ellipticity was actually calculated by him, long before any measurement had confirmed such a conclusion.

The tendency of modern research is thus to give probability to the conception that not only in our own solar system, but throughout the regions of space, there has been a common plan of evolution, and that the matter diffused through space in stars, nebulæ, and systems is substantially the same as that with which we are familiar. Hence the study of the structure and probable history of the sun and the other heavenly bodies comes to possess an evident geological interest, seeing that it may yet enable us to carry back the story of our planet far beyond the domain of ordinary geological evidence, and upon data not less reliable than those furnished by the rocks of the earth's crust.

II. The Movements of the Earth in their Geological Relations.

We are here concerned only with those aspects of the earth's motions which materially influence the progress of geological phenomena.

1. *Rotation.*—In obedience to the impulse communicated to it at its original separation, the earth rotates on its axis. This movement is completed in about 24 hours, and to it is due the succession of day and night. So far as observation has yet gone, this movement is uniform, though recent calculations of the influence of the tides in retarding rotation tend to show that a very slow diminution of the angular velocity is in progress. This velocity varies relatively in different places, according to their position on the surface of the planet. At each pole there can be no velocity, but from these two points towards the equator there is a continually increasing rapidity of motion, till at the equator it is equal to a rate of 507 yards in a second.

To the rotation of the earth are due certain remarkable influences upon currents of air, which circulate either towards the equator or towards the poles. Currents which move from polar latitudes travel from parts of the earth's surface where the velocity of rotation is small to others where it is great. Hence they lag behind, and their course is bent more and more westward. An air current quitting the north polar or north temperate regions as a north wind is deflected out of its course and becomes a north-east wind. On the opposite side of the globe a similar current setting out straight for the equator is changed into a south-east wind. This is the reason why the well-known trade-winds have their characteristic westward deflexion. On the other hand, a current setting out northwards or southwards from the equator passes into regions having a less velocity of rotation than it possesses itself, and hence it travels on in advance and is gradually deflected eastward. The aerial currents blowing steadily across the surface of the ocean produce currents in its waters which have a westward tendency communicated to them indirectly from the effect of rotation. A certain deflexion is said to be experienced by such rivers as flow in a meridional direction, like the Volga. Those which flow polewards are asserted to press upon their eastern rather than their western banks, while those which run in the opposite direction are stated to be thrown more against the western than the eastern. The reality of this action may be doubted.

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[1] On the constitution of the sun see Roscoe's *Spectrum Analysis;* Lockyer's *Solar Physics*, 1873; and memoirs in *Proc. of Roy. Soc.*, by B. Stewart, Loewy, and De la Rue.

[2] Huggins, *Proc. Roy. Soc.*, 1863–66, and *Brit. Assoc. Lecture* (Nottingham, 1866); Huggins and Miller, *Phil. Trans.*, 1864.

[3] Lockyer, *Comptes Rendus*, Dec., 1873.

[4] Herschel, *Astronomy*, p. 139.

[5] A. R. Clark, *Mem. Roy. Astron. Soc.*, xxix.; Herschel, *Astron.* p. 691. See also a more recent paper by Colonel Clark, *Phil. Mag.*, August, 1878.

2. *Revolution.*—Besides turning on its axis the globe performs a movement round the sun, termed revolution. This movement is accomplished in rather more than 365 days. It determines for us the length of our year, which is, in fact, merely the time required for one complete revolution. The path or orbit followed by the earth round the sun is not a perfect circle but an ellipse, with the sun in one of the foci, the mean distance of the earth from the sun being 92,400,000 miles. By slow secular variations the form of the orbit alternately approaches and recedes from that of a circle. At the nearest possible approach between the two bodies, owing to change in the ellipticity of the orbit, the earth is 14,368,200 miles nearer the sun than when at its greatest possible distance. These maxima and minima of distance occur at vast intervals of time. The last considerable eccentricity took place about 200,000 years ago, and the previous one more than half a million of years earlier. Since the amount of heat received by the earth from the sun is inversely as the square of the distance, eccentricity must have had in past time much effect upon the climate of the earth, as will be pointed out further on (section 7, p. 194).

3. *Precession of the Equinoxes.*—If the axis of the earth were perpendicular to the plane of its orbit, there would be equal day and night all the year round. But it is really inclined to that plane at an angle of $23\frac{1}{2}°$. Hence our hemisphere is alternately presented to and turned away from the sun, and in this way brings us the familiar alternation of the seasons—the long days of summer and the short days of winter. Again, were the earth a perfect sphere of uniform density throughout, the position of its axis of rotation would not change. But owing to the protuberance along the equatorial regions, the attraction chiefly of the sun and moon tends to pull the axis aside, or to make it describe a conical movement like that of the axis of a top round the vertical. Hence each pole points successively to different stars. This movement, called the precession of the equinoxes, in combination with other planetary movements, completes its cycle in 21,000 years. At present the winter in our northern hemisphere coincides with the earth's approach to the sun, or *perihelion*. In 10,500 years hence it will take place when the earth is at the farthest part of its orbit from the sun, or in *aphelion*. This movement acquires great importance when considered in connection with the secular variations in the eccentricity of the orbit (see section 7).

4. *Change in the Obliquity of the Ecliptic.*—The angle at which the axis of the earth is inclined to the plane of its orbit does not remain strictly constant. It oscillates through long periods of time to the extent of about a degree and a half, or perhaps a little more, on either side of the mean. According to Dr. Croll,[1] this oscillation must have considerably affected former conditions of climate on the earth, since, when the obliquity is at its maximum, the polar regions receive about eight and a half days more of heat than they do at present—that is, about as much heat as lat. 76° enjoys at this day. This movement must have augmented the geological effects of precession, to which reference has just been made, and which are described in section 7.

5. *Stability of the Earth's Axis.*—That the axis of the earth's rotation has successively shifted, and consequently that the poles have wandered to different points on the surface of the globe, has been maintained by geologists as the only possible explanation of certain remarkable conditions of climate, which can be proved to have formerly obtained within the Arctic Circle. Even as far north as lat. 81° 45′ abundant remains of a vegetation indicative of a warm climate, and including a bed of coal 25 to 30 feet thick, have been found *in situ*. It is contended that where these plants lived the ground could not have been permanently frozen or covered for most of the year with thick snow. In explanation of the difficulty, it has been suggested that the north pole did not occupy its present position, and that the locality where the plants occur lay in more southerly latitudes. Without at present entering on the discussion of the question whether the geological evidence requires necessarily so important a geographical change, let us consider how far a shifting of the axis of rotation has been a possible cause of change during that section of geological time for which there are records among the stratified rocks.

From the time of Laplace[2] astronomers have strenuously denied the possibility of any sensible change in the position of the axis of rotation. It has been urged that, since the planet acquired its present oblate spheroidal form, nothing but an utterly incredible amount of deformation could overcome the greater centrifugal force of the equatorial protuberance. It is certain, however, that the axis of rotation does not strictly coincide with the principal axis of inertia. Though the angular difference between them must always have been small, we can, without having recourse to any extra-mundane influence, recognize two causes which, whether or not they may suffice to produce any change in the position of the main axis of inertia, undoubtedly tend to do so. In the first place a widespread upheaval or depression of certain portions of the surface to a considerable vertical amount might shift that axis. In the second place an analogous result might arise from the denudation of continental masses of land and the consequent filling up of sea-basins. Sir William Thomson freely concedes the physical possibility of such changes. "We may not merely admit," he says, "but assert as highly probable, that the axis of maximum inertia and axis of rotation, always very near one another, may have been in ancient times very far from their present geographical position, and may have gradually shifted through 10, 20, 30, 40, or more degrees, without at any time any perceptible sudden disturbance of either land or water."[3] But though, in the earlier ages of the planet's history, stupendous deformations may have occurred, and the axis of rotation may have often shifted, it is only the alterations which can possibly have occurred during the accumulation of the stratified rocks that need to be taken into account in connection with former changes of climate. If it can be shown therefore that the geographical revolutions necessary to shift the axis are incredibly stupendous in amount, improbable in their distribution, and completely at variance with geological evidence, we may reasonably withhold our belief from this alleged cause of the changes of climate during geological history.

It has been estimated by Sir William Thomson "that an elevation of 600 feet, over a tract of the earth's surface 1000 miles square and 10 miles in thickness, would only alter the position of the principal axis by one-third of a second, or 34 feet."[4] Mr. George Darwin has shown that on the supposition of the earth's complete rigidity no redistribution of matter in new continents could ever shift the pole from its primitive position more than 3°, but that, if its degree of rigidity is consistent with a periodical readjustment to a new form of equilibrium, the pole may have wandered some 10° or 15° from its primitive position, or have made a smaller excursion and returned to near its old place. In order, however, that these maximum effects should be produced, it would be necessary that each elevated area should have an area of depression corresponding in size and diametrically opposite to it, that they should lie on the same complete meridian, and that they should both be situated in lat. 45°. With all those coincident favorable circumstances, an effective elevation of $\frac{1}{300}$ of the earth's surface to the extent of 10,000 feet would shift the pole $11\frac{1}{3}'$; a similar elevation of $\frac{1}{20}$ would move it $1° 46\frac{1}{2}'$; of $\frac{1}{10}$, 3° 17′; and of $\frac{1}{2}$, $8° 4\frac{1}{2}'$. Mr. Darwin admits these to be superior limits to what is possible, and that, on the supposition of intumescence or contraction under the regions in question, the deflexion of the pole might be reduced to a quite insignificant amount.[5]

Under the most favorable conditions, therefore, the possible amount of deviation of the pole from its first position would appear to have been too small to have seriously influenced the climates of the globe within geological history. If we grant that these changes were cumulative, and that the superior limit of deflexion was reached only after a long series of concurrent elevations and depressions, we must suppose that no movements took place elsewhere to counteract the effect of those about lat. 45° in the two hemispheres. But this is hardly credible. A glance at a geographical globe suffices to show how large a mass of land exists now both to the north and south of that latitude, especially in the northern hemisphere, and that the deepest parts of the ocean are not antipodal to the greatest heights of the land. These features of the earth's surface are of old standing. There seems, indeed, to be no geological evidence in favor of any such geographical changes as could have produced even the comparatively small displacement of the axis considered possible by Mr. Darwin.

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[1] Croll, *Trans. Geol. Soc. Glasgow*, ii. 177.

[2] *Mécanique Céleste*, tome v. p. 14.

[3] *Brit. Assoc. Rep.* (1876), Sections, p. 11.

[4] *Trans. Geol. Soc. Glasgow*, iv.

[5] *Phil. Trans.*, November, 1876.

In an ingenious suggestion Dr. John Evans contended that, even without any sensible change in the position of the axis of rotation of the nucleus of the globe, there might be very considerable changes of latitude due to disturbance of the equilibrium of the shell by the upheaval or removal of masses of land between the equator and the poles, and to the consequent sliding of the shell over the nucleus until the equilibrium was restored. This hypothesis starts on the assumption of a thin crust enclosing a liquid or viscous interior—an assumption which, as will be shown in subsequent pages, is negatived by considerations in physics. The Rev. O. Fisher has suggested that the almost universal traces of present or former volcanic action, the evidence from the compressed strata in mountain regions that the crust of the earth must have a capacity for slipping towards certain lines, the great amount of horizontal compression of strata which can be proved to have been accomplished, and the secular changes of climate—notably the former warm climate near the north pole—furnish grounds for inquiry "whether a fluid substratum over a rigid nucleus would not be compatible with mechanical considerations, and whether, under those circumstances, changes in latitude would not result from unequal thickening of the crust."[1]

6. *Changes of the Earth's Centre of Gravity.*—Though no known geological operation seems to have been capable of producing an effective change in the position of the axis of rotation of the earth, there may have been variations in the position of its centre of gravity. Any change of that kind must affect the ocean, which of course adjusts itself in relation to the earth's centre of gravity. The enormous accumulation of ice at one pole during the maximum of eccentricity will displace the centre of gravity, and, as the result of this change will raise the level of the ocean in the glacial hemisphere,[2] Dr. Croll has estimated that, if the present mass of ice in the southern hemisphere is taken at 1000 feet thick extending down to lat. 60°, the transference of this mass to the northern hemisphere would raise the level of the sea 80 feet at the north pole. Other methods of calculation give different results. Mr. Heath puts the rise at 128 feet; Archdeacon Pratt makes it more; while the Rev. O. Fisher gives it at 409 feet.[3] More recently, in returning to this question, Dr. Croll remarks "that the removal of two miles of ice from the Antarctic continent [and at present the mass of ice there is probably thicker than that] would displace the centre of gravity 190 feet, and the formation of a mass of ice equal to the one-half of this, on the Arctic regions, would carry the centre of gravity 95 feet farther, giving in all a total displacement of 285 feet, thus producing a rise of level at the north pole of 285 feet, and in the latitude of Edinburgh of 234 feet." A very considerable additional displacement would arise from the increment of water to the mass of the ocean by the melting of the ice. Supposing half of the two miles of Antarctic ice to be replaced by an ice-cap of similar extent and one mile thick in the northern hemisphere, the other half being melted into water and increasing the mass of the ocean, Dr. Croll estimates that from this source an extra 200 feet of rise would take place in the general ocean level, so that there would be a rise of 485 feet at the north pole, and 434 feet in the latitude of Edinburgh.[4] There must thus have been an alternate submergence and emergence of the low polar lands due to the alternate shifting of the centre of gravity.

7. *Influence of the Earth's Movements upon Climate.*—Although the treatment of this subject involves a reference to questions which must be discussed in their proper place in subsequent parts of this article, it will be most appropriately inserted here as a distinct and most important branch of the astronomical relations of geology. In later pages it will be shown that the climate of the earth has undergone many great vicissitudes during geological history,—for example, that a warm and genial temperature has once prevailed in arctic latitudes, while at another time snow and ice extended far down into the heart of Europe. Of this latter change, which took place within a comparatively recent geological period, the traces still remain remarkably fresh, and have excited great interest and discussion. It is known as the Glacial Period or Ice Age. But we now know that other similar periods of great cold probably preceded it at widely separated intervals.

Various theories have been proposed in explanation of such striking variations in climate. Some of these have appealed to a change in the position of the earth's axis relatively to the mass of the planet (p. 193). Others have been based on the notion that the earth may have passed through hot and cold regions of space. Others, again, have called in the effects of terrestrial changes, such as the distribution of land and sea, on the assumption that elevation of land about the poles must cool the temperature of the globe, while elevation round the equator would raise it. But as the changes of temperature have affected vast areas of the earth's surface, while there is a total absence of all proof of any such enormous vicissitudes in physical geography as would be required, and since there is accumulating proof in favor of periodic alternations of climate, there is a growing conviction that no mere local changes could have sufficed, but that secular variations in climate must be assigned to some general and probably recurring cause.[5]

By degrees geologists accustomed themselves to the belief that the cold of the glacial period was not due to mere terrestrial changes, but was to be explained somehow as the result of cosmical causes. Among the various suggestions, one deserves careful consideration—change in the eccentricity of the earth's orbit. Sir John Herschel[6] pointed out many years ago that the direct effect of a high condition of eccentricity is to produce an unusually cold winter followed by a correspondingly hot summer on the hemisphere whose winter occurs in aphelion, while an equable condition of climate will at the same time prevail on the opposite hemisphere. But both hemispheres must receive precisely the same amount of solar heat, because the deficiency of heat resulting from the sun's greater distance during one part of the year is exactly compensated by the greater length of that season. Sir John Herschel even considered that the direct effects of eccentricity must thus be nearly neutralized.[7] As a like verdict was afterwards given by Arago, Humboldt, and others, geologists were satisfied that no important change of climate could be attributed to change of eccentricity.

It is to the luminous memoirs of Dr. James Croll that geology is indebted for the first fruitful suggestion in this matter, and for the subsequent elaborate development of the whole subject of the physical causes on which climate depends. He has been so good as to draw up for this article the following summary of his views (taken chiefly from his paper in the *Phil. Mag.* for February, 1870). The reader will find the subject fully worked out in Dr. Croll's work, *Climate and Time*, 1875.

"Assuming the mean distance of the sun to be 92,400,000 miles, then when the eccentricity is at its superior limit, ·07775, the distance of the sun from the earth, when the latter is in the aphelion of its orbit, is no less than 99,584,100 miles, and when in the perihelion it is only 85,215,900 miles. The earth is, therefore, 14,368,200 miles farther from the sun in the former than in the latter position. The direct heat of the sun being inversely as the square of the distance, it follows that the amount of heat received by the earth in these two positions will be as 19 to 26. The present eccentricity being ·0168, the earth's distance during our northern winter is 90,847,680 miles. Suppose now that, from the precession of the equinoxes, winter in our northern hemisphere should happen when the earth is in the aphelion of its orbit, at the time that the orbit is at its greatest eccentricity; the earth would then be 8,736,420 miles farther from the sun in winter than it is at present. The direct heat of the sun would therefore, during winter, be one-fifth less and during summer one-fifth greater than now. This enormous difference would necessarily affect the climate to a very great extent. Were the winters under these circumstances to occur when the earth was in the perihelion of its orbit, the earth would then be 14,368,200 miles nearer the sun in winter than in summer. In this case the difference between winter and summer in our latitudes would be almost annihilated. But as the winters in the one hemisphere correspond with the summers in the other, it follows that while the one hemisphere would be enduring the greatest extremes of summer heat and winter cold, the other would be enjoying perpetual summer.

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[1] *Geol. Mag.*, 1878, p. 552.

[2] Adhemar, *Revolutions de la Mer*, 1840.

[3] Croll, in *Reader* for 2d Sept., 1865, and *Phil. Mag.*, April, 1866; Heath, *Phil. Mag.*, April, 1869; Pratt, *Phil. Mag.*, March, 1866; Fisher, *Reader*, 10th February, 1866.

[4] Croll, *Geol. Mag.*, new series, i. (1874), p. 347; *Climate and Time*, chaps. xxiii. and xxiv.

[5] In Lyell's *Principles of Geology* the doctrine of the influence of geographical changes is maintained.

[6] *Trans. Geol. Soc.*, vol. iii. p. 293 (2d series).

[7] *Cabinet Cyclopædia*, sec. 315; *Outlines of Astronomy*, sec. 368.

"It is quite true that whatever may be the eccentricity of the earth's orbit, the two hemispheres must receive equal quantities of heat per annum; for proximity to the sun is exactly compensated by the effect of swifter motion. The total amount of heat received from the sun between the two equinoxes is therefore the same in both halves of the year, whatever the eccentricity of the earth's orbit may be. For example, whatever extra heat the southern hemisphere may at present receive per day from the sun during its summer months, owing to greater proximity to the sun, is exactly compensated by a corresponding loss arising from the shortness of the season; and, on the other hand, whatever deficiency of heat we in the northern hemisphere may at present have per day during our summer half-year, in consequence of the earth's distance from the sun, is also exactly compensated by a corresponding length of season.

"It is well known, however, that those simple changes in the sun's summer and winter distances would not alone produce a glacial epoch, and that physicists, confining their attention to the purely astronomical effects, were perfectly correct in affirming that no increase of eccentricity of the earth's orbit could account for that epoch. But the important fact was overlooked that, although the glacial epoch could not result directly from an increase of eccentricity, it might nevertheless do so indirectly from physical agents that were brought into operation as a result of an increase of eccentricity. The following is an outline of what these physical agents were, how they were brought into operation, and the way in which they may have led to the glacial epoch.

"With the eccentricity at its superior limit and the winter occurring in the aphelion, the earth would, as we have seen, be 8,736,420 miles farther from the sun during that season than at present. The reduction in the amount of heat received from the sun, owing to his increased distance, would lower the midwinter temperature to an enormous extent. In temperate regions the greater portion of the moisture of the air is at present precipitated in the form of rain, and the very small portion which falls as snow disappears in the course of a few weeks at most. But in the circumstances under consideration, the mean winter temperature would be lowered so much below the freezing-point that what now falls as rain during that season would then fall as snow. This is not all; the winters would then not only be colder than now, but they would also be much longer. At present the winters are nearly eight days shorter than the summers; but with the eccentricity at its superior limit and the winter solstice in aphelion, the length of the winters would exceed that of the summers by no fewer than thirty-six days. The lowering of the temperature and the lengthening of the winter would both tend to the same effect, viz., to increase the amount of snow accumulated during the winter; for, other things being equal, the larger the snow-accumulating period the greater the accumulation. It may be remarked, however, that the absolute quantity of heat received during winter is not affected by the decrease in the sun's heat,[1] for the additional length of the season compensates for this decrease. As regards the absolute amount of heat received, increase of the sun's distance and lengthening of the winter are compensatory, but not so in regard to the amount of snow accumulated. The consequence of this state of things would be that, at the commencement of the short summer, the ground would be covered with the winter's accumulation of snow. Again, the presence of so much snow would lower the summer temperature, and prevent to a great extent the melting of the snow.

"There are three separate ways whereby accumulated masses of snow and ice tend to lower the summer temperature, viz.:—

"*First*, By means of direct radiation. No matter what the intensity of the sun's rays may be, the temperature of snow and ice can never rise above 32°. Hence the presence of snow and ice tends by direct radiation to lower the temperature of all surrounding bodies to 32°. In Greenland, a country covered with snow and ice, the pitch has been seen to melt on the side of a ship exposed to the direct rays of the sun, while at the same time the surrounding air was far below the freezing-point; a thermometer exposed to the direct radiation of the sun has been observed to stand above 100°, while the air surrounding the instrument was actually 12° below the freezing-point. A similar experience has been recorded by travellers on the snow-fields of the Alps. These results, surprising as they no doubt appear, are what we ought to expect under the circumstances. Perfectly dry air seems to be nearly incapable of absorbing radiant heat. The entire radiation passes through it almost without any sensible absorption. Consequently the pitch on the side of the ship may be melted or the bulb of the thermometer raised to a high temperature by the direct rays of the sun, while the surrounding air remains intensely cold. The air is cooled by *contact* with the snow-covered ground, but is not heated by the radiation from the sun.

"When the air is charged with aqueous vapor, a similar cooling effect also takes place, but in a slightly different way. Air charged with aqueous vapor is a good absorber of radiant heat, but it can only absorb those rays which agree with it in *period*. It so happens that rays from snow and ice are, of all others, those which it absorbs best. The humid air will absorb the total radiation from the snow and ice, but it will allow the greater part of, if not nearly all, the sun's rays to pass unabsorbed. But during the day, when the sun is shining, the radiation from the snow and ice to the air is negative; that is, the snow and ice cool the air by radiation. The result is, the air is cooled by radiation from the snow and ice (or rather, we should say, *to* the snow and ice) more rapidly than it is heated by the sun; and, as a consequence, in a country like Greenland, covered with an icy mantle, the temperature of the air, even during summer, seldom rises above the freezing-point. Snow is a good reflector, but as simple reflection does not change the character of the rays they would not be absorbed by the air, but would pass into stellar space. Were it not for the ice, the summers of North Greenland, owing to the continuance of the sun above the horizon, would be as warm as those of England; but, instead of this, the Greenland summers are colder than our winters. Cover India with an ice sheet, and its summers would be colder than those of England.

"*Second*, Another cause of the cooling effect is that the rays which fall on snow and ice are to a great extent reflected back into space. But those that are not reflected, but absorbed, do not raise the temperature, for they disappear in the mechanical work of melting the ice. For whatsoever may be the intensity of the sun's heat the surface of the ground will be kept at 32° so long as the snow and ice remain unmelted.

"*Third*, Snow and ice lower the temperature by chilling the air and condensing the vapor into thick fogs. The great strength of the sun's rays during summer, due to his nearness at that season, would, in the first place, tend to produce an increased amount of evaporation. But the presence of snow-clad mountains and an icy sea would chill the atmosphere and condense the vapor into thick fogs. The thick fogs and cloudy sky would effectually prevent the sun's rays from reaching the earth, and the snow, in consequence, would remain unmelted during the entire summer. In fact, we have this very condition of things exemplified in some of the islands of the Southern Ocean at the present day. Sandwich Land, which is in the same parallel of latitude as the north of Scotland, is covered with ice and snow the entire summer; and in the island of South Georgia, which is in the same parallel as the centre of England, the perpetual snow descends to the very sea-beach. Captain Sir James Ross found the perpetual snow at the sea-level at Admiralty Inlet, South Shetland, in lat. 64°; and while near this place the thermometer in the very middle of summer fell at night to 23° F. The reduction of the sun's heat and lengthening of the winter, which would take place when the eccentricity is near to its superior limit and the winter in aphelion, would in this country produce a state of things perhaps as bad as, if not worse than, that which at present exists in South Georgia and South Shetland.

"The cause which above all others must tend to produce great changes of climate, is the deflexion of great ocean currents. A high condition of eccentricity tends, we have seen, to produce an accumulation of snow and ice on the hemisphere whose winters occur in aphelion. The accumulation of snow in turn tends to lower the summer temperature, cut off the sun's rays, and retard the melting of the snow. In short, it tends to produce on that hemisphere a state of glaciation. Exactly opposite effects take place on the other hemisphere, which has its winter in perihelion. There the shortness of the winters, combined with the high temperature arising from the nearness of the sun, tends to prevent the accumulation of snow. The general result is that the one hemisphere is cooled and the other heated. This state of things now brings into play the agencies which lead to the deflexion of the Gulf-stream and other great ocean currents.

"Owing to the great difference between the temperature of the equator and the poles, there is a constant flow of air from the poles to the equator. It is to this that the trade-winds owe their existence. Now, as the strength of these winds will, as a general rule, depend upon the difference of temperature that may exist between the equator and higher latitudes, it follows that the trades on the cold hemisphere will be stronger than those on the warm. When the polar and temperate regions of the one hemisphere are covered to a large extent with snow and ice, the air, as we have just seen, is kept almost at the freezing-point during both summer and winter. The trades on that hemisphere will, of necessity, be exceedingly powerful; while on the other hemisphere, where there is comparatively little snow or ice, and the air is warm, the trades will consequently be weak. Suppose now the northern hemisphere to be the cold one. The north-east trade winds of this hemisphere will far exceed in strength the south-east trade winds of the southern hemisphere. The *median line* between the trades will consequently lie to a very considerable distance to the south of the equator. We have a good example of this at the present day. The difference of temperature between the two hemispheres at present is but trifling to what it would be in the case under consideration; yet we find that the south-east trades of the Atlantic blow with greater force than the north-east trades, sometimes extending to 10° or 15° N. lat., whereas the north-east trades seldom blow south of the equator. The effect of the northern trades blowing across the equator to a great distance will be to impel the warm water of the tropics over into the Southern Ocean. But this is not all; not only would the median line of the trades be shifted southwards, but the great equatorial currents of the globe would also be shifted southwards.

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[1] When the eccentricity is at its superior limit, the absolute quantity of heat received by the earth during the year is, however, about one three-hundredth part greater than at present. But this does not affect the question at issue.

"Let us now consider how this would affect the Gulf-stream. The South American continent is shaped somewhat in the form of a triangle, with one of its angular corners, called Cape St. Roque, pointing eastwards. The equatorial current of the Atlantic impinges against this corner; but as the greater portion of the current lies a little to the north of the corner, it flows westwards into the Gulf of Mexico and forms the Gulf-stream. A considerable portion of the water, however, strikes the land to the south of the cape, and is deflected along the shore of Brazil into the Southern Ocean, forming what is known as the Brazilian current. Now, it is obvious that the shifting of the equatorial current of the Atlantic only a few degrees to the south of its present position—a thing which would certainly take place under the conditions which we have been detailing—would turn the entire current into the Brazilian branch, and instead of flowing chiefly into the Gulf of Mexico, as at present, it would all flow into the Southern Ocean, and the Gulf-stream would consequently be stopped. The stoppage of the Gulf-stream, combined with all those causes which we have just been considering, would place Europe under a glacial condition, while at the same time the temperature of the Southern Ocean would, in consequence of the enormous quantity of warm water received, have its temperature (already high from other causes) raised enormously. And what holds true in regard to the currents of the Atlantic holds also true, though perhaps not to the same extent, of the currents of the Pacific.

"If the breadth of the Gulf-stream be taken at 50 miles, its depth at 1000 feet, its mean velocity at 2 statute miles an hour, the temperature of the water when it leaves the Gulf at 65°, and the return current at 40° F.,[1] then, as has been shown in *Climate and Time*, chapter ii., the quantity of heat conveyed into the Atlantic by this stream is equal to one-fourth of all the heat received from the sun by that ocean from the Tropic of Cancer to the Arctic Circle.[2] From principles discussed at considerable length in the chapter referred to, it is shown that, but for the Gulf-stream and other currents, London would have a mean annual temperature 40° lower than at present.

"But there is still another cause which must be noticed:—a strong undercurrent of air *from* the north implies an equally strong upper current *to* the north. Now if the effect of the undercurrent would be to impel the warm water at the equator to the south, the effect of the upper current would be to carry the aqueous vapor formed at the equator to the north; the upper current, on reaching the snow and ice of temperate regions, would deposit its moisture in the form of snow: so that it is probable that, notwithstanding the great cold of the glacial epoch, the quantity of snow falling in the northern region would be enormous. This would be particularly the case during summer, when the earth would be in the perihelion and the heat at the equator great. The equator would be the furnace where evaporation would take place, and the snow and ice of temperate regions would act as a condenser.

"The foregoing considerations, as well as many others which might be stated, lead to the conclusion that, in order to raise the mean temperature of the globe, *water* should be placed along the equator, and not *land*, as was contended by Sir Charles Lyell and others. For if land be placed at the equator, the possibility of conveying the sun's heat from the equatorial regions by means of ocean currents is prevented."

Inter-Glacial Periods.—Allusion has already been made to the fact that there is accumulating evidence to show that changes of climate have been recurrent, and that this alternation or periodicity goes far to prove them to be due to some general or cosmical cause. Dr. Croll has ingeniously shown that every long cold period in each hemisphere must have been interrupted by several shorter warm periods, and "when the one hemisphere," he says, "is under glaciation, the other is enjoying a warm and equable climate. But, owing to the precession of the equinoxes, the condition of things on the two hemispheres must be reversed every 10,000 years or so. When the solstice passes the aphelion, a contrary process commences; the snow and ice gradually begin to diminish on the cold hemisphere and to make their appearance on the other hemisphere. The glaciated hemisphere turns by degrees warmer, and the warm hemisphere colder, and this continues to go on for a period of ten or twelve thousand years, until the winter solstice reaches the perihelion. By this time the conditions of the two hemispheres have been reversed; the formerly glaciated hemisphere has now become the warm one, and the warm hemisphere the glaciated. The transference of the ice from the one hemisphere to the other continues as long as the eccentricity remains at a high value. It is probable that, during the warm inter-glacial periods, Greenland and the Arctic regions would be comparatively free from snow and ice, and enjoying a temperate and equable climate."

PART II.—GEOGNOSY:

AN INVESTIGATION OF THE MATERIALS OF THE EARTH'S SUBSTANCE.

Before we enter upon any discussion of the geological changes which our planet has undergone, it is needful first of all to study the materials of which the planet consists. It is from the evidence furnished by the nature and arrangement of these materials that geological history must be compiled.

Viewed in a broad way then, the earth may be considered as consisting of (1) two envelopes,—an outer one of gas completely surrounding the planet, and an inner one of water covering about three-fourths of the globe; and (2) a globe cool and solid on its surface but possessing a high internal temperature.

I. The Envelopes.

1. *The Atmosphere.*—The gaseous envelope to which the name of atmosphere is given extends at least to a distance of 40 or 45 miles from the earth's surface, perhaps in a state of extreme tenuity to a much greater height. But its thickness must necessarily vary with latitude and changes in atmospheric pressure; the layer of air lying over the poles is not so deep as that which surrounds the equator.

Geologically considered, the atmosphere presents itself as an agent of change by virtue of its composition and the chemical reactions which it effects, its varying temperature and consequent influence in expanding and contracting rocks, and its movements.

Many speculations have been made regarding the chemical composition of the atmosphere during former geological periods. There can indeed be no doubt that it must originally have differed very greatly from its present condition. The oxygen which now forms fully a half of the outer crust of the earth was originally doubtless part of the atmosphere. So, too, the vast beds of coal found all over the world, in geological formations of many different ages, represent so much carbonic acid once present in the air. The chlorides in the sea likewise were probably carried down out of the atmosphere in the primitive condensation of the aqueous vapor. It has often been suggested that during the Carboniferous period the atmosphere must have been warmer and with more aqueous vapor and carbonic acid in its composition than at the present day, to admit of so luxuriant a flora as that from which the coal seams were formed. There seems, however, to be at present no method of arriving at any certainty on this subject.

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[1] Sir Wyville Thomson states that in May, 1873, the *Challenger* expedition found the Gulf-stream, at the point where it was crossed, to be about 60 miles in width, 100 fathoms deep, and flowing at the rate of 3 knots per hour. This makes the volume of the stream one-fifth greater than the above estimate.

[2] The quantity of heat conveyed by the Gulf-stream for distribution is equal to 77,479,650,000,000,000,000 foot-pounds per day. The quantity received from the sun by the North Atlantic is 310,923,000,000,000,000,000 foot-pounds.

As now existing, the atmosphere is considered to be normally a mechanical mixture of nearly 4 volumes of nitrogen and 1 of oxygen, with a minute proportion of carbonic acid, and still smaller quantities of other substances. Expressed in a tabular form this composition is as follows:—

Nitrogen	79·00
Oxygen	20·96
Carbonic acid	0·04

These quantities are liable to some variation according to locality. On the sea, for example, the proportion of carbonic acid is said to average about 0·03. In the air of streets and houses the proportion of oxygen diminishes, while that of carbonic acid increases. According to the minute researches of Dr. Angus Smith, very pure air should contain not less than 20·99 of oxygen, with 0·030 of carbonic acid; but he found impure air in Manchester to have only 20·21 of oxygen, while the proportion of carbonic acid in that city during fog was ascertained to rise sometimes to 0·0679, and in the pit of the theatre to the very large amount of 0·2734. Small as the percentage of carbonic acid in ordinary air may seem, yet the total amount of this gas in the whole atmosphere probably exceeds what would be disengaged if all the vegetable and animal matter on the earth's surface were burnt.

The other substances present in much more minute quantities are gases, vapors, and solid particles. Of these by much the most important is the vapor of water, which is always present, but in very variable amount according to temperature, ranging from about 4 to a maximum of 16 grains in 1000 grains of air.[1] It is this vapor which condenses into dew, rain, hail, and snow. In assuming a visible form, and descending through the atmosphere, it takes up a minute quantity of air, and of the different substances which the air may contain. Being caught by the rain, and held in solution or suspension, these substances can be best examined by analyzing rain-water. In this way ammonia, nitric, sulphurous, and sulphuric acids, chlorides, various salts, solid carbon, inorganic dust, and organic matter have been detected. M. J. J. Pierre found as the result of his analysis that in the neighborhood of Caen, in France, a hectare of land receives annually from the atmosphere, by means of rain—

Chloride of	sodium	37·5	kilogrammes.
"	potassium	8·2	"
"	magnesium	2·5	"
"	calcium	1·8	"
Sulphate of	soda	8·4	"
"	potash	8·0	"
"	lime	6·2	"
"	magnesia	5.9	"

To these ingredients must be added traces of ammonia, various salts, and organic substances, besides others still undetermined.[2] The powerful oxidizing agent ozone is present in variable but always minute quantities in the air.

The comparatively small but by no means unimportant proportions of these various components of the atmosphere are much more liable than the more essential gases to great variations. Chloride of sodium, for instance, is, as might be expected, particularly abundant in the air bordering the sea. Nitric acid, ammonia, and sulphuric acid appear in the air of towns most conspicuously. The organic substances present in the air are sometimes living germs, such as probably often lead to the propagation of disease, and sometimes mere fine particles of dust derived from the bodies of living or dead organisms.[3]

2. *The Oceans.*—About three-fourths of the surface of the globe (or about 144,712,000 square miles) is covered by the irregular sheet of water known as the sea. Within the last ten years much new light has been thrown upon the depths, temperatures, and biological conditions of the ocean-basins, more particularly by the "Lightning," "Porcupine," and "Challenger" expeditions fitted out by the British Government. It has been ascertained that few parts of the Atlantic Ocean exceed 3000 fathoms, the deepest sounding obtained there being one taken about 100 miles north from the island of St. Thomas, which gave 3875 fathoms, or rather less than 4½ miles. The Atlantic appears to have an average depth in its more open parts of from 2000 to 3000 fathoms or from about 2 to 3½ miles. In the Pacific Ocean the "Challenger" got soundings of 3950 and 4475 fathoms, or about 4½ and rather more than 5 miles. But these appear to mark exceptionally abyssal depressions, the average depth being, as in the Atlantic, between 2000 and 3000 fathoms. We may therefore assume, as probably not far from the truth, that the average depth of the ocean is about 2500 fathoms, or nearly 3 miles.

The water of the oceans is distinguished from the ordinary terrestrial waters by a higher specific gravity, and the presence of so large a proportion of saline ingredients as to impart a strongly salt taste. The average density of sea-water is about 1·026, but it varies slightly in different parts even of the same ocean. According to the recent observations of Mr. J. Y. Buchanan during the "Challenger" expedition, some of the heaviest sea-water occurs in the pathway of the trade-winds of the North Atlantic, where evaporation must be comparatively rapid, a density of 1·02781 being registered. Where, however, large rivers enter the sea, or where there is much melting ice, the density diminishes; Mr. Buchanan found among the broken ice of the Antarctic Ocean that it had sunk to 1·02418.[4]

The greater density of sea-water depends of course upon the salts which it contains in solution. There seems no reason to doubt that these salts are, in the main, parts of the original constitution of the sea, and thus that the sea has always been salt. It is also probable that, as in the case of the atmosphere, the composition of the ocean water has in former geological periods been very different from what it is now, and that it has acquired its present character only after many ages of slow change, and the abstraction of much mineral matter originally contained in it. There is evidence indeed among the geological formations that large quantities of lime, silica, chlorides, and sulphates have in the course of time been removed from the sea.[5]

But it is evident also that, whatever may have been the original composition of the oceans, they have for a vast section of geological time been constantly receiving mineral matter in solution from the land. Every spring, brook, and river removes various salts from the rocks over which it moves, and these substances, thus dissolved, eventually find their way into the sea. Consequently sea-water ought to contain more or less traceable proportions of every substance which the terrestrial waters can remove from the land, in short, of probably every element present in the outer shell of the globe, for there seems to be no constituent of this earth which may not, under certain circumstances, be held in solution in water. Moreover, unless there be some counteracting process to remove these mineral ingredients, the ocean water ought to be growing, insensibly perhaps, but still assuredly, salter, for the supply of saline matter from the land is incessant. It has been ascertained indeed, with some approach to certainty, that the salinity of the Baltic and Mediterranean is gradually increasing.[6]

The average proportion of saline constituents in the water of the great oceans far from land is about three and a half parts in every hundred of water. But in enclosed seas, receiving much fresh water, it is greatly reduced, while in those where evaporation predominates it is correspondingly augmented. Thus the Baltic water contains from one-seventh to nearly a half of the ordinary proportion in ocean water, while the Mediterranean contains sometimes one-sixth more than that proportion. The mineral constituents include the following average ratios of salts[7]:—

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[1] The quantity of aqueous vapor depends upon the temperature, warm air being able to retain more than cold air. Air at a temperature of 10° C. is saturated when it contains 9·362 grammes of vapor in a cubic metre of air.

[2] *Chimie Agricole*, quoted by Dr. Angus Smith, *Air and Rain*, p. 232.

[3] The air of towns is peculiarly rich in impurities, especially in manufacturing districts, where much coal is used. These impurities, however, though of serious consequence to the towns in a sanitary point of view, do not sensibly affect the general atmosphere, seeing that they are probably in great measure taken out of the air by rain, even in the districts which produce them. They possess, however, a special geological significance, and in this respect, too, have important economic bearings. See on this whole subject Dr. Angus Smith's work already cited.

[4] Buchanan, *Proc. Roy. Soc.* (1876), vol. xxiv.

[5] Dr. Sterry Hunt even supposes that the saline waters of Canada and the northern States derive their mineral ingredients from the salts still retained among the sediments and precipitates of the ancient sea in which the earlier Palæozoic rocks were deposited.—*Geological and Chemical Essays*, p. 104.

[6] Paul, in Watts's *Dictionary of Chemistry*, v. 1020.

[7] Bischof, *Chemical Geology*, i. 379.

	Percentage.
Chloride of sodium (common salt)	75·786
Chloride of magnesium	9·159
Chloride of potassium	3·657
Sulphate of lime (gypsum)	4·617
Sulphate of magnesia (Epsom salts)	5·597
Bromide of sodium	1·184
	100·000
Total percentage of salts in sea-water	3·527

Besides these chief ingredients, sea-water has yielded minute traces of iodine, fluorine, silica, phosphoric acid, carbonate of lime and magnesia, silver, lead, copper, arsenic. Doubtless more perfect analysis will greatly increase this list.

In addition to its salts sea-water always contains dissolved atmospheric gases. From the researches conducted during the voyage of the "Bonité" in the Atlantic and Indian Oceans it was estimated that the gases in 100 volumes of sea-water ranged from 1·85 to 3·04, or from two to three per cent. From observations made during the "Porcupine" cruise of 1868 it was inferred that the proportion of oxygen was greatest (25·1 per cent.) in the surface water, and least (19·5) in the bottom water, while that of carbonic acid was least at the top (20·7) and greatest (27·9) at the bottom, and that the action of the waves was partially to eliminate the latter gas and to increase the amount of oxygen. More recently, however, during the voyage of the "Challenger," Mr. J. Y. Buchanan ascertained that the proportion of carbonic acid was always nearly the same for similar temperatures, the amount in the Atlantic surface water, between 20° and 25° C., being 0·0466 gramme per litre, and in the surface Pacific water 0·0268. He points out the curious fact that, according to his analyses, sea-water contains sometimes at least thirty times as much carbonic acid as an equal bulk of fresh water would do, and he traces the greater power of absorption to the presence of the sulphates.

II. The Solid Globe.

1. *General Considerations.*—Within the atmospheric and oceanic envelopes lies the inner solid globe. Reference has already been made to the comparative density of the planet among the other members of the solar system. In all speculation about the history of the earth, the density of the whole mass of the planet as compared with water—the standard to which the specific gravities of terrestrial bodies are referred—is a question of prime importance. Various methods have been employed for determining the earth's density. The deflexion of the plumb-line on either side of a mountain of known structure and density, the time of oscillation of the pendulum at great heights, at the sea-level, and in deep mines, the comparative force of gravitation as measured by the torsion balance—each of these processes has been tried with the following various results:—

Plumb-line experiments on Schiehallien (Maskelyne and Playfair) gave as the mean density of the earth	4·713
Do. on Arthur's Seat, Edinburgh, (James)	5·316
Pendulum experiments on Mont Cenis (Carlini and Giulio)	4·950
Do. in Harton coal-pit, Newcastle (Airy)	6·565
Torsion balance experiments (Cavendish)	5·480
Do. Do. (Baily)	5·660

Though these observations are somewhat discrepant, we may feel satisfied that the globe has a mean density neither much more nor much less than 5·5; that is to say, it is five and a half times heavier than one of the same dimensions formed of pure water. Now the average density of the materials which compose the accessible portions of the earth is between 2·5 and 3; so that the mean density of the whole globe is about twice as much as that of its outer part. We might therefore infer that the inside consists of much heavier materials than the outside, and consequently that the mass of the planet must contain at least two dissimilar portions—an exterior lighter crust or rind, and an interior heavier nucleus. But the effect of pressure must necessarily increase the specific gravity of the interior, as will be alluded to further on.

2. *The Crust.*—It was formerly a prevalent belief that the exterior and interior of the globe differed from each other to such an extent that, while the outer parts were cool and solid, the vastly more enormous inner part being intensely hot was more or less completely fluid. Hence the term "crust" was applied to the external rind in the usual sense of that word. This crust was variously computed to be 10, 15, 20, or more miles in thickness. For reasons which will be afterwards given, the idea of internal liquidity has been opposed by eminent physicists and is now abandoned by most geologists. The term "crust," however, continues to be used as a convenient word to denote the cool, upper, or outer layer of the earth's mass, accessible to human observation. It is in the structure and history of this crust that the main subjects of geological investigation are contained. It will therefore be fully treated of in the following parts of this article.

There are, however, some general views as to its composition and the arrangement of its materials, which may appropriately find a place in this preliminary section. Evidently our direct acquaintance with the chemical constitution of the globe must be limited to that of the crust, though by inference we may eventually reach highly probable conclusions regarding the constitution of the interior. Chemical research has discovered that sixty-four simple or as yet indecomposable bodies, called elements, in various proportions and compounds, constitute the accessible part of the crust. Of these, however, the great majority are comparatively of rare occurrence. The crust, so far as we can examine it, is mainly built up of about sixteen elements, which may be arranged in the two following groups, the most abundant bodies being placed first in each list:—

Metalloids.	Atomic Weight.	*Metals.*	Atomic Weight.
Oxygen	15·96	Aluminium	27·30
Silicon	28·00	Calcium	39·90
Carbon	11·97	Magnesium	23·94
Sulphur	31·98	Potassium	39·04
Hydrogen (really a metal)	1·00	Sodium	22·99
Chlorine	35·37	Iron	55·90
Phosphorus	30·96	Manganese	54·80
Fluorine	19·10	Barium	136·80

By far the most abundant and important of these elements is oxygen. It forms about 23 per cent. by weight of air, 88·88 per cent. of water, and about a half of all the rocks which compose the visible portion or "crust" of the globe. Another metalloid, silicon, comes next in abundance. It is always united with oxygen, forming the mineral silica which, either alone or in combination with various metallic bases as silicates, constitutes a half of all the known mass of the globe. Of the remaining metalloids carbon and sulphur sometimes occur in the free state, but usually in combination with oxygen or some base or metal. Chlorine and fluorine are found associated with metallic bases. Hydrogen is properly a metal, and occurs chiefly in combination with oxygen as the oxide, water. Phosphorus occurs with oxygen principally in phosphate of lime.

Of the metals by far the most important in the architecture of the exterior of the earth is aluminium. In conjunction with oxygen and silicon it forms the basis of most crystalline rocks. Calcium, magnesium, potassium, and sodium, combined with oxygen, enter largely into the composition of rocks. Iron is the great coloring material in nature, most of the yellow, brown, red, and green hues of rocks being due to some of its combinations. The sixteen elements mentioned in the foregoing lists form about ninety-nine parts of the earth's crust; the other elements constitute only about a hundredth part, though they include gold, silver, copper, tin, lead, and the other useful metals, iron excepted.

It is clear then that, so far as accessible to our observation, the outer portion of our planet consists mainly of metalloids, and its metallic constituents have in great part entered into combination with oxygen, so that the atmosphere contains the residue of that gas which has not yet united itself to terrestrial compounds. In a broad view of the arrangement of the chemical elements in the external crust, the suggestive speculation of Durocher deserves attention.[1] He regarded all rocks as referable to two layers or magmas co-existing in the earth's crust the one beneath the other, according to their specific gravities. The upper or outer layer, which he termed the acid or siliceous magma, contains an excess of silica, and has a mean density of 2·65. The lower or inner layer, which he called the basic magma, has from six to eight times more of the earthy bases and iron oxides, with a mean density of 2·96. To the former he assigned the early plutonic rocks, granite, felsite, etc., with the more recent trachytes; to the latter he relegated all the heavy lavas, basalts, diorites, etc. The ratio of silica is 7 in the acid magma to 5 in the basic. Though the proportion of this acid or of the earthy and metallic bases cannot be regarded as any certain evidence of the geological date of rocks, nor of their probable depth of origin, it is nevertheless a fact that (with many important exceptions) the eruptive rocks of the older geological periods are very generally super-silicated and of lower specific gravity, while those of later time are very frequently poor in silica but rich in the earthy bases and in iron and manganese, with a consequent higher specific gravity. The latter, according to Durocher, have been forced up from a lower zone through the lighter siliceous crust.

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[1] Translated by Haughton in his *Manual of Geology*, 1866, p. 16.

3. *The Interior or Nucleus.*—Though we cannot hope ever to have direct acquaintance with more than the mere outside skin of our planet, we may be led to infer the irregular distribution of materials within the crust from the present distribution of land and water, and the observed differences in the amount of deflexion of the plumb-line near the sea and near mountain-chains. The fact that the southern hemisphere is almost wholly covered with water appears explicable only on the assumption of an excess of density in the mass of that portion of the planet. The existence of such a vast sheet of water as that of the Pacific Ocean is to be accounted for, says Archdeacon Pratt, by the presence of "some excess of matter in the solid parts of the earth between the Pacific Ocean and the earth's centre, which retains the water in its place, otherwise the ocean would flow away to the other parts of the earth."[1] The same writer points out that a deflexion of the plumb-line towards the sea, which has in a number of cases been observed, indicates that "the density of the crust beneath the mountains must be less than that below the plains, and still less than that below the ocean-bed."[2] Apart therefore from the depressions of the earth's surface in which the oceans lie, we must regard the internal density, whether of crust or nucleus, to be somewhat irregularly arranged,—there being an excess of heavy materials in the water hemisphere and beneath the ocean-beds as compared with the continental masses.

In our ignorance regarding the chemical constitution of the nucleus of our planet, an argument has sometimes been based upon the known fact that the specific gravity of that nucleus is about double that of the crust. This has been held by some writers to prove that the interior must consist of much heavier material, and is therefore probably metallic. But in so reasoning they forget that the effect of pressure ought to make the density of the nucleus much higher, even if the interior consisted of matter no heavier than the crust. In fact, we might argue for the probable comparative lightness of the substance composing the nucleus. That the total density of the planet does not greatly exceed its observed amount seems only explicable on the supposition that some antagonistic force counteracts the effects of pressure. The only force we can suppose capable of so acting is heat. But how and to what extent this counterbalancing takes place is still unknown.

If we regard the question from another point of view, however, the idea of a metallic nucleus seems not improbable. When the materials of the globe existed in a fluid condition, as they are usually supposed to have done, they would doubtless arrange themselves in accordance with their relative specific gravities. The denser elements would sink towards the centre, the lighter would remain outside. That this distribution has certainly taken place to some extent is evident from the structure of the envelopes and crust. It is what might be expected if the constitution of the globe resembles on a small scale the larger planetary system of which it forms a part. The existence of a metallic interior has always been inferred from the metalliferous veins which traverse the crust, and which are commonly supposed to have been filled from below.

Admitting the possibility or even probability of a metallic nucleus, in spite of the comparatively low density of the globe as a whole, we might speculate further as to the arrangement of the denser internal materials. The late Mr. David Forbes suggested that the planet might be supposed to consist of three layers of uniform densities, enclosed one within the other, the density increasing towards the centre in arithmetical progression. Allowing 2·5 as the specific gravity of the crust or outer layer, he assigned 12·0 or thereabouts as that of the middle layer, and supposed that the inner nucleus might possess one averaging 20·0.[3] Materials do not yet exist for any satisfactory conclusions on this subject.

In the evidence obtainable as to the former history of the earth, no fact is of more importance than the existence of a high temperature beneath the crust, which has now been placed beyond all doubt. This feature of the planet's organization is made clear by the following proofs:—

(1.) *Volcanoes.*—In many regions of the earth's surface openings exist from which steam and hot vapors, ashes and streams of molten rock are from time to time emitted. The abundance of these openings seems inexplicable by any mere local causes, but must be regarded as indicative of a very high internal temperature. If to the still active vents of eruption we add those which have formerly been the channels of communication between the interior and the surface, there are probably few large regions of the globe where proofs of volcanic action cannot be found. Everywhere we meet with masses of molten rock which have risen from below as if from some general reservoir.

(2.) *Hot Springs.*—Where volcanic eruptions have ceased, evidence of a high internal temperature is still often to be found in springs of hot water which continue for centuries to maintain their heat. Thermal springs, however, are not confined to volcanic districts. They sometimes rise even in regions many hundreds of miles distant from any active volcanic vent. The hot springs of Bath (temp. 120° Fahr.) and Buxton (temp. 82° Fahr.) in England are fully 900 miles from the Icelandic volcanoes on the one side, and 1100 miles from those of Italy and Sicily on the other.

(3.) *Borings, Wells, and Mines.*—The influence of the seasonal changes of temperature extends downward from the surface to a depth which varies according to latitude, to the thermal conductivity of the soils and rocks, and perhaps to other causes. The cold of winter and the heat of summer may be regarded as following each other in successive waves downward, until they disappear along a limit at which the temperature remains constant. This zone of invariable temperature is commonly believed to lie somewhere between 60 and 80 feet down in temperate regions. At Yakutsk in eastern Siberia (lat. 62° N.), however, the soil is permanently frozen to a depth of about 700 feet.[4] In Java, on the other hand, a constant temperature is said to be met with at a depth of only 2 or 3 feet.[5]

It is a remarkable fact, now verified by observation all over the world, that below the limit of the influence of ordinary seasonal changes the temperature, so far as we yet know, is nowhere found to diminish downwards. It always rises; and its rate of increment never falls much below the average. The only exceptional cases occur under circumstances not difficult of explanation. On the one hand, the neighborhood of hot-springs, of large masses of lava, or of other manifestations of volcanic activity, may raise the subterranean temperature much above its normal condition; and this augmentation may not disappear for many thousand years after the volcanic activity has wholly ceased, since the cooling down of a subterranean mass of lava would necessarily be a very slow process. On the other hand, the spread of a thick mass of snow and ice over any considerable area of the earth's surface, and its continuance there for several thousand years, would so depress the subterranean isothermals that for many centuries afterwards there might be a fall of temperature for a certain distance downwards. At the present day, in at least the more northerly parts of the northern hemisphere, there are such evidences of a former more rigorous climate, as in the well sinking at Yakutsk already referred to.[6] Sir William Thomson[7] has calculated that any considerable area of the earth's surface covered for several thousand years by snow or ice, and retaining, after the disappearance of that frozen covering, an average surface temperature of 13° C., "would during 900 years show a decreasing temperature for some depth down from the surface, and 3600 years after the clearing away of the ice would still show residual effect of the ancient cold, in a half rate of augmentation of temperature downwards in the upper strata, gradually increasing to the whole normal rate, which would be sensibly reached at a depth of 600 metres." But beneath the limit to which the influence of the changes of the seasons extends, observations in most parts of the globe show that the temperature invariably rises as we penetrate towards the interior of the earth. According to present knowledge the average rate of increase amounts to 1° Fahr. for every 50 or 60 feet of descent, and this rise is found whether the boring be made at the sea-level or on elevated ground. The subjoined table gives the results of temperature observations at widely separated localities[1] :—

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[1] *Figure of the Earth*, 4th edit., p. 236.

[2] *Op. cit.*, p. 200. See also Herschel, *Phys. Geog.*; and O. Fisher, *Cambridge Phil Trans.*, xii., part ii.

[3] *Popular Science Review*, April, 1869.

[4] Helmersen, *Brit. Assoc. Report*, 1871.

[5] Junghuhn's *Java*, ii. p. 771.

[6] Professor Prestwich (*Inaugural Lecture*, 1875, p. 45) has suggested that to the more rapid refrigeration of the earth's surface during this cold period, and to the consequent depression of the subterraneous isothermal lines, the alleged present comparative quietude of the volcanic forces is to be attributed, the internal heat not having yet recovered its dominion in the outer crust.

[7] *Brit. Assoc. Reports*, 1876, Sections, p. 3.

			Feet.
Dukinfield, near Manchester (2040 ft., coal measures)	1° Fahr.	for every	83·2
Rose Bridge, Wigan (2445 ft., coal measures)	"	"	54·3
South Balgray, Glasgow (525 ft., coal measures)	"	"	41
Kentish Town, London (1100 ft., London clay chalk, gault, etc.)	"	"	54·6
La Chapelle, Paris (660 metres, chalk, etc.)	"	"	84
Grenelle Well, Paris (1795·6 ft., do.)	"	"	56·9
St. André, do. (263 metres, do.)	"	"	56·4
Neu Salzwerk boring, Westphalia (2281 ft.)	"	"	54·68
Mendorff bore, near Luxembourg (2394 ft.)	"	"	57·0
Bore near Geneva	"	"	55
Mont Cenis tunnel (5280 ft. below summit of Mount Frejus, metamorphic rocks)	"	"	(?) 81
Yakutsk, Siberia (656 ft., limestone, etc., and granite)	"	"	60

(4.) *Irregularities in the Downward Increment of Heat.*—While these examples prove a progressive increase of temperature, they show also that this rate of increase is not strictly uniform. The more detailed observations which have been made in recent years have brought to light the important fact that considerable variations in the rate of increase take place even in the same bore. If, for instance, we examine the temperatures obtained at different depths in the Rose Bridge colliery shaft cited in the foregoing list, we find them to read as in the following columns:—

Depth in Yards.	Temperature (Fahr.).	Depth in Yards.	Temperature (Fahr.).
558	78	745	89
605	80	761	90½
630	83	775	91½
663	85	783	92
671	86	800	93
679	87	806	93½
734	88½	815	94

At La Chapelle, in an important well made for the water-supply of Paris, observations have been taken of the temperature at different depths, as shown in the subjoined table[2] :—

Depth in Metres.	Temperature (Fahr.).	Depth in Metres.	Temperature (Fahr.).
100	59·5	500	72·6
200	61·8	600	75·0
300	65·5	660	76·0
400	69·0		

In drawing attention to the temperature-observations at the Rose Bridge colliery—the deepest mine in Great Britain—Professor Everett points out that, assuming the surface temperature to be 49° Fahr., in the first 558 yards the rate of rise of temperature is 1° for 57·7 feet; in the next 257 yards it is 1° in 48·2 feet; in the portion between 605 and 671 yards—a distance of only 198 feet—it is 1° in 33 feet; in the lowest portion of 432 feet it is 1° in 54 feet.[3] When such irregularities occur in the same vertical shaft, it is not surprising that the average should vary so much in different places.

There can be little doubt that one main cause of these variations is to be sought in the different thermal conductivities of the rocks of the earth's crust. The first accurate measurements of the conducting powers of rocks were made by the late Professor J. D. Forbes at Edinburgh (1837–1845). He selected three sites for his thermometers, one in "trap-rock" (a porphyrite of Lower Carboniferous age), one in loose sand, and one in sandstone, each instrument being sunk to a depth of 24 French feet from the surface. He found that the wave of summer heat reached the first instrument on 4th January, the second on 25th December, and the third on 3d November, the trap-rock being by far the worst conductor, and the solid sandstone by far the best.[4]

The British Association has recently appointed a committee to investigate this subject in greater detail. Already some important determinations have been made by it regarding the absolute conductivity of various rocks. As a rule the lighter and more porous rocks offer the greatest resistance to the passage of heat, while the more dense and crystalline offer the least resistance. The resistance of opaque white quartz is expressed by the number 114, that of basalt by 273, while that of cannel coal stands very much higher at 1538, or more than thirteen times that of quartz.[5]

It is evident also that, from the texture and structure of most rocks, the conductivity must vary in different directions through the same mass, heat being more easily conducted along than across the "grain," the bedding, and the other numerous divisional surfaces. Experiments have been made to determine these variations in a number of rocks. Thus, the conductivity in a direction transverse to the divisional planes being taken as unity, the conductivity parallel with these planes was found in a variety of magnesian schist to be 4·028. In certain slates and schistose rocks from central France the ratio varied from 1 : 2·56 to 1 : 3·952. Hence in such fissile rocks as slate and mica-schist heat may travel four times more easily along the lines of cleavage or foliation than across them.[6]

In reasoning upon the discrepancies in the rate of increase of subterranean temperatures, we must also bear in mind that certain kinds of rock are more liable than others to be charged with water, and that, in almost every boring or shaft, one or more horizons of such water-bearing rocks are met with. The effect of this interstitial water is to diminish thermal resistance. Dry red brick has its resistance lowered from 680 to 405 by being thoroughly soaked in water, its conductivity being thus increased 68 per cent. A piece of sandstone has its conductivity heightened to the extent of 8 per cent. by being wetted.[7]

Mr. Mallet has contended that the variations in the amount of increase in subterranean temperature are too great to permit us to believe them to be due merely to differences in the transmission of the general internal heat, and that they point to local accessions of heat arising from transformation of the mechanical work of compression, which is due to the constant cooling and contraction of the globe.[8] But it may be replied that these variations are not greater than, from the known divergencies in the conductivities of rocks, they might fairly be expected to be.

(5.) *Probable Condition of the Earth's Interior.*—Various theories (mostly fanciful) have been propounded on this subject. There are only three which merit serious consideration. (1.) One of these supposes the planet to consist of a solid crust and a molten interior. (2.) The second holds that, with the exception of local vesicular spaces, the globe is solid and rigid to the centre. (3.) The third contends that, while the mass of the globe is solid, there lies a liquid substratum beneath the crust.

1. The arguments in favor of internal liquidity may be summed up as follows. (*a.*) The ascertained rise of temperature inwards from the surface is such that, at a very moderate depth, the ordinary melting point of even the most refractory substances would be reached. At 20 miles the temperature, if it increases progressively, as it does in the depths accessible to observation, must be about 1760° Fahr.; at 50 miles it must be 4600°, or far higher than the fusing-point even of so stubborn a metal as platinum, which melts at 3080° Fahr. (*b.*) All over the world volcanoes exist from which steam and torrents of molten lava are from time to time erupted. Abundant as are the active volcanic vents, they form but a small proportion of the whole which have been in operation since early geological time. It has been inferred therefore that these numerous funnels of communication with the heated interior could not have existed

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[1] See "Reports of Committee on Underground Temperature," *Brit. Assoc. Rep.* from 1868 to 1877.

[2] "Report of Committee on Underground Temperature," *Brit. Assoc. Rep.*, 1873, p. 254.

[3] "Report of Committee on Underground Temperature," *Brit. Assoc. Rep.* for 1870, p. 31.

[4] *Trans. Roy. Soc. Edin.*, xvi. 180.

[5] Herschel and Lebour, *Brit. Assoc. Rep.*, 1875, p. 59.

[6] Jannettaz, *Bull. Soc. Géol. de France* (April–June, 1874) tom. ii. p. 264; "Report of Committee on Thermal Conductivities of Rock," *Brit. Assoc. Rep.*, 1875, p. 61.

[7] Herschel and Lebour, *Brit. Assoc. Rep.*, 1875, p. 58.

[8] "Volcanic Energy," *Phil. Trans.* 1875.

and poured forth such a vast amount of molten rock, unless they drew their supplies from an immense internal molten nucleus. (*c.*) When the products of volcanic action from different and widely-separated regions are compared and analyzed, they are found to exhibit a remarkable uniformity of character. Lavas from Vesuvius, from Hecla, from the Andes, from Japan, and from New Zealand present such an agreement in essential particulars as, it is contended, can only be accounted for on the supposition that they have all emanated from one vast common source.[1] (*d.*) The abundant earthquake shocks which affect large areas of the globe are maintained to be inexplicable unless on the supposition of the existence of a thin and somewhat flexible crust. These arguments, it will be observed, are only of the nature of inferences drawn from observations of the present constitution of the globe. They are based on geological data, and have been frequently urged by geologists as supporting the only view of the nature of the earth's interior compatible with geological evidence.

2. The arguments against the internal fluidity of the earth are based on physical and astronomical considerations of the greatest importance. They may be arranged as follows:—

(*a.*) Argument from precession and nutation.—The problem of the internal condition of the globe was attacked as far back as the year 1839 by the late Mr. Hopkins of Cambridge, who endeavored to calculate how far the planetary motions of precession and nutation would be influenced by the solidity or liquidity of the earth's interior. He found that the precessional and nutational movements could not possibly be as they are if the planet consisted of a central ocean of molten rock surrounded with a crust of 20 or 30 miles in thickness, that the least possible thickness of crust consistent with the existing movements was from 800 to 1000 miles, and that the whole might even be solid to the centre, with the exception of comparatively small vesicular spaces filled with melted rock.[2]

M. Delaunay, in a paper on *The Hypothesis of the Interior Fluidity of the Globe*,[3] threw doubt on Hopkins's views, and suggested that, if the interior were a mass of sufficient viscosity, it might behave as if it were a solid, and thus the phenomenon of precession and nutation might not be affected. Sir William Thomson, who had already arrived at the conclusion that the interior of the globe must be solid, and acquiesced generally in Hopkins's conclusions, pointed out that M. Delaunay had not worked out the problem mathematically, otherwise he could not have failed to see that the hypothesis of a viscous and quasi-rigid interior "breaks down when tested by a simple calculation of the amount of tangential force required to give to any globular portion of the interior mass the precessional and nutational motions which, with other physical astronomers, he attributes to the earth as a whole."[4] Sir William, in making this calculation, holds that it demonstrates the earth's crust down to depths of hundreds of kilometres to be capable of resisting such a tangential stress (amounting to nearly $\frac{1}{10}$th of a gramme weight per square centimetre) as would with great rapidity draw out of shape any plastic substance which could properly be termed a viscous fluid. "An angular distortion of $8''$ is produced in a cube of glass by a distorting stress of about ten grammes weight per square centimetre. We may therefore safely conclude that the rigidity of the earth's interior substance could not be less than a millionth of the rigidity of glass without very sensibly augmenting the lunar nineteen-yearly nutation."[5]

In Hopkins's hypothesis he assumed the crust to be infinitely rigid and unyielding, which is not true of any material substance. Sir William Thomson has recently returned to the problem, in the light of his own researches in vortex-motion. He now finds that, while the argument against a thin crust and vast liquid interior is still invincible, the phenomena of precession and nutation do not decisively settle the question of internal fluidity, though the solar semi-annual and lunar fortnightly nutations absolutely disprove the existence of a thin rigid shell full of liquid. If the inner surface of the crust or shell were rigorously spherical, the interior mass of supposed liquid could experience no precessional or nutational influence, except in so far as, if heterogeneous in composition, it might suffer from external attraction due to non-sphericity of its surfaces of equal density. But "a very slight deviation of the inner surface of the shell from perfect sphericity would suffice, in virtue of the quasi-rigidity due to vortex-motion, to hold back the shell from taking sensibly more precession than it would give to the liquid, and to cause the liquid (homogeneous or heterogeneous) and the shell to have sensibly the same precessional motion as if the whole constituted one rigid body."[6]

The assumption of a comparatively thin crust requires that the crust shall have such perfect rigidity as is possessed by no known substance. The tide-producing force of the moon and sun exerts such a strain upon the substance of the globe that it seems in the highest degree improbable that the planet could maintain its shape as it does unless the supposed crust were at least 2000 or 2500 miles in thickness.[7] That the solid mass of the earth must yield to this strain is certain, though the amount of deformation is so slight as to have hitherto escaped all attempts to detect it. Had the rigidity been even that of glass or of steel, the deformation would probably have been by this time detected, and the actual phenomena of precession and nutation, as well as of the tides, would then have been very sensibly diminished.[8] The conclusion is thus reached that the mass of the earth "is on the whole more rigid certainly than a continuous solid globe of glass of the same diameter."[9]

(*b.*) Argument from the tides.—The phenomena of the oceanic tides are only explicable on the theory that the earth is either solid to the centre, or possesses so thick a crust (2500 miles or more) as to give to the planet practical solidity. Sir William Thomson remarks that, "were the crust of continuous steel, and 500 kilometres thick, it would yield very nearly as much as if it were india-rubber to the deforming influences of centrifugal force, and of the sun's and moon's attractions." It would yield, indeed, so freely to these attractions "that it would simply carry the waters of the ocean up and down with it, and there would be no sensible tidal rise and fall of water relatively to land."[10] Mr. George H. Darwin has recently investigated mathematically the bodily tides of viscous and semi-elastic spheroids, and the character of the ocean tides on a yielding nucleus.[11] His results tend to increase the force of Sir William Thomson's argument, since they show that "no very considerable portion of the interior of the earth can even distantly approach the fluid condition," the effective rigidity of the whole globe being very great.

(*c.*) Argument from relative densities of melted and solid rock.—The two preceding arguments must be considered decisive against the hypothesis of a thin shell or crust covering a nucleus of molten matter. It has been further urged, however, as an objection to this hypothesis, that cold solid rock is necessarily more dense than hot melted rock, and that even if a thin crust were formed over the central molten globe it would immediately break up and the fragments would sink towards the centre.[12] Undoubtedly this would happen were the material of the earth's mass of the same density throughout. But, as has been already pointed out, the specific gravity of the interior is at least twice as much as that of the visible parts of the crust. If this difference be due, not merely to the effect of pressure, but to the presence in the interior of intensely heated metallic substances, we cannot suppose that solidified portions of such rocks as granite and the various lavas could ever have sunk into the centre of the earth, so as to build up there the honey-combed cavernous mass which might have served as a nucleus in the ultimate solidification of the whole planet. From the considerations above advanced we have seen that the earth's central mass may be plausibly conjectured to be metallic. Into this dense central mass the comparatively light crust could not sink, though its earliest formed portions would no doubt descend until they reached a stratum with specific gravity agreeing with their own, or until they were again melted.[13]

3. The ingenious suggestion of Mr. Fisher, already cited

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[1] See D. Forbes, "On the Nature of the Interior of the Earth," *Popular Science Review*, April, 1869.

[2] *Phil. Trans.*, 1839; *Researches in Physical Geology*, 1839–1842; *Brit. Assoc. Rep.*, 1847.

[3] *Comptes Rendus*, July 13, 1868.

[4] *Nature*, February 1, 1872.

[5] *Loc. cit.* p. 258.

[6] Sir W. Thomson, *Brit. Assoc. Rep.*, 1876, Sections, p. 5.

[7] Thomson, *Proc. Roy. Soc.*, April, 1862.

[8] Thomson, *loc. cit.*

[9] Thomson, *Trans. Roy. Soc. Edin.*, xxiii. 157.

[10] Thomson, *Brit. Assoc. Rep.*, 1876, Sections, p. 7.

[11] *Proc. Roy. Soc.*, No. 188, 1878.

[12] This objection has been repeatedly urged by Sir William Thomson. See *Trans. Roy. Soc. Edin.*, xxiii. 157; and *Brit. Assoc. Rep.*, 1870, Sections, p. 7.

[13] See D. Forbes, *Geol. Mag.*, vol. iv. p. 435.

(*ante*, p. 194), in favor of the existence of a possible fluid or viscous substratum between the flexible outer shell and an inner rigid nucleus, is made with the view of reconciling the requirements of physics with those facts in geology which seem to demand the existence of a mobile mass of intensely hot matter at no great depth beneath the surface. Whether it does so must be left for physicists to decide. But, on geological grounds, it may be questioned whether such a fluid substratum is needed. We must bear in mind that the land of the globe, regarding the geological structure of which alone we know anything, covers but a small part of the whole surface of the planet; that the existing continents seem from earliest times to have specially suffered from the reaction between the heated interior and the cooled exterior, forming, as it were, lines of relief from the strain of compression; and that along such lines, if the substance of the interior be everywhere just about the melting point, relief from pressure by corrugation would cause liquefaction of the matter so relieved, and its ascent towards the surface; so that evidences of volcanic action on the terrestrial ridges might be expected to occur, and to be referable to all ages. Mr. Fisher assumes the contraction of rock in cooling to be ·000007 linear for one degree Fahr.; and he argues that, as this amount would not account for the observed contraction in the crust, we must have recourse to some additional explanation, such as the escape of steam and vapors from volcanic orifices. The validity of the assertion that the amount of horizontal compression of the superficial strata is greater than the cooling of a solid earth can account for may be questioned. The violently contorted rocks indicative of great horizontal compression occur chiefly along the crests of the great terrestrial ridges where the maximum effects of corrugation were to be looked for. To the argument from climate it may be replied on the other hand, with great plausibility, that secular changes may be accounted for by the effect of the variations in the eccentricity of the earth's orbit combined with the precession of the equinoxes, as already described.

(6.) *Age of the Earth and Measures of Geological Time.*—The age of our planet is a problem which may be attacked either from the geological or physical side.

1. The geological argument rests chiefly upon the observed rates at which geological changes are being effected at the present time, and is open to the obvious preliminary objection that it assumes the existing rate of change as the measure of past revolutions—an assumption which may be entirely erroneous, for the present may be a period when all geological events march forward more slowly than they used to do. The argument proceeds on data partly of a physical and partly of an organic kind. (*a*) The physical evidence is derived from such facts as the observed rates at which the surface of a country is being lowered by rain and streams, and new sedimentary deposits are formed. These facts will be more particularly dwelt upon in later portions of this article. If we assume that the land has been worn away, and that stratified deposits have been laid down nearly at the same rate as at present, then we must admit that the stratified portion of the crust of the earth must represent a very vast period of time. Dr. Croll puts this period at not less, but possibly much more, than 60 million years. (*b*) On the other hand, human experience, so far as it goes, warrants the belief that changes in the organic world proceed with extreme slowness. Yet in the stratified rocks of the earth's crust we have abundant proof that the whole fauna and flora of the earth's surface have passed through numerous cycles of revolution—species, genera, families, appearing and disappearing many times in succession. On any supposition it must be admitted that these vicissitudes in the organic world can only have been effected with the lapse of vast periods of time, though no reliable standard seems to be available whereby these periods are to be measured. The argument from geological evidence is strongly in favor of an interval of probably not much less than 100 million years since the earliest form of life appeared upon the earth, and the oldest stratified rocks began to be laid down.

2. The argument from physics as to the age of our planet is based by Sir William Thomson upon three kinds of evidence:—(1) the internal heat and rate of cooling of the earth; (2) the tidal retardation of the earth's rotation; and (3) the origin and age of the sun's heat.

(1.) Sir William Thomson, applying Fourier's theory of thermal conductivity, pointed out some years ago (1862) that in the known rate of increase of temperature downward and beneath the surface, and the rate of loss of heat from the earth, we have a limit to the antiquity of the planet. He showed, from the data available at the time, that the superficial consolidation of the globe could not have occurred less than 20 million years ago, or the underground heat would have been greater than it is; nor more than 400 million years ago, otherwise the underground temperature would have shown no sensible increase downwards. He admitted that very wide limits were necessary. In more recently discussing the subject, he inclines rather towards the lower than the higher antiquity, but concludes that the limit, from a consideration of all the evidence, must be placed within some such period of past time as 100 millions of years.[1]

(2.) The argument from tidal retardation proceeds on the admitted fact that, owing to the friction of the tide-wave, the rotation of the earth is retarded, and is therefore much slower now than it must have been at one time. Sir William Thomson contends that had the globe become solid some ten thousand million years ago, or indeed any high antiquity beyond 100 million years, the centrifugal force due to the more rapid rotation must have given the planet a very much greater polar flattening than it actually possesses. He admits, however, that, though 100 million years ago that force must have been about 3 per cent. greater than now, yet "nothing we know regarding the figure of the earth and the disposition of land and water would justify us in saying that a body consolidated when there was more centrifugal force by 3 per cent. than now might not now be in all respects like the earth, so far as we know it at present."[2] Professor Tait, in repeating this argument, concludes that, taken in connection with the previous one, "it probably reduces the possible period which can be allowed to geologists to something less than ten millions of years."[3] He does not state, however, on what grounds he so reduces the available period, nor does he notice the objection urged by Dr. Croll that, granting the gradual submergence of the polar lands owing to the slackened speed of rotation, the subaerial denudation of the rising equatorial land might well keep pace with the effects of the oceanic subsidence, so that we cannot infer from the present form of the earth what may have been its precise amount of polar compression at the time of solidification.[4]

(3.) The third argument, based upon the age of the sun's heat, is confessedly less reliable than the two previous ones. It proceeds upon calculations as to the amount of heat which would be available by the falling together of masses from space, which gave rise by their impact to our sun. The vagueness of the data on which this argument rests may be inferred from the fact that in one passage Professor Tait places the limit of time during which the sun has been illuminating the earth as, "on the very highest computation, not more than about 15 or 20 millions of years," while, in another sentence of the same volume, he admits that, "by calculations in which there is no possibility of large error, this hypothesis [of the origin of the sun's heat by the falling together of masses of matter] is thoroughly competent to explain 100 millions of years, solar radiation at the present rate, perhaps more."[5] One hundred millions of years is probably amply sufficient for all the requirements of geology.

III. Composition of the Earth's Crust.

MINERALS AND ROCKS.

The visible and accessible portion of the earth is formed of minerals and rocks. A mineral may be classified as an inorganic body distinguished by a more or less definite chemical composition, and usually a characteristic geometrical form. A rock is an aggregate mass, sometimes of one, more commonly of two or more minerals. Upwards of 800 species of minerals and a vast number of varieties have been described. A very large proportion of these occur but rarely, and, though interesting and important to the mineralogist, do not demand the special attention of the geologist. While almost every mineral may be made to yield data of more or less geological significance, only those which enter into the composition of rock masses, or which are of frequent occurrence as accessories there, require to be familiarly known by the student of geology.

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[1] *Trans. Roy. Soc. Edin.*, xxiii. 157; *Trans. Geol. Soc. Glasgow*, iii. 25.

[2] *Trans. Geol. Soc. Glasgow*, iii. 16.

[3] *Recent Advances in Physical Science*, p. 174.

[4] *Quart. Journ. Science*, July, 1877.

[5] *Op. cit.*, pp. 153, 175.

1. Rock-Forming Minerals.

The following are the more important minerals which enter into the composition of rocks:—

Quartz (SiO_2) occurs either crystallized as rock-crystal, or non-crystalline as calcedony. In the former condition it is an essential constituent of granite, felsite, and many other igneous rocks, as well as of sandstone and numerous aqueous rocks. The non-crystallized or colloid quartz is chiefly met with in cavities and fissures of rock where it has been slowly deposited from aqueous solution. Numerous varieties of calcedony occur, as agate, carnelian, jasper, flint, chert, Lydian-stone, etc.

Felspars (silicates of alumina, with potash, soda, or lime) constitute the most abundant group of rock-forming minerals. For the purposes of the petrographer they are conveniently divided into two series—(1) the Monoclinic or Orthoclase felspars (with cleavage angles of 90°), containing from 4 to 16 per cent. of potash and usually more or less soda, sometimes as much as 10 per cent., and (2) the Triclinic or Plagioclase felspars (with oblique cleavage angles, or less than 90°), including a soda group with 8 to 12 per cent. of soda, and a lime group with 6 to 20 per cent. of lime. The felspars form a large part of most igneous rocks. By their decay they form clay, and in that condition enter largely into the composition of the argillaceous stratified rocks, such as shale, mudstone, slate, etc.

Hornblende is a meta-silicate of magnesium, with lime, iron, or manganese, and frequently alumina. The white non-aluminous varieties (tremolite, actinolite, anthophyllite, asbestos) chiefly occur as constituents of such metamorphic rocks as crystalline limestone, gneiss, etc. The black or dark green aluminous varieties enter as essential constituents into the composition of many rocks, as diorite and hornblende slate.

Augite (resembling hornblende in composition) is divisible into two groups. The pale non-aluminous varieties (diopside, sahlite, coccolite, etc.) occur under conditions like those of the pale hornblendes. The dark aluminous or common augite is abundant as an ingredient of some igneous rocks, as basalt. Allied to augite are diallage (important as a constituent of diallage-rock or gabbro), hypersthene, and bronzite. Uralite is the name of a mineral of frequent occurrence among Palæozoic rocks, having the external form of augite and the cleavage of hornblende.

Olivine (an ortho-silicate of magnesium, with part of the magnesium replaced by iron or manganese) is a conspicuous ingredient among the basalt rocks. It appears also to have been the original magnesian constituent of many rocks now altered into serpentine.

Nepheline (a silicate of alumina and soda with a little potash) takes the place of felspar in some lavas. It likewise occurs among the ejected blocks of Somma, and, in the form of elæolite, among the ancient crystalline rocks of Norway.

Leucite ($K_2Al_2Si_4O_{12}$) is a characteristic ingredient of many Tertiary and recent lavas. It has not been met with among any of the Palæozoic or Secondary igneous rocks, nor ever in association with quartz.

Haüyne and *Nosean* are two minerals allied to garnet, found in some Tertiary lavas.

Mica.—Under this general term are included several species of minerals distinguished by their basal cleavage into thin laminæ and by their splendent or silvery lustre. The non-magnesian micas include muscovite or potash-mica, the most abundant of all, and lepidolite or lithia-mica; of the magnesian micas the most important is biotite. Muscovite enters into the composition of granite, gneiss, mica-schist, micaceous sandstone, and many other rocks. Biotite is likewise abundantly distributed among the older crystalline rocks. Lepidomelane is a black mica often found in fine-grained granites. Other species are margarodite—an abundant constituent of many unctuous schists formerly called talc-schists, and Haughtonite—which, according to Heddle, is the common mica of the granites in the Scottish Highlands.

Garnet (an aluminous ortho-silicate with lime, magnesia, iron, or manganese) occurs in rhombic dodecahedrons or allied forms, and also massive in many metamorphic rocks, as mica-schist, eclogite, etc.

Epidote (a variable silicate of lime, alumina, iron, or manganese) occurs in yellow or greenish translucent crystals or crystalline masses in many of the older crystalline rocks, though seldom as an abundant constituent. It is probably always an alteration-product.

Tourmaline, in its common black variety, *schorl*, forms with quartz the rock known as schorl-rock, and occurs in some granites, gniesses, schists, and other crystalline rocks.

Zircon (silicate of zirconium) is found as a constituent of zircon-syenite, and more sparingly in other crystalline rocks.

The hydrous silicates have resulted from the alteration of the anhydrous forms. As constituents of rocks they may be grouped into two series:—(1) the aluminous, including the zeolites, and (2) the magnesian, embracing talc, chlorite, serpentine, and their allies.

Zeolites form a numerous genus of minerals distinguished usually by their boiling up before the blowpipe, owing to the escape of their water of crystallization, by their frequent pearly lustre, inferior hardness, and their occurrence in cavities and veins where they have been deposited from solution. They are found as abundant secondary products in many amygdaloids, also in altered limestones and other metamorphic rocks.

Serpentine (SiO_2,44·14; MgO,42·97; H_2O,12·89) is a dull impure, usually green, granular to compact, more rarely foliated, mineral, with a hardness of 3 to 4 or even sometimes 5. Like the other hydrous magnesian silicates it has a soapy or greasy feel. It occurs abundantly in many altered rocks as a pseudomorph after some of the anhydrous magnesian silicates, also as a massive rock forming huge beds often associated with metamorphosed limestones.

Chlorite is a general term including several minerals which agree in possessing a greenish color, soapy feel, hardness of only 2 to 2·5, and specific gravity of 2·65 to 2·85. It occurs in chlorite slate and in many rocks as an alteration-product.

Talc (SiO_2,59 to 63: MgO,30 to 33; H_2O, from a trace up to 7 per cent.) occurs in hexagonal plates or scales, cleaving readily into flexible non-elastic laminæ, but most commonly granular and massive, white to pale leek or apple-green, with marked pearly lustre on cleavage-planes. It is met with in talc-slate, also frequently in crystalline rocks as a result of the alteration of hornblende, augite, or other anhydrous magnesian silicate.

Delessite and *Saponite* are soft, green, hydrous, magnesian silicates, found as products of alteration in basalt-rocks.

Carbon occurs chiefly as beds in the form of coal, lignite, peat, etc. Graphite, however, is often met with in black or steel-grey splendent scales and granular masses in metamorphosed rocks. Anthracite also takes sometimes the form of black glancing grains or of a diffused fine black dust through certain Palæozoic formations.

Carbonates play an important part both as individual minerals and as rock-masses. The three most important are calcite, dolomite, and siderite.

Calcite (carbonite of lime) is one of the most abundant minerals. It occurs crystallized as a secondary product in most rocks which have undergone decomposition, especially where they contain silicates into the composition of which lime enters. It is also found massive as limestone, forming beds having sometimes an aggregate thickness of many hundred feet and an extent of thousands of square miles.

Dolomite (carbonate of lime and magnesia) is likewise both a product of alteration and an original formation. In the former condition it is met with crystallized as bitter-spar in many metamorphic rocks as well as in veins and cavities of unaltered formations. It occurs also as an amorphous granular substance, sometimes replacing calcite, and sometimes in vast beds or masses of original deposit.

Siderite, Chalybite, or *Spathic Iron* (carbonate of iron) occurs both crystallized and massive. In the crystallized form it is comparatively unimportant as a constituent of rocks, being then found chiefly in veins and cavities where other alteration-products have been deposited. But in its massive condition it is found mixed with clay and other impurities, and forming beds and nodules which are among the most important ores of iron.

Sulphur, though seldom occurring in large masses, is widely diffused as an accessory ingredient of rocks. It occurs crystallized or finely granular in mineral veins, in nodules of limestone, and other concretions, and in beds of limestone and marl. It also takes the form of a crust in the sublimations of volcanic vents. Its frequent association in Tertiary strata with the remains of lacustrine shells, insects, and plants shows that it has in these cases been formed at ordinary temperatures from aqueous solutions.

Sulphides, combinations of sulphur with the metals, iron, copper, lead, zinc, and a few others, have a wide distribution among rocks. Where aggregated into masses they form mineral veins. It is the iron sulphides which deserve chiefly the attention of the petrographer. They occur in two varieties—*pyrite*, crystallizing in isometric forms, and *marcasite*, in rhombic forms. The former has a remarkably extensive diffusion throughout rocks of all ages, usually as minute crystals and thin streaks, but often in concretions and more massive veins. Marcasite also is abundantly distributed, though less so than pyrite. From its greater liability to oxidation the strata through which it is diffused are apt to yield rapidly to the action of the weather, sulphuric acid and different alum compounds being produced.

Sulphates.—The most generally occurring sulphates in rocks are gypsum and barytes. *Gypsum* (hydrous sulphate of lime) in minute monoclinic prisms and macles may be obtained by the evaporation of sea-water, and in larger crystals of the same form it is found in many stratified formations. It likewise occurs as a secondary product in laminar or fibrous veins through rocks of igneous origin. Beds of gypsum, resulting from aqueous deposition, frequently appear interstratified with rock-salt and the associated products of evaporation. The anhydrous sulphate, anhydrite, likewise occurs among rock-salt deposits, but has a much more limited diffusion than gypsum. *Barytes* (sulphate of baryta) almost always occurs in veins or threads running through rocks. It is a common vein-stone in association with metallic ores.

Halite or *Rock-salt* (chloride of sodium) is more widely diffused than was formerly supposed. Microscopic research has shown its presence in the form of cubes in the minute cavities in the quartz of granite and other rocks. It occurs as scattered crystals, generally replaced by clay or some other substance, in many stratified formations. Its chief habitat, however, is in the various saliferous deposits where it takes the form of solid beds of salt.

Fluorite or *Fluor-spar* (fluoride of lime) is essentially a vein-stone, associated with metallic ores, especially with sulphides of lead and zinc. It occurs also in scattered cubes through various crystalline rocks, such as granite, gneiss, porphyrite.

Apatite (phosphate of lime, with fluorine and often chlorine) has been shown by microscopic investigation to have a very wide distribution among crystalline rocks. It occurs in fine needles or stouter hexagonal prisms in a large number of crystalline rocks, as granite, quartz-trachyte, syenite, diorite, basalt, and many others. It also occurs massive as beds among the more ancient geological formations.

Iron oxides.—These are abundantly distributed through rocks of all ages. Hæmatite (peroxide of iron) occurs crystallized in veins through crystalline rocks, also massive and earthy in beds, and sometimes in minute scales (rubin glimmer) disseminated through the minerals of many crystalline rocks. Magnetite (Fe_3O_4) has an extensive diffusion in the form of minute octohedra or grains through crystalline rocks. In some of these rocks indeed, as in basalt, it plays the part of a chief constituent. It also occurs in many metamorphic rocks both scattered in detached crystals and segregated into veins or beds. Titanoferrite or titaniferous iron is likewise found as a plentiful ingredient in many crystalline rocks, particularly among the older basalts and dolerites. Hydrous iron oxide or limonite is diffused through almost all rocks. It is the usual brown or yellow coloring substance of minerals, and may be looked for wherever rocks containing iron have been exposed to the weather. It occurs also mixed with clay and other impurities in beds, as in the bog-iron ore of lakes and marshes.

2. Rocks.

I. General Characters.

A rock may be defined as a mass of mineral matter, composed of one, more usually of several, kinds of minerals—having, as a rule, no definite external form, and liable to vary considerably in chemical composition. The crust of the earth is built up of rocks, including under this term, not only hard solid masses like granite and limestone, but even all loose incoherent deposits such as mud, soil, peat, and blown sand.

Rocks may be distinguished by external and internal characters.

i. *External Characters.*

1. *Structure*, or the manner in which the component particles have been built up into the mineral masses called rocks, is the fundamental character. Viewed broadly, there are two leading types of structure among rocks—crystalline or massive, and fragmental.

(*a.*) Crystalline—consisting of a network of interlaced crystals and crystalline particles. Sometimes those crystals are large (half an inch or more in length), as in many granites, when the texture is called coarse or macrocrystalline; in other cases they are so minute as not to be discernible with the naked eye, when the texture is microcrystalline or compact. While the crystalline structure is particularly characteristic of rocks which have crystallized from igneous fusion, it is not altogether peculiar to them. It may be produced by chemical deposit from aqueous solutions, or it may be developed in rocks previously granular by chemical infiltration and metamorphism.

Under the head of crystalline it is usual to include the *glassy* or *vitreous* structure. Rocks possessing this character are natural glasses produced by igneous fusion, such as obsidian and pitchstone. In most of these rocks, however, the process of devitrification may be observed; the glass has evidently become more and more stony as it cooled, by the appearance in it of small spherules, or hairs, or crystals, until in some cases it has become entirely lithoid. These stages are best studied with the microscope, and belong to the internal rather than the external characters.

When larger crystals than those of the compact base are scattered through a rock, the texture is said to be *porphyritic.* Many rocks, when in a melted condition, have had a cellular texture given to them by their imprisoned steam, like the open, cavernous texture of ill-baked bread. Several varieties of this texture are distinguished—as *vesicular*, when there are comparatively few and small holes; *scoriaceous*, when the cavities occupy about as much space as the solid part, and are of very unequal sizes and forms; *pumiceous*, when the cells are much more numerous than the solid portion, and when, consequently, a piece of the rock may even float in water; *amygdaloidal*, when by subsequent infiltration the cells have been filled up with concretions of calcite, calcedony, zeolite, etc., which, from the elongated flattened form of the cells, are frequently almond-shaped.

Foliated rocks have their crystalline ingredients arranged in more or less defined layers, which usually inosculate. *Schistose* rocks are those where the foliated arrangement has been so produced that the rock splits into rude rough laminæ or plates.

Most of the crystalline rocks have resulted from igneous fusion. Some, like limestone, have been formed as deposits in water. The foliated rocks are generally believed to have acquired their peculiar character from the re-crystallization of their ingredients along original divisional planes, such as the lines of deposit.

(*b.*) Fragmental or Clastic.—These are all derivative from previously formed masses. They vary in texture from coarse masses consisting of accumulated blocks, several feet or even yards in length, to such fine aggregates as only show their secondary origin by microscopic investigation. They are said to be *conglomeratic* when they consist of beds of rounded water-worn pebbles like compacted gravel; *agglomeratic*, when the blocks are large, rounded, or subangular and tumultuously thrown together; *brecciated*, when the fragments are angular and not water-worn. Most clastic rocks are *bedded*, that is, arranged in beds or layers. Each bed may consist of many thin layers or laminæ, which, when they enable the rock to split up into thin leaves, give what is called a *shaly* or *fissile* structure. Many fragmental rocks show a *concretionary* structure. When the concretions are like the roe of a fish, and of a calcareous nature, they form the *oolitic* structure; when of larger size, like peas, they give the *pisolitic* structure. There is often also a crystalline structure developed in rocks originally quite fragmental; many limestones, for example, made up originally of water-worn fragments of shells, corals, etc., slowly acquire a crystalline character from the action of percolating and slightly acidulous water. The action of rain on the exposed parts of a recent coral reef produces this change in the dead coral.

2. *Color.*—This character varies so much even in the same rock, according to the freshness of the surface examined, that it possesses but a subordinate value as a means of discriminating rocks. Nevertheless, when cautiously used, it may be made to afford valuable indications as to the probable nature and composition of rocks. It is in this respect always desirable to compare a freshly-broken with a weathered piece of the rock. *White* indicates usually the absence or comparatively small amount of the metallic oxides, especially iron. It may either be the original color of the rock, as in chalk and calc-sinter, or may be developed by weathering, as the white crust on flints and on many porphyries. *Black* seldom occurs on a weathered surface of rock. Its existence may be due either to the presence of carbon, when weathering will not change it much, or to some iron-oxide (magnetite chiefly), or some silicate rich in iron (as hornblende and augite). Many rocks (basalts and dolerites particularly) which look quite black on a fresh surface, become red, brown, or yellow on exposure. *Yellow*, as a dull earthy coloring matter, almost always indicates the presence of hydrated peroxide of iron. Bright, metallic, gold-like yellow is usually that of iron-sulphide. *Brown* occurs as the original color in some carbonaceous rocks (lignite), and ferruginous beds (bog-iron-ore, clay-ironstone, etc.). It very generally, on weathered surfaces, points to the oxidation and hydration of minerals containing iron. *Red*, in the vast majority of cases, is due to the presence of granular peroxide of iron. This mineral gives dark blood-red to pale flesh-red tints. As it is liable, however, to hydration, these hues are often mixed with brown and yellow. *Green*,

as the prevailing tint of rocks, occurs among metamorphic schists, when its presence is usually due to some of the hydrous magnesian silicates (chlorite, talc, serpentine). It occurs also among the igneous rocks, especially those of older geological formations, where some of the hornblende, olivine, or other similar silicates have been altered. Among the sedimentary rocks it is principally due to the protosilicate of iron in glauconite. Carbonate of copper colors some rocks a bright emerald or verdigris green. The mottled character so common among many stratified rocks is frequently traceable to unequal weathering, some portions being more oxidized than others; while some, on the other hand, become deoxidized from the reducing action of decaying organic matter. To the latter cause may be attributed the circular green spots so often found among red strata.

3. *Lustre*, as an external character of rocks, does not possess the value which it has among minerals. In most rocks the granular texture prevents the appearance of any distinct lustre. Where a rock shows a completely vitreous lustre it will usually be found to consist of a volcanic glass. A splendent semi-metallic lustre may often be observed upon the foliation planes of schistose rocks and upon the laminæ of micaceous sandstones. As this silvery lustre is almost invariably due to the presence of mica, it is commonly called distinctively micaceous. A metallic lustre is met with sometimes in beds of anthracite; more usually its occurrence among rocks indicates the presence of metallic oxides or sulphides.

4. *Hardness and Frangibility.*—A rock which can easily be scratched with the nail is almost always much decomposed, though some chloritic and talcose schists are soft enough to be thus affected. Compact rocks which can easily be scratched with the knife, and are apparently not decomposed, may be limestones, or other fragmental masses. Crystalline rocks, as a rule, cannot be scratched with the knife unless considerable force be used. The ease with which a rock may be broken is the measure of its frangibility. Most rocks break most easily in one direction; attention to this point will sometimes throw light upon their internal structure.

5. *Fracture* is the surface produced when a rock is split or broken, and depends for its character upon the texture of the mass. Finely granular compact rocks are apt to break with a *splintery* fracture where wedge-shaped plates adhere by their thicker ends to, and lie parallel with, the general surface. When the rock breaks off into concave and convex rounded shell-like surfaces, the fracture is said to be conchoidal, as may be seen in obsidian and other vitreous rocks, and in exceedingly compact limestones. The fracture may also be *foliated*, *slaty*, or *shaly*, according to the structure of the rock. Many black, opaque, compact rocks are translucent on the thin edges of fracture, and afford there, with the aid of a lens, a glimpse of their internal composition.

6. *Feel.*—Practice enables a geologist to discriminate some rocks by the feel of their weathered or fresh surfaces. The hydrous magnesian silicates, as already mentioned, have a marked soapy or greasy feeling under the fingers. Some micaceous schists, with margarodite or an allied mica, likewise exhibit the same character.

7. *Smell.*—Many rocks when freshly broken emit distinctive odors. Those containing volatile hydrocarbons give sometimes an appreciable *bituminous* odor, as is the case with some of the dolerites, which in central Scotland have been intruded through coal-seams and carbonaceous shales. Limestones have often a *fetid* odor; rocks full of decomposing sulphides are apt to give a *sulphurous* odor; those which are highly siliceous yield, on being struck, an *empyreumatic* odor. It is very characteristic of argillaceous rocks to emit a strong earthy smell when breathed upon.

8. *Specific gravity* is an important character among rocks as among minerals. It varies from 0·6 among the hydrocarbon compounds to 3·1 among the basalts. As already stated, the average specific gravity of the rocks of the earth's crust may be taken to be about 2·5, or from that to 3·0.

9. *Magnetism* is a distinguishing feature of many igneous and some metamorphic rocks. In some cases it exists in such development as powerfully to affect the magnetic needle, so that observations with that instrument among rocks of this character are deceptive. But even when much more sparingly present, the existence of magnetic iron in a rock may be shown by reducing the rock to powder in an agate mortar, washing carefully the triturated powder, and drying the heavy residue, from which grains of magnetite may be extracted with a magnet. This may be done with any basalt.

ii. *Internal Characters.*

These are revealed chiefly by the microscope and chemical analysis. By the former we learn what are the component minerals of a rock, how they are built up into its mass, and what changes they have undergone. By the latter we are taught the chemical constitution of rocks, and are enabled to bring into close relations rocks which have externally no resemblance to each other, or, on the other hand, to show that rocks externally similar are chemically very distinct.

1. *Microscopic Examination.*—This method of inquiry has made great advances during the last 20 years, especially from the labors of German petrographers. Slices are cut from the rocks to be examined, and after being polished on one side with great care, are cemented by that side with Canada balsam to glass, and are then ground down until they attain the requisite transparency, In this way the minutest features in the structure of a rock can be leisurely studied. By the application of polarized light to these thin slices a marvellously delicate method of petrographical analysis is afforded.

Among the igneous rocks three leading types of microscopic structure have been established, chiefly through the researches of Professor Zirkel of Leipsic:—(1.) Purely-crystalline.—Granite (fig. 1) is a good example, consisting, as it does, entirely of crystals interlaced with each other. (2.) Half-crystalline.—In this division, which embraces most of the eruptive masses, the rocks consist of a non-crystalline amorphous matrix with crystals scattered through it. This matrix may be either (*a*) entirely glassy (figs. 2 and 3); (*b*) partly devitrified through separation of peculiar little granules and needles which are not "microlites" of the component parts of the rock; (*c*) an aggregation of such little granules, needles, and hairs, between which no glass, or almost none, appears (microcrystallitic); or (*d*) microfelsitic, nearly related to the two previous groups, and consisting of an amorphous mass marked usually with indefinite or half-effaced granules and filaments. (3.) Non-crystalline.—Rocks of this class are much less common than those of the other two. In their most typical condition they consist entirely of a non-crystallized or amorphous (*nicht individualisirten*) substance, sometimes glassy and sometimes microfelsitic.

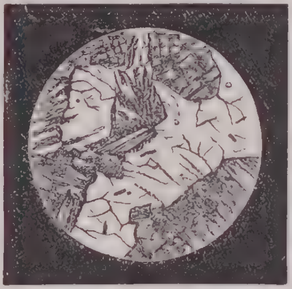

FIG. 1.—*Microscopic Structure of Rocks*—Purely crystalline—Section of Granite (× 18 diameter). The white mineral is quartz; that with shading, orthoclase. Some flakes of mica are shown as striated forms.

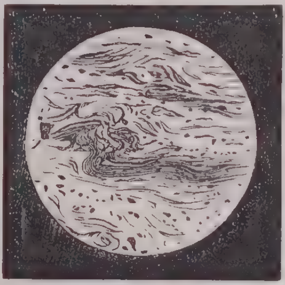

FIG. 2.—Microscopic Structure of Obsidian. A volcanic glass, with numerous microlites, which have been drawn out in a general direction during the flow of the melted rock (fluid-structure). (× 18 diameter.)

Rocks really formed of compacted sediment become sometimes so close-grained that their origin may not be apparent to the naked eye. Their truly derivative character is well brought out by the microscope. In fig. 4, for example, the structure of a piece of fine greywacke is shown. It will be observed that the component particles are not crystals, but broken and more or less rounded fragments of different minerals. The larger white pieces are quartz, the darker portions consist of granules of slate, felspar, and other substances, with a little siliceous ferruginous cement. Many exceedingly compact and even flinty argillaceous rocks are in this way shown by microscopic examination to be formed of water-worn particles.

Rocks which have been so affected by subsequent changes as to acquire a new crystalline character, and to receive the name Metamorphic, exhibit many characteristic features of structure under the microscope. Limestones, for example, which have been altered into saccharoid marble are found to consist of crystalline grains of calcite, showing the characteristic cleavage of that mineral (fig. 5). The foliated rocks (schists) show a curious blending of the characters of igneous and sedimentary rocks. Thus they have often a distinctly granular structure resembling that of sedimentary deposits, with, at the same time, an arrangement of the micaceous folia reminding us of the fluid structure of igneous rocks. In fig. 6, for instance, the quartz-grains are to be observed in layers separated by folia of mica which curve and twist like the microlites in an obsidian (compare fig. 2).

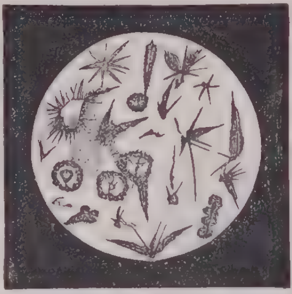

Fig. 3.—Microscopic Structure of Pitchstone. A glassy base, with numerous feathered and needle-shaped microlites, and a sanidine crystal.

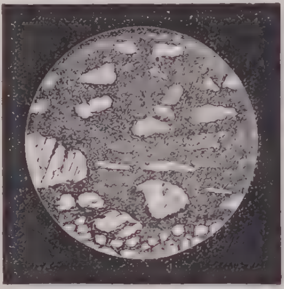

Fig. 4.—Microscopic Structure of a fragmental rock. Greywacke.

Much light has been cast on the origin and history of igneous rocks by microscopic investigation. It is easy, for example, to see in what order the several mineral components have crystallized out of the original glass. Thus in basalt the magnetite has appeared before the augite, in which it has been abundantly enclosed. Again, the movement of the still liquid or viscid rock, when many of its crystals had already been produced, is beautifully shown by the "fluid structure" (fig. 2), where minor crystals and particles are drawn into curving lines which bend round the large crystals, and also by the frequent fracture of the larger crystals and the insertion of portions of the general ground-mass of the rock between the separated pieces. That intensely saline water was present during the formation of many crystalline rocks is proved by the presence in their crystals of minute cavities filled with fluid and containing cubes of halite (common salt). Liquid carbonic acid has been observed in such cavities.

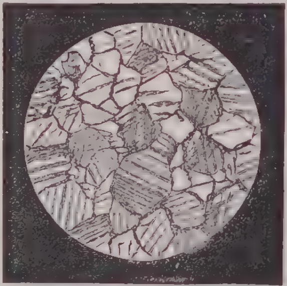

Fig. 5.—Microscopic Structure of Saccharoid white Marble (Carrara).

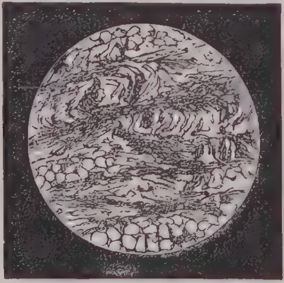

Fig. 6.—Microscopic Structure of Mica-schist.

Most interesting and important information is likewise afforded by the microscope regarding the subsequent changes which rocks have undergone through the influence chiefly of percolating water. Every gradation of alteration from the fresh mineral to its complete pseudomorph may be observed. In this way many serpentines have been shown to have been originally olivine rocks. It can be seen, too, how certain minerals decay, and to what products their alteration gives rise, even when the general mass of the rock looks to the eye still tolerably fresh. There can be little doubt that the application of microscopic analysis is destined to throw much light upon both the formation and the subsequent history of the sedimentary rocks. These have not yet been so sedulously explored as the igneous groups. The obscure subject of metamorphism is especially open to elucidation by the microscopic method.[1]

2. *Chemical Analysis.*—This method of investigation must supplement the work of the microscope. A mere chemical analysis gives the ultimate chemical constitution of a rock, but may afford little clue to its mineral structure, which can only be thoroughly examined by means of the microscopic method. On the other hand many rocks do not allow of satisfactory determination of their constitution by means of the microscope. For these, chemical analysis is, of course, indispensable. But our knowledge of no rock can be considered complete until the rock has been subjected to both processes of investigation.

II. Classification and Description.

A precise yet convenient classification of rocks is still required. We may adopt chemical characters as the basis of arrangement, and group rocks according as they may be sulphates, carbonates, silicates, etc.; but in so doing we place together rocks which, from a geological point of view, have no real affinity. Again, we may select mineralogical composition as the groundwork of the classification; but in this case also great violence may be done in the geological relationships of the rocks. In many respects the long established geological arrangement according to manner of production is a useful one—igneous, aqueous, and metamorphic rocks. There is, of course, the obvious objection to it that it starts upon a preconceived theory of the origin of the rocks, and this objection must be admitted to be serious. Every year, however, is diminishing its force by making us more certain of the mode of formation of different rocks; and, probably, some modification of it will in the end be very generally adopted. In the mean time the most eligible course seems to be to choose a scheme of arrangement which, confessedly imperfect and temporary, shall recognize at once the mineralogical, chemical, and geological relations of the rocks. With this object the following classification will be adopted here:—

I. *Crystalline and Glassy Non-Fragmental Rocks.*
  1. Simple Rocks (composed of one mineral substance),—chiefly of aqueous rocks formed from chemical precipitates.
  2. Compound Rocks (composed of two or more minerals), including (*a*) Massive series, embracing the various igneous rocks, as granite and lava, and (*b*) Schistose series, including all the crystalline schists and most of the so-called metamorphic rocks.

II. *Fragmental or Clastic Rocks,* including (*a*) Gravel and Sand Rocks, (*b*) Clay Rocks, (*c*) Plant-formed Rocks, (*d*) Rocks formed from animal remains, (*e*) Volcanic Agglomerates and Tuffs.

I. *Crystalline and Glassy or Non-Fragmental Rocks.*

The great majority of these rocks are original formations; that is, they have not been palpably derived from the destruction of pre-existing rocks, as in the case of the fragmental series. They include all chemical precipitates, whether these possess a distinctly crystalline or a dull granular texture, all rocks which have consolidated from igneous fusion, and all the schistose and metamorphic rocks which, whatever may have been their original character, now possess a crystalline or foliated structure.

1. *Simple Rocks.*

Limestone is a mass of carbonate of lime, either nearly pure or mixed with clay or other impurity. Few rocks vary more in texture and composition. It may be a hard flinty close-grained mass, breaking with a splintery or conchoidal fracture; or a crystalline rock built up of fine crystals of calcite and resembling loaf sugar in color and texture (fig. 5); or a dull earthy friable chalk-like deposit; or a compact massive finely-granular rock resembling a close-grained sandstone or freestone. The colors, too, vary extensively, the most common being shades of blue-grey and cream-color passing into white. Some limestones are highly siliceous, the calcarous matter having been accompanied with silica in the act of deposition; others are argillaceous, sandy, ferruginous, dolomitic, or bituminous. To some of these varieties particular names have been assigned:—*Oolite*, a granular limestone built up of small roe-like grains, each of which consists of concentric coats of lime; *Pisolite*, an oolitic or pisolitic limestone where the grains are as large as peas; *Travertine* (*calcareous-tufa*), the material deposited by calcareous springs, usually white or yellowish, varying in texture from a soft chalk-like substance or marl to a compact building-stone; *Stalactite*, the calcareous pendent deposit formed on the roofs of caverns, vaults, bridges, etc. The water from which the hanging lime-icicles are derived drips to the floor, and on further evaporation there gives rise to the crust-like deposit known as *stalagmite*. *Hydraulic limestone* contains sufficient silica (and usually alumina) that when it is burnt and subsequently mixed with water, a compound containing silicate of calcium is formed, which has the property of "setting" or hardening under water. Limestones containing perhaps as much as 25 per cent. of silica, alumina, iron, etc., which in themselves would be unsuitable for many of the ordinary purposes for which limestones are used, can be used for making hydraulic mortar. These limestones occur sometimes in beds like those in the Lias of Lyme Regis, sometimes in nodules like those of Sheppey, from which Roman cement is made. *Cement-stone* is the name given to many pale dull ferruginous limestones, which contain an admixture of clay, and some of which can be profitably used for making hydraulic mortar or cement. *Fetid limestone* (*stinkstein, swinestone*) gives off a fetid smell, like that of sulphuretted hydrogen gas, when struck with a hammer. In some cases, as in that at North Berwick, the rock seems to have been deposited by volcanic springs containing decomposable sulphides as well as lime. In other instances the odor may be connected with the decomposition of organic matter. In some quarries in the Carboniferous Limestone of Ireland, as mentioned by Mr. Jukes, the freshly broken rock may be smelt at a distance of a hundred yards when the men are at work, and occasionally the stench becomes so strong that the workmen are sickened by it and require to leave off work for a time. *Cornstone* is an arenaceous or siliceous limestone particularly characteristic of some of the Palæozoic red sandstone formations. *Rottenstone* is a decomposed siliceous limestone from which most or all of the lime has been removed, leaving a siliceous skeleton of the rock. A similar decomposition takes place in some ferruginous limestone with the result of leaving a yellow skeleton of ochre.

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[1] The reader will find the subject fully treated in Zirkel's *Mikroskopische Beschaffenheit der Mineralien und Gesteine* (1873), Rosenbusch's *Mikroskopische Physiographe der Mineralien und Gesteine* (1873–7), Vogelsang's *Krystalliten* (1874), and De la Vallée and Renard, *Sur les roches plutoniennes de la Belgique* (Acad. Royale de Belgique, 1876).

Marble is limestone which has acquired a granular crystalline structure. Ordinary statuary marble is a familiar example of this rock. It is white, fine-grained, composed of minute crystalline granules of calcite, and resembles loaf-sugar, whence the term "saccharoid" often applied to it (fig. 5). Fine silvery scales of mica or talc may often be noticed even in the purest marble. Some limestones associated with gneiss and schist are peculiarly rich in minerals,—tremolite, actinolite, anthophyllite, zoisite, and many other species occurring there, often in great abundance. Many varieties of color and texture occur among these limestones, as may be seen in the numerous kinds of ornamental marble.

Dolomite (*Magnesian Limestone*) is a massive formation of the carbonates of lime and magnesia, commonly associated with gypsum, rock-salt, and other results of the evaporation of saturated saline waters. It is dull granular to finely crystalline in texture, sometimes full of cavities lined with crystals of dolomite, sometimes aggregated into botryoidal, mammillated, and other concretionary forms. Dolomite also occurs as the result of a chemical transformation of ordinary limestone, carbonate of magnesia replacing carbonate of lime. This process, known as *dolomitization*, was largely insisted on by Von Buch and has been discussed by Bischof. The metamorphic variety of the rock is generally quite crystalline, resembling saccharoid marble in texture, and sometimes even in color, though yellowish tints are apt to predominate. As a proof of the dolomitization or conversion of limestone into dolomite the fact may be noticed that fossil shells, and other organisms consisting originally of calcite, have been altered into dolomite. On a small scale a similar change may be observed in a limestone where it is traversed by some igneous dyke. Even along the vertical joints of limestone where no igneous matter has penetrated, and where percolating water has probably been the only agent of change, the limestone is changed for some distance on either side into a dull yellow dolomite, locally termed "dunstone."

Gypsum occurs as a rock in the form of beds and concretions as well as in strings and veins. It is associated with red strata, often with dolomite, rock-salt, and anhydrite.

Rock-salt, massive chloride of sodium, occurs in beds sometimes 60 to 90 feet in thickness, rudely crystalline, usually stained red from an admixture of red sediment, like that of the red clays and sandstones among which the salt-beds occur.

Ironstone.—Besides the iron ores met with in veins associated with other accompaniments of metalliferous lodes, there are many which were doubtless formed as chemical precipitates on the floors of lakes and other sheets of water. Some of these deposits (either peroxide or carbonate of the protoxide of iron) arise from precipitation in water or on moist ground where organic matter, especially of vegetable origin, has decomposed. The hard crust of hydrous peroxide of iron which forms under wet or boggy soil (*moorband pan, bog-iron-ore*) is an example of such a deposit now in course of formation. Where the peroxide has been reduced and become carbonate, it occurs in beds or nodules usually mixed with a variable proportion of clay (*clay ironstone*), and sometimes with a good deal of carbonaceous matter from associated vegetation (*blackband ironstone*). Clay iron-ore is one of the most valuable ores of the metal, and occurs largely in beds and nodules in the Carboniferous system, as well as in parts of the Jurassic series in Britain. In some of the oldest geological formations extensive beds occur of hæmatite and magnetite.

Serpentine.—This mineral occurs massive, forming large bands of rock. In some places it may have been an original deposit from oceanic water, comparable to the glauconite found filling the chambers of *Foraminifera*, and occurring extensively both in old geological formations and on the present ocean-floor. The serpentines associated with the gneisses and other crystalline rocks have had this origin assigned to them by Sterry Hunt. There can be no doubt, however, that many, probably most, serpentines are the results of the alteration of pre-existing rocks. Tschermak pointed out that much serpentine has been produced by the hydration and alteration of olivine, and this view has been confirmed by illustrations from all parts of the world. In many serpentines the forms of the original crystals of olivine may still be detected. Hence the difficulty in understanding how there could be intrusive masses of serpentine—a hydrated magnesian silicate—is now removed, for we see that the original olivine rocks may have been intruded as molten masses which would preserve their external characters as eruptive rocks though undergoing an internal conversion into serpentine. With many Palæozoic limestones, and more particularly with the crystalline beds which occur among the schistose rocks, serpentine is frequently associated. Some of this may represent the result of an alteration of dolomite, though, as above stated, it may with more probability be connected with some original oceanic deposit of a magnesian silicate.

2. *Compound Rocks.*

Nearly the whole of the rocks in this division consist of two or more minerals. A few examples occur, however, where, at least in some parts of their mass, the rocks are formed of only one mineral. Strictly speaking, these exceptions should be placed among the simple rocks. But they are so closely linked with the compound masses that to separate them would do much more violence to geological continuity than any harm likely to arise from the present arrangement. Besides, a rock which, like obsidian, may appear quite simple at one place may, at a short distance, show the presence of other minerals entitling it to a place among the compound rocks.

(*a.*) *Massive Rocks.*—This important division consists almost entirely of rocks which have resulted from igneous fusion. Considered from a chemical point of view, these rocks may be described as mixtures in different proportions of silicates of alumina, magnesia, lime, potash, and soda, usually with magnetic iron and phosphate of lime, and, in a great group of rocks, with an excess of silicic acid, existing as free quartz. Taking this last feature as a basis of arrangement, some petrographers have proposed to divide the igneous rocks into an acid group, including such rocks as granite, quartz-porphyry, and quartz-trachyte, where the percentage of silica ranges from 60 to 75, and a basic group, typified by such rocks as leucite-lava and basalt, where the proportion of silica is only about 50 per cent.

In the vast majority of igneous rocks the chief silicate is a felspar,—the number of rocks where the felspar is represented by another silicate (as leucite or nepheline) being comparatively few and unimportant. As the felspars group themselves into two great series, the monoclinic or orthoclase, and the triclinic or plagioclase, the former with, on the whole, a preponderance of silica, and as the minerals occur under tolerably distinct and definite conditions, it has been proposed to divide the felspar-bearing massive rocks into two series,—(1) the orthoclase rocks, having orthoclase as their chief silicate, and often with free silica in excess, and (2) the plagioclase rocks, where the chief silicate is some species of triclinic felspar. The former series corresponds generally to the acid group above mentioned, while the plagioclase rocks are on the whole decidedly basic. It has been objected to this arrangement that the so-called plagioclase felspars are in reality very distinct minerals, with proportions of silica, ranging from 43 to 69 per cent.; soda from 0 to 12; and lime from 0 to 20. But in the state of minute subdivision in which the minerals occur in many igneous rocks, it is often scarcely possible to determine the species of felspar.

Without attempting here any formal classification, according either to relative proportion of silica or to the distinguishing felspar, it may be sufficient to arrange the following description of the massive rocks in a continuous series, with the most typical acid or orthoclase rocks at the beginning, and the basic felsparless rocks at the end.

Granite is a thoroughly crystalline-granular admixture of felspar, mica, and quartz. The felspar is chiefly orthoclase, but striated triclinic felspars (as oligoclase and albite) may often be observed in smaller quantity. The mica in most granites seems to be the potash or muscovite variety, usually of a white silvery aspect; sometimes it is dark brown or black, and belongs to biotite (magnesian mica) or lepidomelane. Dr. Heddle finds the common mica of the granites in the Scottish Highlands to be a new variety, which he has called haughtonite. The quartz may be observed to form a kind of paste or magma wrapping round the other ingredients (see fig. 1). It is only in cavities of the granite that the component minerals occur as independent well-formed crystals, and there too the accessory minerals are chiefly found, such as beryl, topaz, tourmaline, etc.

Microscopic examination of granite by Sorby and other later observers has shown that the quartz is full of cavities containing liquid, sometimes in such numbers as to amount to a thousand millions in a cubic inch. The liquid in these cavities appears usually to be water containing chlorides of soda and potash, with sulphates of potash, soda, and lime.

Granites vary in texture from extremely coarse crystalline masses, with crystals an inch or more in length, to fine granular rocks which pass into elvanite or felsite. They are sometimes porphyritic, with large scattered orthoclase crystals. The variety known as graphic granite is distinguished by the way in which the quartz is crystallized through the felspar in imperfect or hemihedral shells arranged with their longer axes generally parallel, so as to produce on cross fracture the appearance of Hebrew characters.

The mean of eleven analyses of granites made by Dr. Haughton gave the following average composition: Silica, 72·07; alumina, 14·81; peroxide of iron, 2·22; potash, 5·11; soda, 2.79; lime, 1·63; magnesia, 0·33; loss by ignition, 1·09; total, 100·05,—with a mean specific gravity of 2·66.

Granite occurs (1) as an eruptive rock, forming huge bosses, which rise through other formations both stratified and unstratified, and sending out veins into the surrounding and overlying rocks, which usually show evidence of much alteration as they approach the granite; (2) connected with true volcanic rocks, and forming probably the lower portions of masses which flowed out at the surface as lavas; and (3) in the heart of mountain chains and elsewhere, so intimately connected with metamorphic rocks as to suggest that it is itself a final stage of the metamorphism of rocks. Granite is thus a decidedly *plutonic* rock; that is, it has consolidated at some depth beneath the surface, and in this respect differs from the superficial *volcanic* rocks, such as lavas, which have flowed out above ground from volcanic orifices.

Quartz-porphyry, Felsite-porphyry, Felstone, Felsite.—These names are given to different conditions under which orthoclase and quartz unite to form a massive eruptive rock. When the quartz forms well-marked grains, blebs, or crystals, the rock is a quartz-porphyry; when the felspar and quartz are so intimately mixed as to appear to the eye as a homogeneous matrix, the rock is called by one of the other epithets.

The base of the rock, whether in the form of quartz-porphyry or felstone, is usually exceedingly compact or even flinty in texture. Under the microscope it shows the microfelsitic character, the true nature and origin of which is still the subject of much discussion among petrographers. When the quartz occurs in forms visible to the naked eye it usually appears as round or irregular grains, varying in size from mere specks up to pieces as large as a pea or larger. Less frequently it occurs definitely crystallized, and sometimes in perfect doubly terminated pyramids.

Besides the orthoclase of the diffused matrix, this mineral occurs in crystalline fragments and crystals, which sometimes reach to the length of an inch or more, so as to give a markedly porphyritic character to the rock. Triclinic felspars usually occur, though perhaps not so commonly as in granite. Mica and hornblende are among the most frequent of the minerals which accompany the two essential constituents, while apatite, magnetite, and pyrite are not infrequent accessories.

The colors of quartz-porphyry and felstone depend chiefly upon those of the felspar,—flesh-red, reddish-brown, purple, yellow, bluish or slate grey, and even white, being in different places characteristic. The presence of much mica or hornblende gives dark grey, brown, or greenish tints. It will be observed in this, as in other rocks containing much felspar, that the color, besides depending on the hue of that mineral, is greatly regulated by the nature and stage of decomposition. A rock weathering externally with a pale yellow or white crust may be found to be quite dark in the central undecayed portion.

The flesh-red quartz-porphyry of Dobritz, near Meissen, in Saxony, was found by Rentzsch to have the following chemical composition: Silica, 76·92; alumina, 12·89; potash, 4·27; soda, 0·68; lime, 0·68; magnesia, 0·98; oxide of iron, 1·15; water, 1·97; total, 99·54,—specific gravity, 2·49.

Besides the differences of color already referred to, minor varieties in composition are produced by the relative abundance and size of the felspar crystals, and by the presence of mica (*micaceous quartz-porphyry, micaceous felstone,* or *felsite*), hornblende (*hornblendic quartz-porphyry* or *felstone*), or other accessory ingredient. The variety called minette consists of a felsite base with crystals of orthoclase and dark mica, and may be regarded as a micaceous felstone, bearing the same relation to the acid felspar rocks (felstones) that mica-porphyrite does to the more basic forms (porphyrites). When the base is very compact, and the felspar-crystals well defined and of a different color from the base, the rock sometimes takes a good polish, and may be used with effect as an ornamental stone. In ordinary language such a stone is classed with the "marbles," under the name of "porphyry."

Closely related to the quartz-porphyries and felstones, of which, indeed, it can be regarded only as a variety, comes the rock known as *elvan* or *elvanite*. This is a Cornish term for a crystalline granular mixture of quartz and orthoclase, forming veins which proceed from granite, or occur only in its neighborhood and are evidently associated with it. It forms an immediate stage between granite and quartz-porphyry.

Quartz-porphyry and the other varieties included under this species occur (1) with plutonic rocks, as eruptive bosses or veins, often associated with granite, from which, indeed, the elvanite, as just stated, may be seen to proceed directly; of frequent occurrence also as veins and irregularly intruded masses among highly convoluted rocks, especially when these have been more or less metamorphosed; (2) in the chimneys of old volcanic orifices, forming there the "neck" or plug by which the vent is filled up; and (3) as truly volcanic rocks which have been erupted at the surface in the form of flows of lava, either (*a*) submarine as in the felstones of Wales, associated with the marine Lower Silurian rocks, or (*b*) subaerial, as probably in the quartz-porphyry of Arran, and perhaps in the series of the "green-slates and porphyries" of the Silurian system in Cumberland, which Professor Ramsay has conjectured to be the products of a subaerial volcano.

Pitchstone (*Retinite*) is a glassy rock, having a pitch-like or resinous lustre, and a black or dark-green color ranging through shades of green, brown, and yellow to nearly white. It is essentially an orthoclase rock, and may be regarded as the natural glass of many of the more granular or crystalline orthoclase rocks, such as the quartz-porphyries or felsites. Examined microscopically, it is found to consist of glass in which are diffused, in greater or less abundance, hair-like microlites, angular or irregular grains, or more definitely formed crystals. The pitchstone of Corriegills, in the island of Arran, presents abundant green, feathery, and dendritic microlites of a pyroxenic character (see fig. 3).

According to Durocher the mean composition of pitchstone is—silica, 70·6; alumina, 15·0; potash, 1·6; soda, 2·4; lime, 1·2; magnesia, 0·6; oxides of iron and manganese, 2·6; loss by ignition, 6·0. The mean specific gravity is given as 2·34.

Pitchstone is found either as intrusive dykes, veins, or bosses, probably in close connection with former volcanic activity, or in sheets which, like the porphyritic pitchstone of the Isle of Eigg, flowed out at the surface as lava-streams.

Liparite (*Rhyolite, Quartz-trachyte*) is an orthoclase rock containing an excess of silica which usually appears in distinct grains or in doubly terminated pyramids. The orthoclase, which is of the variety termed sanidine, is sparingly accompanied with triclinic felspar. Other frequent ingredients are magnesia-mica, hornblende, augite, apatite, and magnetite. Considerable diversity exists in the texture of this rock. Some varieties are coarse and granitoid in character, and are regarded by some petrographers as the equivalents in Tertiary times of the granite of older geological periods. From this crystalline aspect intermediate varieties may be obtained like the quartz-porphyries, passing by degrees into more or less distinctly vitreous rocks. Throughout all these gradations, however, a characteristic ground mass can be seen under the microscope having a glassy, enamel-like, or porcellanous character. An analysis by Vom Rath of a rhyolite from the Euganean Hills gave—silica, 76·03; alumina, 13·32; soda, 5·29; potash, 3·83; protoxide of iron, 1·74; magnesia, 0·30; lime, 0·85; loss, 0·32; total, 101·68,—specific gravity, 2·553. Liparite is a volcanic rock of late geological date occurring in the form of erupted lavas.

Obsidian is a volcanic glass representing the vitreous condition of a highly silicated sanidine rock, such as liparite. It resembles bottle glass, having a perfect conchoidal fracture, and breaking into sharp splinters, semi-transparent or translucent at the edges. The colors of the rock are black, brown, or greyish-green, rarely yellow, blue, or red, but not infrequently streaked or banded with paler and darker lines. When a thin slice of obsidian is prepared for the microscope it is found to be very pale yellow, grey, or nearly colorless. On being magnified it shows that the usual dark colors are almost always produced by the presence of minute crystals, needles, and black hair-like bodies. In rare examples the obsidian appears as a perfect glass without any foreign admixture. The minute crystals and hair-like bodies sometimes so increase in abundance as to make the rock lose the aspect of a glass and assume that of a dull flint-like or enamel-like stone. This devitrification can only be properly studied with the microscope. Again little granules (*spherulites*) of a dull grey enamel (pearlstone) appear, and in some parts of the rock so abundantly as to alter its character and convert it from obsidian into pearlstone. The average chemical composition of the rock is—silica, 71·0; alumina, 13·8; potash, 4·0; soda, 5·2; lime, 1·1; magnesia, 0·6; oxides of iron and manganese, 3·7; loss, 0·6; total, 100·0, —mean specific gravity, 2·40. Obsidian occurs as a product of the volcanoes of late geological periods.

Pearlstone (*Perlite*) is another vitreous condition of sanidine lava. As its name denotes, it consists of vitreous or enamel-like globules, occasionally assuming polygonal forms by mutual pressure. These globules sometimes constitute the entire rock, their outer portions shading off into each other so as to form a compact mass; in other cases they are separated by and cemented in a compact glass or enamel. They consist of successive very thin shells, which, in a transverse section, are seen as concentric rings, usually full of the same kind of hair-like crystallites and crystals as in obsidian. Occasionally there are found among them true spherulites where the internal structure is radiating fibrous. When such spherulites occupy the main mass they give rise to *spherulite-rock*.

Pumice is a general term for the cellular and filamentous or froth-like parts of lavas. In the great majority of cases it is a form of the obsidians, showing under the microscope the usually vitreous characters, and possessing a specific gravity of 2·0 to 2·53, though, owing to its porous nature, it possesses great buoyancy and readily floats on water. At Hawaii, however, some of the pyroxenic or olivine lavas give rise to a pumiceous froth which has the usual outward characters of ordinary pumice.

The rocks enumerated up to this point are all orthoclase-rocks, and markedly siliceous, frequently showing their excess of silica in the form of quartz grains or crystals. In the succeeding group free quartz is not found as a marked constituent, although occasionally it occurs in some quantity. In this series syenite may be regarded as the equivalent of granite in the quartzose series, orthoclase porphyry of quartz-porphyry and felstone, and trachyte of liparite.

Syenite.—According to the modern nomenclature, this name, which was formerly given in England to a granite with hornblende replacing mica, is now restricted to a rock consisting essentially of a mixture of orthoclase and hornblende, to which plagioclase, quartz, and mica are occasionally added. The name syenite, first used by Pliny in reference to the rock of Syene, was introduced by Werner as a scientific designation, and applied to the rock of the Plauenscher-Grund, Dresden. Werner afterwards, however, made that rock a greenstone. The base of all syenites like that of granites is crystalline, without a trace of any amorphous substance between the crystals, such as most igneous rocks contain. Hence the texture is of that crystalline kind commonly known as granitic.

The typical syenite of the Plauenscher-Grund, formerly described as a coarse-grained mixture of flesh-colored orthoclase and black hornblende, containing no quartz, and with no indication of plagioclase, was regarded as a normal orthoclase-hornblende rock. Microscopical research has, however, shown that well-striated triclinic felspar, as well as quartz, occurs in it. Its composition is shown by the following analysis:—silica, 59·83; alumina, 16·85; protoxide of iron, 7·01; lime, 4·43; magnesia, 2·61; potash, 6·57; soda, 2·44; water, etc., 1·29; total, 101·03. The average specific gravity of syenite is from 2·75 to 2·90.

Syenite occurs under conditions similar to those in which granite is found; it has been erupted in large irregular masses, especially among metamorphic rocks, as well as in smaller bosses and veins.

Orthoclase Porphyry (*Quartzless Porphyry*) is an orthoclase rock containing no quartz, or a very sparing admixture of that mineral, but with a little plagioclase, and not unfrequently with some hornblende and dark biotite. It contains from 55 to 65 per cent. of silica. It differs thus from quartz-porphyry and felstone in its smaller proportion of silica, but the distinction is one which, except by chemical or microscopical analyses, must often be difficult to establish between the fine compact felstones and the orthoclase porphyries, especially when the latter contain free quartz. This rock is sometimes termed syenite-porphyry, since it is associated with syenite much in the same way that elvanite is with granite. It is like syenite a plutonic rock, and occurs in veins, dykes, and intrusive sheets. Probably, however, many of the so-called "felstones" which occur as lavas, contemporaneously ejected with the older Palæozoic formations, are really orthoclase-porphyries.

Trachyte, a term originally applied to a large series of modern volcanic rocks possessing a characteristic roughness (τραχύς) under the finger, is now restricted to rocks consisting essentially of sanidine, with more or less triclinic felspar, usually with hornblende, biotite, or augite, and sometimes with magnetite and apatite. In microscopic structure the rock is distinguishable from the quartz-trachytes or liparites by the absence or feeble development of any microfelsitic ground-mass, and in general by the presence of a porphyritic base, consisting either of a pure glass or of one with devitrification products. The average composition of trachyte may be stated thus:—silica, 60·0; alumina, 17·0; protoxide of iron, 8·0; magnesia, 1·0; lime, 3·5; soda, 4·0; potash, 5·0; loss by ignition, 1·5. Average specific gravity, 2·65. Trachyte is a volcanic rock of Tertiary and post-Tertiary date.

Phonolite (*Clinkstone*), a term suggested by the metallic ringing sound emitted by the compact varieties when struck, is applied to a mixture of sanidine felspar and nepheline with hornblende and usually nosean. An average specimen contained silica, 57·7; alumina, 20·6; potash, 6·0; soda, 7·0; lime, 1·5; magnesia, 0·5; oxides of iron and manganese, 3·5; loss by ignition, 3·2 per cent. The specific gravity may be taken as about 2·58. Phonolite is sometimes found splitting into thin slabs which can be used for roofing purposes. Occasionally it assumes a porphyritic texture from the presence of large crystals of sanidine or of hornblende. When the rock is partly decomposed and takes a somewhat porous texture, it resembles trachyte in appearance.

Like trachyte, phonolite is a thoroughly volcanic rock and of late geological date. It occurs sometimes filling the pipes of volcanic orifices, sometimes as sheets which have been poured out in the form of lava-streams, and sometimes as dykes and veins.

In the rocks enumerated up to this point the essential felspar constituent is orthoclase; in the felspar rocks now to be described the corresponding ingredient is nearly always some triclinic form. In the volcanic rocks of this series there is usually some mineral of the hornblende or augite family present in such quantity as to give a green or even black color to the mass.

Porphyrite may be used as the designation of rocks which consist essentially of some triclinic felspar, and show a glassy or partially devitrified ground-mass containing abundant crystals of plagioclase with magnetite or titaniferous iron, and sometimes hornblende, augite, or mica. These rocks include many varieties which have not yet been thoroughly examined. The texture varies from coarse crystalline-granular to exceedingly close-grained, and passes occasionally even into vitreous. Porphyrite is a volcanic rock very characteristic of the later Palæozoic formations, occurring there as interstratified lava-beds, and in eruptive sheets, dykes, veins, and irregular bosses.

Diorite (*Greenstone* in part) is a crystalline mixture of oligoclase or some allied felspar and hornblende with magnetic iron and apatite. Where free quartz occurs the rock is called *quartz-diorite.* The more compact dark varieties have been termed *aphanite.* The average chemical composition of this rock may be taken to be—silica, 53·2; alumina, 16·0; potash, 1·3; soda, 2·2; lime, 6·3; magnesia, 6·0; oxides of iron and manganese, 14·0; loss by ignition, 1·0. The mean specific gravity is about 2·95. Diorite occurs as an eruptive rock under conditions similar to those of quartz-porphyry and syenite. It is found in Palæozoic volcanic regions, as in North Wales, in "neck"-like masses which may mark the position of some of the volcanic orifices of eruption.

Propylite is a name given to certain Tertiary volcanic rocks consisting of a plagioclase felspar and hornblende in a fine-grained ground-mass. They are subject to considerable alteration, the hornblende being converted into epidote. Some quartziferous propylites have been described by Zirkel from Clarence King's *Survey of the 40th Parallel*, wherein the quartz abounds in liquid cavities containing briskly moving bubbles, and sometimes double enclosures with an interior of liquid carbonic acid.

Hornblende-Andesite is a rock of late geological date consisting of a plagioclase felspar and hornblende often with a little sanidine. The ground-mass is frequently quite crystalline, or shows a small proportion of a felsitic nature, with microlites and granules. When the rock contains free quartz it is called *Dacite.*

In the next series of rocks augite plays a similar part to that taken by hornblende in the foregoing species.

Diabase.—This name has been given to certain dark-green or black eruptive rocks found in the older geological formations and consisting essentially of a triclinic or plagioclase felspar, augite, magnetic or titaniferous iron, sometimes olivine, and usually with more or less of a diffused greenish substance which has resulted from the alteration of the augite or olivine. The texture is sometimes quite crystalline; in other cases it shows a felsitic ground-mass. Except that the so-called diabases are confined to Palæozoic rocks and the basalts to Tertiary and post-Tertiary formations, there seems no essential distinction between these two groups, though, of course, as the diabases are much older and have been far longer exposed to metamorphic processes, they are in general less fresh than the basalts.

Melaphyre is a term which has been so variously used that the sense in which it is taken must always be explained. Thus Seuft described it as a rock having an indistinctly mixed character, with colors ranging from dirty greenish-brown, or reddish-grey, or greenish black-brown, to a complete black; hard and tough when fresh, and then showing crystals of reddish-grey labradorite, with magnetic titaniferous iron, and usually with carbonates of lime and iron, and ferruginous chlorite (delessite), in crystalline grains; compact or earthy, or sometimes porphyritic or amygdaloidal. Naumann defines melaphyre as a close-grained rock, very often amygdaloidal, composed essentially of labradorite, with an undetermined silicate, some titaniferous iron, carbonates of lime and of iron, and sometimes crystals of augite, rubellan, and mica. Zirkel called it generally crypto-crystalline, sometimes porphyritic, very often amygdaloidal rock, consisting of a mixture of oligoclase and augite with magnetic iron. Lastly, Rosenbusch proposes to restrict it to those plagioclase-augite rocks which contain olivine, and possess a distinct porphyry ground-mass. There can be little doubt that, like the so-called diabases, the melaphyres are merely older forms of the great basalt-family.

Augite-Andesite is the name given to certain dark eruptive rocks of Tertiary and post-Tertiary date which consist of a triclinic felspar (oligoclase, or some species rather richer in silica than labradorite) and augite, with sometimes sanidine, hornblende, biotite, magnetite, or apatite, and in some varieties quartz. The composition of an example from Santorin, erupted in the year 1866, was found to be as follows:—silica, 67·35; alumina, 15·72; magnesia, 1·16; lime, 3·60; soda, 5·04; potash, 1·86; oxides of iron, 1·94; loss by ignition, 0·36; total, 101·06. Mean specific gravity, 2·75.

Basalt.—Under this term are included those widespread and important volcanic rocks which consist of a triclinic felspar, probably always labradorite, augite, olivine, and magnetic or titaniferous iron, with apatite, and sometimes sanidine or nepheline. The more coarsely crystalline varieties are known as *dolerite*, while those of intermediate texture have been termed *anamesite*, the more close-grained black heavy kinds being distinctively *basalts*. The chemical composition of an average variety may be set down as silica, 45·0; alumina, 15·0; magnesia, 6·5; lime, 10·5; soda, 3·5; potash, 1·5; oxides of iron and manganese, 15·0; loss by ignition, 3·0. Mean specific gravity, 2·95.

Zirkel has described under the name of basalt certain rocks in which the part of the felspar is played by another mineral, in some cases nepheline, in others leucite.

Basalt occurs as dykes and veins, intrusive bosses and sheets, and successive contemporaneous flows. It often presents a columnar structure, as at Staffa and the Giant's Causeway, whence the structure has been popularly termed basaltic.

Tachylite is a black volcanic glass often found in association with basalt, of which indeed it is merely the vitreous condition. Thus a basalt-dyke sometimes shows a thin crust of this pitch-like substance on its walls, where the molten rock was first suddenly cooled.

Palagonite is a volcanic glass related to basalt, and found in fragments in some tuffs.

Gabbro (*Diallage-rock*) is a compound of a triclinic felspar and diallage often with olivine, and also very generally with magnetic or titaniferous iron and apatite, more rarely with hornblende, biotite, or quartz. An average chemical composition is silica, 50·0; alumina, 15·0; magnesia, 7·0; lime, 10·0; soda, 2·5; potash, 0·5; oxides of iron and manganese, 12·5; loss by ignition, 2·5. Mean specific gravity, 2·95.

A very few crystalline massive rocks occur without felspar as an essential constituent; but they are of comparatively little importance as rock-masses, though interesting in themselves and sometimes of considerable beauty.

Pikrite is a rock rich in olivine, usually more or less serpentinized, with augite, magnetite, or ilmenite, and a little brown biotite, hornblende, or apatite.

Eulysite is a mixture of olivine, augite, and red garnet.

Garnet-olivine-rock is composed of olivine, diallage, and garnet.

Enstatite-olivine-rock consists of olivine and enstatite (bronzite or hypersthene) with magnetite or chromite.

Lherzolite is a mixture of olivine, pyroxene, picotite, and usually some magnetite.

Eclogite is a compound of garnet and omphacite, or smaragdite (hornblende).

Dunite is a mixture of olivine and chromite, found with serpentine,

Limburgite is composed of crystals of olivine, augite, and magnetite, in a base more or less vitreous.

(*b.*) *Schistose or Foliated Rocks.*—These form an exceedingly well-defined characteristic series. They are distinguished from the massive rocks by the possession of an internal arrangement into more or less closely parallel layers or folia, consisting of materials which have assumed a crystalline character along these layers. The layers may be composed of only one mineral, but are usually of two or more, which occur either in distinct, often alternate, laminæ or intermingled in the same layer Moreover, the layers are not usually continuous for more than a short space. As a rule they are strikingly lenticular, thickening out and then dying away, and reappearing after an interval on the same or a different plane. They are likewise characteristically welded, as it were, into each other, the crystalline particles of one lamina being so intermingled with those of the layers above and below it that the whole coheres as a tough not easily fissile mass. Though arranged in distinct layers, a schistose rock is usually distinguished from an ordinary sedimentary one by the irregularity of its lamination, and by a remarkable and eminently distinctive puckering or crumpling of the folia. The vast plications which can be seen from a distance running up the face of a mountain are repeated on a smaller scale in hand specimens, and even down to such proportions as can only be seen with a microscope. As already stated, the origin of these rocks has been the subject of much discussion. That they are metamorphosed sediments, and not original chemical precipitates, is the general opinion of geologists. See part iv.

A foliated rock showing this characteristic irregular fissility in a marked degree is termed a "schist." This word, placed after the distinguishing mineral of the rock, is used as the name of the rock, as mica-schist, chlorite-schist, hornblende-schist. If the mass loses its fissile tendency owing to the felting together of the component mineral into a tough coherent whole, the word rock is usually substituted for schist, as in hornblende-rock, actinolite-rock, and so on. There are thus three kinds of fissility among rocks;—(1) that of original deposit, as in shale,—this is termed lamination; (2) that of cleavage, as in clay slate; (3) that of foliation, as in the schists. There is a fourth kind of divisional planes, that of joints, sometimes so closely placed together as almost to rival the others, as will be pointed out in part iv.

Mica-schist (*Mica-slate*) is a schistose aggregate of quartz and mica. The relative proportions of the two minerals vary widely even in the same mass of rock. Each is arranged in lenticular wavy laminæ. The quartz shows greater inconstancy in the number and thickness of its folia. Frequently a layer of this mineral may often be seen to swell out to a thickness of an inch or more, and, dwindling rapidly down to a mere thread, disappear. The quartz may often be observed to retain a granular character like that of quartz-rock, no doubt indicative of its originally sedimentary origin (see fig. 6). The mica lies in thin plates, sometimes so dovetailed into each other as to form long continuous irregular crumpled folia, separating the quartz layers, and often in the form of thin spangles and membranes running in the quartz. Among the accessory minerals, garnet, felspar, and hornblende are not infrequent. Mica-schist forms extensive regions in Norway, Scotland, the Alps, and other parts of Europe, in connection with other members of the schistose family of rocks. It is also found encircling granite masses in Scotland and Ireland as a metamorphic zone a mile or so broad, which shades away into the unaltered strata of greywacke or slate outside.

Though the possession of a fissile structure, showing abundant divisional surfaces covered with glistening mica, is characteristic of mica-schist, we must distinguish between this structure and that of many micaceous sandstones which can be split into thin seams each splendent with the sheen of its mica-flakes. A little examination will show that in the latter case the mica has not crystallized *in situ*, but exists merely in the form of detached worn scales, which, though lying on the same general plain, are not welded into each other as in a schist; also that the quartz does not exist in folia but in rounded separate grains.

Gneiss is a crystalline schistose aggregate of the same minerals as in granite—felspar, quartz, and mica. The relative proportions of these minerals, and the manner in which they are grouped with each other, give rise to numerous varieties of the rock. As a rule the folia are coarser and the schistose character less perfect than in mica-schist. Sometimes the quartz lies in tolerably pure bands a foot or even more in thickness with plates of mica scattered through it. These quartz layers may be replaced by a crystalline mixture of quartz and felspar, or the felspar will take the form of independent lenticular folia, while the mica runs abundantly through the rock, and by its own ready cleavage imparts a fissile structure to the whole. Sometimes the mica is mostly or wholly replaced by hornblende, in other cases by talc (*protogenic-gneiss*). Like mica-schist, gneiss occupies a large space in regions where the older geological formations come to the surface. Varieties of it are also found in the metamorphic zone encircling some masses of granite. So coarse is the texture of many gneisses that they cannot, in hand-specimens nor even in large blocks, be certainly discriminated from granite. In such cases it is only by examination in the field and the detection of clear evidence of foliated structure that their true character can be determined.

An interesting and important variety is met with in some regions of gneiss and schist, viz., conglomerate bands in which pebbles of quartz and other materials from less than an inch to more than a foot in diameter are imbedded in a foliated matrix. Examples of this kind are found in the pass of the Tête Noir between Martigny and Chamouni, in N. W. Ireland, in the islands of Bute and Islay, and in different parts of Argyllshire. These enclosures are not to be distinguished from the ordinary water-worn blocks of true conglomerates; but the original matrix which encloses them has been so altered as to acquire a micaceous foliated structure, and to wrap the pebbles round as with a kind of glaze. These facts are of considerable value in regard to the theory of the origin of the crystalline schists.

Granulite (*Leptynite*) is a crystalline schistose aggregate of orthoclase and quartz, with some garnet and kyanite.

Chlorite-schist (or *Chlorite-slate*) is a schistose aggregate of green chlorite, often with some quartz, felspar, mica, or talc. The more massive forms (*lapis ollaris*, potstone) can be cut as building stone, or for the manufacture of articles for domestic use.

Talc-schist is a schistose aggregate of whitish-green or yellowish talc often combined with felspar or quartz. Dr. Heddle has recently shown that many so-called talc-schists contain no talc, but owe their unctuous character to a variety of mica (margarodite).

Hornblende-schist is a schistose mass of black or dark-green hornblende, but often interleaved with felspar, quartz, or mica. When the schistose character disappears, the mass becomes a *hornblende rock* (amphibolite). When the variety actinolite occurs instead of common hornblende it forms actinolite-schist.

Numerous other varieties of schists have been described, but they occupy very subordinate places among the foliated rocks. The following analyses show the chemical composition of the more important of those which have been enumerated:—

	Silica.	Alumina.	Oxides of Iron.	Protoxide of Manganese.	Magnesia.	Lime.	Soda.	Potash.	Water.			Specific Gravity.
Mica-schist	65·13	18·16	5·27	0·51	2·70	0·32	0·53	2·99	3·73	TiO_2 1·54	=100·88	2·773
Mica gneiss.........	70·20	14·04	6·84	...	0·80	2·03	0·91	2·98	1·67	" 0·72	=100·19	...
Hornblende gneiss	56·83	19·68	8·64	trace	3·28	1·89	3·14	2·34	2·69	" 0·47 CuO 0·09	= 99·05	2·80
Granulite	73·47	14·86	3·28	...	0·67	1·62	1·80	3·95	0·57	...	=100·22	...
Chlorite-schist.....	42·08	3·51	26·85	0·59	17·10	1·04	...	...	11·24	...	=102·41	2·75
Talc-schist..........	50·81	4·53	7·58	...	31·55	...	...	...	4·42	...	= 98·89	...
Hornblende-rock..	49·42	18·12	15·01	...	3·16	8·65	2·57	1·27	1·80 loss	...	=100·00	...

As the disappearance of the schistose structure produces a crystalline amorphous compound like that of a massive or ordinary igneous rock, we are brought at last round again to rocks which we cannot distinguish from those to which elsewhere an igneous origin is assigned. In gneiss, for example, the same minerals occur which form granite, and possess a crystalline character. Any process, such as irregular internal motion of the mass, which could destroy the schistose structure and produce a thoroughly granite-like texture, would give rise to a rock which, whatever its previous history might have been, could not be distinguished from granite. That such internal transformations have taken place among the crystalline gneissose masses can hardly be doubted. And thus, at the one end of the schistose series, we may have ordinary unaltered sediment; at the other, after many intermediate stages, a thoroughly crystalline amorphous rock like granite or syenite.

II. Fragmental (Clastic) Rocks.

This great series embraces all rocks of a secondary or derivative origin; in other words, all formed of particles which had previously existed on the surface of the earth in another form, and the accumulation and consolidation of which gave rise to new compounds. Some of these rocks have been produced by the mechanical action of running water, such as gravel, sand, and mud; others have arisen from the gathering together of the remains of once living plants or animals; others have been formed by the consolidation of the loose debris thrown out by volcanoes.

(*a*.) *Gravel and Sand Rocks.*—Ordinary *gravel* and *sand* are produced by the action of running water on every seacoast and river-course. These sedimentary materials, being mere mechanical formations, vary indefinitely in composition, according to the nature of the source from which they are derived. As a rule they consist of the detritus of siliceous rocks, these being among the most durable materials. Quartz, in particular, enters largely into the composition of sandy and gravelly detritus. Fragmentary materials tend to group themselves according to their size and relative density. Hence they are apt to occur in layers, and to show the characteristic *stratified* arrangement of *sedimentary* rocks. They may enclose the remains of any plants or animals entombed on the same sea-floor, river-bed, or lake-bottom.

Blown sand is sand which has been produced by previous wave-action, and is blown into long ridges or dunes by prevailing winds. It varies in composition as ordinary sandstones do, being sometimes entirely siliceous, sometimes calcareous where derived from triturated shells or other calcareous organisms. Layers of finer and coarser particles often alternate as in water-formed sandstone. Grasses and other plants bind the surface of the shifting sand, but are apt to be covered by fresh encroachments of the loose material, and then by their decay they give rise to dark peaty layers in the sand. Calcareous blown sand is compacted into hard stone by the action of rain-water which alternately dissolves a little of the lime and re-deposits it on evaporation as a thin crust cementing the grains of sand together.

Cliff-debris consists of angular rubbish disengaged by frost and ordinary atmospheric waste from the face of cliffs, crags, and steep slopes. It slides down the declivities of hilly regions, and accumulates at the base of slopes and precipices, until washed away by rain or by brooks. It naturally depends for its composition upon the nature of the solid rocks from which it is derived. The material constituting glacier moraines is of this kind.

Rain-wash is a loam or earth which accumulates on the lower parts of slopes or at their base, and is due to the gradual descent of the finest particles of disintegrated rocks by the transporting action of rain. *Brick-earth* is the name given in the south-east of England to thick masses of such loam which are extensively used for making bricks.

Subsoil is the broken-up part of the rocks immediately under the soil. Its character of course is determined by that of the rock out of which it is formed by subaerial disintegration.

Soil is the product of the subaerial decomposition of rocks and of the decay of plants and animals. Primarily the character of the soil is determined by that of the subsoil, of which in deed it is merely a further disintegration. The formation of soil is treated in part iii., pages 236, 239.

Conglomerate (*Puddingstone*) is a name given to any rock formed of consolidated gravel or shingle. The component pebbles are rounded and water-worn. They may consist of any kind of rock, though usually of some hard and durable sort, such as quartz or quartz-rock. A special name may be given according to the nature of the pebbles, as quartz-conglomerate, limestone-conglomerate, granite-conglomerate, etc. The paste or cementing matrix may consist of a hardened sand or clay, and may be siliceous, calcareous, argillaceous, or ferruginous. In the coarser conglomerates, where the blocks may exceed 6 feet in length, there is often very little indication of stratification. Except where the flatter stones show by their general parallelism the rude lines of deposit, it may be only when the mass of conglomerate is taken as a whole, in its relation to the rocks below and above it, that its claim to be considered a stratified rock will be conceded.

Breccia is a rock in which the stones are angular and not rounded, and usually with less trace of stratification than in conglomerate. Intermediate stages between this rock and the preceding, where the stones are partly angular and partly subangular and rounded, are known as *brecciated conglomerate.*

Sandstone is a rock formed of consolidated sand. The component grains are for the most part of quartz—a most durable mineral, which must here be regarded as the residue left after all the more decomposable minerals of the original rocks have been carried away in solution or in suspension as fine mud. The colors of sandstones arise, not so much from that of the quartz, which is commonly white or grey, as from the film or crust which often coats the grains and holds them together as a cement. As already stated iron is the great coloring ingredient of rocks. In sandstones it gives rise to red, brown, yellow, and green hues, according to its degree of oxidation and hydration. In ordinary red sandstones, for example, each grain of sand is coated with red earthy hæmatite. In yellow sandstone the oxide has become hydrous in the form of limonite.

There is as much variety of composition among sandstones as among conglomerates. Though they consist for the most part of siliceous grains, they include others of clay, felspar, mica, or other mineral; and these may increase in number so as to give a special character to the rock. Thus sandstones may be argillaceous, felspathic, micaceous, calcareous, etc. By an increase in the argillaceous constituents, a sandstone may pass into one of the clay-rocks, just as modern sand on the sea-floor shades imperceptibly into mud. On the other hand, by an augmentation in the size of the grains a sandstone may become a grit, or a pebbly or conglomeratic sandstone, and pass into a fine conglomerate. A piece of fine-grained sandstone seen under the microscope looks like a coarse conglomerate, so that the difference between the two rocks is little more than one of relative size.

Among the varieties of sandstones may be mentioned *Flagstone*, a thin-bedded sandstone capable of being split into slabs or flags; *Freestone*, a sandstone which can be cut freely in any direction (the term is popularly applied to some limestones and other rocks); and *Buhrstone*, a highly siliceous, exceedingly compact, though cellular, rock (with *Chara* seeds, etc.), found alternating with unaltered Tertiary strata in the Paris basin, and forming from its hardness and roughness an excellent material for the grindstones of flour-mills.

Greywacke is a compact aggregate of rounded or subangular grains of quartz, slate, felspar, or other minerals or rocks cemented by a paste which is usually siliceous but may be argillaceous, felspathic, or calcareous. Grey, as its name denotes, is the prevailing color; but it passes into brown, brownish-purple, and sometimes, where anthracite occurs, into black. The rock is distinguished from ordinary sandstone by its darker hue, its hardness, the variety of its component grains, and above all by the compact cement in which the grains are imbedded. In many varieties so pervaded is the rock by the siliceous paste that it possesses great toughness, and its grains seem to graduate into each other as well as into the surrounding matrix. Such rocks when fine-grained can hardly, at first sight or with the unaided eye, be distinguished from some compact igneous rocks, though a microscopic examination at once reveals their fragmental character. In other cases, where the greywacke has been formed mainly out of the debris of granite, quartz-porphyry, or other felspathic masses, the grains consist so largely of felspar, and the paste also is so felspathic, that the rock might be mistaken for some close-grained granular porphyry. Greywacke occurs extensively among the Palæozoic formations in beds alternating with shales and conglomerates. It represents the sand of the Palæozoic sea-floor, retaining often its ripple-marks and sun-cracks. The metamorphism it has undergone has generally not been great, and for the most part is limited to induration, partly by pressure and partly by permeation of a siliceous cement.

Quartz-rock (*Quartzite*) is a close-grained granular aggregate of quartz cemented by a highly siliceous matrix. Originally it consisted of a tolerably pure quartz-sand, which has been metamorphosed by pressure and the transfusion of a siliceous cement into an exceedingly hard mass. This cement was probably produced by the solvent action of heated water upon the quartz grains, which very generally seem to shade off into each other, or into the intervening silica. It is owing no doubt to the purely siliceous character of the grains that the blending of these with the surrounding cement is more intimate than in greywacke, so much so that the rock often assumes an almost flinty homogeneous texture. That quartz-rock as here described is an original sedimentary rock and not a chemical deposit is shown, not only by its granular texture, but by the exact resemblance of all its leading features to ordinary sandstone—false-bedding, alternation of coarser and finer layers, worm-burrows, and fucoid-casts. It occurs in the form of large masses interstratified with limestones, slates, and schists. It is also met with locally as an altered form of sandstone, where this rock is traversed by igneous dykes and indurated into quartz-rock for a distance of a few inches or feet from the intrusive mass. Bands of highly silicated sandstones, having the lustrous aspect, fine grain, and great hardness of quartz-rock, occur among the unaltered shales and other strata of the Carboniferous system. In such cases, the supposition of any general metamorphism being inadmissible, we must suppose either that these quartzose bands have been indurated, for example, by the passage through them of thermal silicated water, or that the quartz-rock is there an original formation.

(*b.*) *Clay-rocks.*—These are composed of the finer argillaceous sediments or muds derived from the waste of previously formed rocks. Perfectly pure clay, hydrated silicate of alumina, may be seen where some granites and other felspar-bearing rocks decompose. But, as a rule, the clay is mixed with various impurities.

Pipe-clay is white, nearly pure, and free from iron. *Fire-clay* is a deposit largely found in connection with coal-seams, contains little iron, and is nearly free from lime and alkalies. Some of the most typical fire-clays are those long used at Stourbridge, Worcestershire, for the manufacture of pottery. The best glass-house pot-clay, that is, the most refractory, and therefore used for the construction of pots which have to stand the intense heat of a glass-house, has the following composition:—silica, 73·82; alumina, 15·88; protoxide of iron, 2·95; lime, trace; magnesia, trace; alkalies, ·90; sulphuric acid, trace; chlorine, trace; water, 6·45; specific gravity, 2·51. A very siliceous close-grained or flinty variety, termed *Gannister*, occurs in the Lower Coal-measures of the north of England, and is now largely ground down as a material for the hearths of iron furnaces. *Brick-clay* is properly rather an industrial than a geological term, since it is applied to any clay, loam, or earth, from which bricks or coarse pottery are made. It is an impure clay, containing a good deal of iron, with other ingredients. An analysis gave the following composition of a brick-clay:—silica, 49·44; alumina, 34·26; sesquioxide of iron, 7·74; lime, 1·48; magnesia, 5·14; water, 1·94.

Mudstone is a fine, usually more or less sandy, argillaceous rock, having no fissile character, and of somewhat greater hardness than any form of clay. The term *Clay-rock* has been applied by some writers to an indurated clay requiring to be ground and mixed with water before it acquires plasticity.

When clay has been deposited intermittently so as to assume a thinly stratified or fissile structure, it receives the general name of *Shale*. Under this term are included all laminated and indurated clays which are capable of being split along the lines of deposit into hard leaves. They present almost endless varieties of texture and composition, passing on the one hand into clays, on the other into flagstones and sandstones, or again, through calcareous gradations, into limestone, or through ferruginous varieties into clay-ironstone, and through bituminous kinds into coal. An important variety, known as *Oil-shale*, and containing so much bituminous matter that it is now extensively used as a source for the manufacture of solid paraffin and mineral oils, is described in the next section.

Flinty-slate (*Lydian-stone, Hornstone*) is siliceous shale or mudstone which has been indurated into an exceedingly compact flinty mass, breaking with a conchoidal or splintery fracture, and usually of dark colors, black, brown, and red, more rarely white.

Clay-slate is a compact close-grained, very hard, fissile argillaceous rock, dull lead-blue, grey, green, red, purple, or black in color, splitting into thin leaves which are not those of original deposit but those produced by a superinduced cleavage. In this case the rock has been affected by great lateral pressure, whereby its particles have been forced to adjust themselves with their longer axes perpendicular to the direction of pressure. This rearrangement has imparted to the rock a fissility wholly independent of original lamination. The possession of this cleavage is the distinctive character of a true slate.

(*c.*) *Rocks formed of the Debris of Plants.*—These have sometimes been produced by the decay and entombment of vegetation on the spot where it grew, sometimes by the drifting of the plants to a distance and their consolidation there. In the latter case, they may be mingled with inorganic sediment, so as to pass into carbonaceous shale.

Peat is vegetable matter, more or less decomposed and chemically altered, found in boggy places and elsewhere where marshy plants grow and decay. It varies from a pale yellow or brown fibrous substance, like turf or compressed hay, in which the plant remains are abundant and conspicuous, to a compact dark-brown or black material, resembling black clay when wet and some varieties of lignite when dried. The nature and proportions of the constituent elements of peat, after being dried at 100° C., are illustrated by the analysis of an Irish example which gave—carbon, 60·48; hydrogen, 6·10; oxygen, 32·55; nitrogen, 0·88; while the ash was 3·30.

There is always a large proportion of water which cannot be driven off even by drying the peat. In the manufacture of compressed peat for fuel this constituent, which of course greatly lessens the value of the peat as compared with an equal weight of coal, is driven off to a great extent by chopping the peat into fine pieces, and thereby exposing a large surface to evaporation. The ash varies in amount from less than 1·00 to more than 65 per cent., and consists of sand, clay, ferric oxide, sulphuric acid, and minute proportions of lime, soda, potash, and magnesia.

Lignite is compressed and chemically altered vegetable matter, often retaining a lamellar or ligneous texture, and stems with woody fibre crossing each other in all directions. It varies from pale brown or yellow to deep brown or black. Some shade of brown is the usual color, whence the name *brown coal*, by which it is often known. It occurs in beds chiefly among the Tertiary strata, under conditions similar to those in which coal is found in older formations. It may be regarded as a stage in the alteration and mineralization of vegetable matter intermediate between peat and true coal.

Coal, the most completely mineralized form of vegetable matter, occurs as a black (sometimes dark-brown), brittle, usually lustrous substance, intercalated in beds between strata of sandstone, shale, fireclay, etc., in geological formations of Palæozoic, Secondary, and Tertiary age. The word coal is rather a popular than a scientific term, as it is indiscriminately applied to any mineral substance capable of being used as fuel. Strictly employed it ought only to be used with reference to beds of fossilized vegetation, the result either of the growth of plants on the spot or of the drifting of them thither.

The following analyses show the chemical constituents in some of the principal varieties of coal:—

	Caking Coal.	Splint Coal.	Cannel Coal.	Anthracite.
Carbon	86·75	79·58	66·44	91·44
Hydrogen	5·24	5·50	7·54	3·46
Oxygen } Nitrogen }	6·61	8·33	10·84	2·58
		1·13	1·36	0·21
Earthy substances	1·40	5·46	13·82	2·31
Specific gravity	1·28	1·31	1·27	1·39

Diatom-earth is a siliceous deposit formed chiefly of the frustules of diatoms. It is laid down both in salt and in fresh water. Wide tracts of it are now being deposited on the bed of the South Pacific. In Virginia, United States, an extensive tract occurs covered with diatom-earth to a depth of 40 feet. It is used as a polishing or tripoli powder.

Oil shale (*Brandschiefer*) is shale containing such a proportion of hydrocarbons as to be capable of yielding mineral oil on slow distillation. This substance occurs as ordinary shales do, in layers or beds, interstratified with other aqueous deposits, as in the Scottish coal-fields. It is in a geological sense true shale, and owes its peculiarity to the quantity of vegetable (or animal) matter which has been preserved among its inorganic constituents. It consists of fissile argillaceous layers, highly impregnated with bituminous matter, passing on one side into common shale, on the other into cannel or parrot coal. The richer varieties yield from 30 to 40 gallons of crude oil to the ton of shale. They may be distinguished from non-bituminous or feebly bituminous shales (throughout the shale districts of Scotland) by the peculiarity that a thin paring curls up in front of the knife, and shows a brown lustrous streak. Some of the shales in the Lothians are crowded with the valves of ostracod crustaceans, besides scales, coprolites, etc., of ganoid fishes (*Palæoniscus, Amblypterus, Megalichthys*, etc.); and it is possible that the bituminous matter may in some cases have resulted from animal organisms, though the abundance of plant remains indicates that it is probably in most cases of vegetable origin. Under the name "pyroschists" Sterry Hunt classes the clays or shales (of all geological ages) which are hydrocarbonaceous, and yield by distillation volatile hydrocarbons, inflammable gas, etc.

(*d.*) *Rocks formed of Animal Remains.*—These may be formed on land, as in bone caves, but most abundantly under water, as on the bottom of lakes and of the sea. They may be calcareous, siliceous, or phosphatic.

Limestone.—Besides the limestones resulting from the deposition of chemical precipitates of carbonate of lime, there is another important series derived from the remains of organisms, either by growth on the spot, or by accumulation as mechanical sediment. Limestone so originating has often been so altered that it cannot always be distinguished from that which has been chemically produced, especially when it has been exposed to the action of percolating acidulated water, for in that case a crystalline texture is gradually superinduced, by which the original organic structures in the mass are wholly or in great part obliterated. Limestone composed of the remains of living organisms forms thin layers and massive beds. In some instances, as in that of the English and Irish Mountain Limestone, it occurs in masses several thousand feet thick, which extend for hundreds of square miles, and form the rock out of which picturesque valleys, gorges, hills, and table-lands have been excavated. Limestone may be either of fresh water or of marine origin. Some of the more common and important varieties may be here enumerated:—

Coral-rock is limestone formed by the continuous growth of coral-building polyps. This substance affords an excellent illustration of the way in which organic structure may be effaced from a limestone entirely formed from the remains of once living animals. Though the skeletons of the reef-building corals remain distinct on the upper surface, those of their predecessors beneath them are gradually obliterated by the passage through them of percolating water dissolving and redepositing carbonate of lime. This same action may be observed among the stalactites of a damp vault, in which, though the successive rings of growth are preserved, a crystalline divergent structure is superinduced, which traverses these rings from the centre outward. We can thus understand how a mass of crystalline limestone may have been produced from one formed out of organic remains without the action of any subterranean heat, but merely by the permeation of water from the surface. *Crinoidal* (*Encrinite*) *Limestone* is a rock composed in great part of joints of encrinites, with *Foraminifera*, corals, and mollusks. It varies in color from white or pale grey, through shades of bluish-grey (sometimes yellow or brown, less commonly red) to a dark-grey or even black color. It is abundant among Palæozoic formations, being especially characteristic of the lower part of the Carboniferous system. *Chalk* as a lithological term is applied to a white soft rock, meagre to the touch, soiling the fingers, formed of a fine calcareous flour derived from the remains of *Foraminifera*, echinoderms, mollusks, and other marine organisms. It occurs in massive beds, and covers a great part of the south-east and east of England. In Ireland and elsewhere it assumes a firmer grain and various colors, so as to pass into some of the numerous varieties of compact white limestone. *Shell-Marl*, a soft white, earthy, or crumbly deposit, is formed in lakes and ponds by the accumulation of the remains of shells and *Entomostraca* on the bottom. When such calcareous deposits become solid compact stone they are known as *fresh-water* (*lacustrine*) *limestone*. These are generally of a smooth texture, and either dull white or pale grey, their fracture only slightly conchoidal, rarely splintery. *Ooze* is a mud of organic origin found covering vast areas of the floor of the Atlantic and other oceans. Some of it is calcareous and formed wholly or mostly of the remains of *Foraminifera*, particularly of forms of the genus *Globigerina*; hence this deposit has been termed foraminiferal or globigerina ooze. Sometimes it is mainly siliceous, consisting of the remains of *Radiolaria* (Radiolarian ooze) or of diatoms (Diatom ooze). These deposits are further referred to in the section of this article which treats of the geological aspects of the ocean. *Shell-sand* is a sand composed in great measure or wholly of comminuted shells, found commonly on a low shelving coast exposed to prevalent on-shore winds. This deposit when thrown above the reach of the waves and often wetted by rain, or by trickling runnels of water, is apt to become consolidated into a mass, owing to the solution and redeposit of lime round the grains of shell.

Flint and *Chert* are siliceous rocks (which, though not strictly fragmental, may be conveniently placed here) found in nodules and layers in limestones of many different geological ages. Flint is a dark horny substance, breaking with a splintery to conchoidal fracture. It is particularly abundant in the chalk formation. Chert is an impure flint, containing more clay or lime with the silica. These substances seem in some cases to have had a directly organic origin, having been secreted from sea-water by the living organisms; in other cases, where for example we find a calcareous shell, or echinus, or coral, converted into silica, it would seem that the substitution of silica for lime has been effected by a process of chemical pseudomorphism either after or during the formation of the limestone.[1]

(*e.*) *Volcanic Fragmental Rocks* form an interesting group composed of the loose materials ejected from volcanic vents. In their typical condition they consist merely of consolidated volcanic debris, including bombs, scoriæ, ejected blocks, sand, lapilli, and dust. It is evident, however, that, when these materials were deposited in water, there would necessarily be a limit beyond which they would not extend, and where they would be mingled with and would insensibly pass into ordinary non-volcanic sediment. Hence we may expect to find transitional varieties between rocks formed directly from the results of volcanic explosion and ordinary sedimentary deposits. Moreover, as these fragmental volcanic masses usually consist almost wholly of the detritus of different lavas, which have been blown into fragments in the volcanic chimneys, we may expect to find, on the other hand, a passage from them into rocks derived from consolidated lava-beds by ordinary aqueous erosion. (See part iv.)

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[1] Hull and Hardman on Chert, *Trans. Roy. Dub. Soc.*, new ser., vol. i. 71, 1878.

Volcanic Conglomerate is a rock composed mainly or wholly of rounded or subangular fragments of any volcanic rocks in a paste derived chiefly or wholly from the same materials, usually exhibiting a stratified arrangement, and often found intercalated between successive sheets of lava. In most cases conglomerates of this kind have been formed by the accumulation of materials ejected from volcanic vents; occasionally, as just remarked, they may have resulted from the aqueous erosion of previously solidified lavas, or from a combination of both these processes. There does not appear at present to be any satisfactory method of always determining the exact mode of formation, except that well-rounded and smoothed stones will almost certainly indicate long-continued water-action rather than trituration in a volcanic vent.

The volcanic conglomerates may receive different names according to the nature of the component fragments: thus we have *basalt-conglomerates*, where these fragments are wholly or mainly of basalt, *trachyte-conglomerates*, *porphyrite-conglomerates*, *phonolite-conglomerates*, etc.

Volcanic Breccia resembles volcanic conglomerates, except that the stones are angular. This angularity indicates an absence of aqueous erosion, and, under the circumstances in which it is found, usually points to volcanic explosions. There is a great variety of breccias, as *basalt-breccia*, *diabase-breccia*, etc.

Volcanic Agglomerate is the name given to a tumultuous assemblage of blocks of all sizes up to masses several yards in diameter. It is met with in the "necks" or pipes of old volcanic orifices. The stones and paste are commonly of one or more volcanic rocks, such as basalt or porphyrite, but they include also fragments of the surrounding rocks, whatever these may be, through which the volcanic orifice has been drilled. As a rule agglomerate is devoid of stratification; but sometimes it includes portions which have a more or less distinct arrangement in beds of coarser and finer detritus, often placed on end or inclined in different directions at high angles.

Volcanic Tuff.—This general term may be made to include all the finer kinds of volcanic detritus, ranging on the one hand through coarse gravelly deposits into conglomerates, and on the other into exceedingly compact fine-grained rocks formed of the finest and most impalpable kind of volcanic dust. Some tuffs are full of microlites or imperfect forms of crystallization derived from the lava which has blown into dust. Others are formed of small rounded or angular grains of different lavas with fragments of various rocks through which the volcanic funnels have been drilled. Minutely cellular grains, as if derived from the ebullition of very fluid glassy lava like palagonite, constitute much of the tuff in some of the volcanic necks of Carboniferous age in central Scotland. Some tuffs have consolidated under water, others on dry land. As a rule they are distinctly stratified. Near the original vents of eruption they commonly present rapid alternations of finer and coarser detritus indicative of successive phases of volcanic activity.

The tuffs may be subdivided according to the nature of the lava from the disintegration of which they have been formed. Thus we have *felsite-tuffs*, *trachyte-tuffs*, *basalt-tuffs*, *pumice-tuffs*, *porphyrite-tuffs*, *palagonite-tuffs*. Some varieties have received special names. *Trass* (*Duckstein*, *Tuffstein*) is a compact yellow pumiceous tuff which has filled up some of the valleys of the Eifel region and is largely quarried as an hydraulic mortar. *Peperino* is an Italian tuff of late geological date, full of separate crystals of augite and other minerals.

PART III.—DYNAMICAL GEOLOGY.

Under this section is included the investigation of those processes of change which are at present in progress upon the earth, whereby modifications are made on the structure and composition of the crust, on the relations between the interior and the surface, as shown by volcanoes, earthquakes, and other terrestrial disturbances, on the distribution of oceans and continents, on the outlines of the land, on the form and depth of the sea-bottom, on climate, and on the races of plants and animals by which the earth is tenanted. It brings before us, in short, the whole range of activities which it is the province of geology to study, and leads us to precise notions regarding their relations to each other, and the results which they achieve. A knowledge of this branch of the subject is thus the essential groundwork of a true and fruitful acquaintance with the principles of geology, seeing that it necessitates a study of the present order of nature, and thus provides a key for the interpretation of the past.

The whole range of operations included within the scope of inquiry in this branch of the science may be regarded as a vast cycle of change, into which we may break at any point, and round which we may travel, only to find ourselves brought back to our starting-point. It is a matter of comparatively small moment at what part of the cycle we begin our inquiries. We shall always find that the changes we see in action have resulted from some that preceded, and give place to others which follow them.

At an early time in the earth's history, anterior to any of the periods of which a record remains in the visible rocks, the chief sources of geological action probably lay within the earth itself. The planet still retained a great store of its initial heat, and in all likelihood was the theatre of great chemical changes, giving rise, perhaps, to manifestations of volcanic energy somewhat like those which have so marvellously roughened the surface of the moon. As the outer layers of the globe cooled, and the disturbances due to internal heat and chemical action became less marked, the influence of the sun, which must always have operated, would then stand out more clearly, giving rise to that wide circle of superficial changes wherein variations of temperature and the circulation of air and water over the surface of the earth come into play.

In the pursuit of his inquiries into the past history and into the present *régime* of the earth, the geologist must needs keep his mind ever open to the reception of evidence for kinds and especially for degrees of action which he had not before imagined. Human experience has been too short to allow him to assume that all the causes and modes of geological change have been definitively ascertained. On the earth itself there may remain for future discovery evidence of former operations by heat, magnetism, chemical change, or otherwise, which may explain many of the phenomena with which geology has to deal. Of the influences, so many and profound, which the sun exerts upon our planet, we can as yet only dimly perceive a little. Nor can we tell what other cosmical influences may have lent their aid in the evolution of geological changes.

In the present state of our knowledge, all the geological energy upon and within the earth must ultimately be traced back to our parent sun. There is, however, a certain propriety and convenience in distinguishing between that part of it which is due to the survival of some of the original energy of the planet, and that part which arises from the present supply of energy received day by day from the sun. In the former case we have to deal with the interior of the earth and its reaction upon the surface; in the latter we deal with the surface of the earth, and to some extent with its reaction on the interior. This distinction allows of a broad treatment of the subject under two divisions:—

I. *Hypogene or Plutonic Action*—the changes within the earth caused by original internal heat and by chemical action.

II. *Epigene or Surface Action*—the changes produced on the superficial parts of the earth, chiefly by the circulation of air and water set in motion by the sun's heat.

DIVISION I.—HYPOGENE ACTION.

An Inquiry into the Geological Changes in Progress beneath the Surface of the Earth.

In the discussion of this branch of the subject we must carry in our minds the conception of a globe still intensely hot in its interior, radiating heat into space, and consequently contracting in bulk. Portions of molten rocks from inside are from time to time poured out at the surface. Sudden shocks are generated by which destructive earthquakes are propagated to and along the surface. Wide geographical areas are pushed up or allowed to sink down. In the midst of these movements very remarkable changes are produced upon the rocks of the crust; they are shattered, fractured, squeezed, crumpled, rendered crystalline, and even fused.

Section I.—Volcanoes and Volcanic Action.

The term volcanic action (vulcanism or vulcanicity) embraces all the phenomena connected with the expulsion of heated materials from the interior of the earth to the surface. Among these phenomena there are some of an evanescent character, while others leave permanent proofs of their existence. It is naturally to the latter that the geologist gives the chief attention, for it is by their means that he can trace the former phases of volcanic activity in regions where, for many ages, there have been no volcanic eruptions. In the operations of existing volcanoes he can observe only the superficial manifestations of volcanic action. But, examining the rocks of the earth's crust, he discovers that in the lapse of ages, amid the many terrestrial revolutions which geology reveals, the very roots of former volcanoes have been laid bare, displaying subterranean phases of vulcanism which could not be studied in any modern volcano. Hence an acquaintance only with active volcanoes will not give us a complete knowledge of volcanic action. It must be supplemented and enlarged by an investigation of the traces of former volcanoes preserved in the crust of the earth.

The openings by which the heated materials from the interior reach the surface include volcanoes (with their accompanying orifices), hot-springs, and gas-springs. A volcano may be defined as a conical eminence, composed wholly or mainly of materials which have been ejected from below, and which have accumulated at the surface round the vent of eruption. As a rule it presents at its summit a cup-shaped cavity termed the crater, at the bottom of which is the top of the main funnel or pipe whereby the communication is maintained with the heated interior. A volcano, when of small size, may consist merely of one diminutive cone; when of the largest dimensions, it forms a huge mountain, with many subsidiary cones and many lateral fissures or pipes, from which the heated volcanic products are given out.

Volcanoes may break through any kind of geological formation. In Auvergne, in the Miocene period, they burst through the granitic and gneissose plateau of central France. In Lower Old Red Sandstone times they pierced contorted Silurian rocks in central Scotland. In late Tertiary and post-Tertiary ages they found their way through soft marine strata, and formed the huge piles of Etna, Somma, and Vesuvius. On the banks of the Rhine, at Bonn and elsewhere, they have penetrated some of the older alluvia of that river. In many instances, also, newer volcanoes have appeared on the sites of older ones. In Scotland the Carboniferous volcanoes have risen on the sites of those of the Old Red Sandstone, those of the Permian period have broken out among the earlier Carboniferous eruptions, while the Miocene lavas have been injected into all these older volcanic masses. Again, the newer *puys* of Auvergne were sometimes erupted through much older and already greatly denuded basalt-streams. Somma and Vesuvius have arisen out of the great Neapolitan plain of marine tuff. In central Italy, also, newer cones have been thrown up upon the great Roman plain of more ancient volcanic debris.

It is usual to class volcanoes as *active*, *dormant*, and *extinct*. This arrangement, however, often presents considerable difficulty in its application. An active volcano cannot of course be mistaken, for even when not in actual eruption it shows, by its abundant evolution of steam and hot vapors, that it might break out into activity at any moment. But it is in many cases impossible to decide whether a volcano should be called extinct or only dormant. The volcanoes of Silurian age in Wales, of Carboniferous age in Ireland, of Permian age in the Hartz, of Miocene age in the Hebrides, are certainly all extinct. But the Miocene volcanoes of Iceland are still represented there by Skaptar-Jökull, Hecla, and their neighbors. Somma, in the first century of the Christian era, would have been naturally regarded as an extinct volcano. Its fires had never been known to have been kindled within human tradition; its vast crater was a wilderness of wild vines and brushwood, haunted, no doubt, by wolf and wild-boar. Yet in a few days, in the autumn of the year 79 the half of the crater walls was blown out by a terrific series of explosions, the present Vesuvius was then formed within the limits of the earlier crater, and since that time volcanic action has been intermittently exhibited up to the present day. Some of the intervals of quietude, however, have been so considerable that the mountain might then again have been claimed as an extinct volcano. Thus, in the 131 years between 1500 and 1631, so completely had eruptions ceased that the crater had once more become choked with copsewood. A few pools and springs of very salt and hot water remained as memorials of the former condition of the mountain. But this period of quiescence closed with the eruption of 1631,—the most powerful of all the known explosions of Vesuvius, except the great one of 79.

In the island of Ischia, Mont Epomeo was last in eruption in the year 1302, its previous outburst having taken place, it is believed, about 17 centuries before that date. From the craters of the Eifel, Auvergne, the Vivarais, and central Italy, though many of them look as if they had only recently been formed, no eruption has been known to come during the times of human history or tradition. From these examples it is clear that no real distinction can be drawn between dormant and extinct volcanoes. Also, from the fact above mentioned, that volcanoes have often appeared on areas occupied by those of previous geological periods, it is equally evident that volcanic action is apt to show itself again and again even at vast intervals within the same regions and over the same sites.

§ 1. *Volcanic Products.*

The materials erupted from volcanic vents may be classed as (1) gases and vapors, (2) lavas, (3) fragmentary substances. A brief summary under each of these heads may be given here; the mode and order of appearance of the several products will be stated in § 2.

1. *Gases and Vapors.*—These play an important part in volcanic activity; they show themselves in the earliest stages of a volcano's history, and continue to appear for centuries after all the other evidences of subterranean action have ceased to be manifested. By much the most abundant of them all is *steam*. It has been estimated to form $\frac{999}{1000}$ths of the whole cloud which hangs over an active volcano. In great eruptions it rises in prodigious quantities, and is rapidly condensed into a heavy rainfall. M. Fouqué calculated that during 100 days Etna had ejected vapor enough to form, if condensed, 2,100,000 cubic metres of water. But even from volcanoes which, like the Solfatara near Naples, have been dormant for many centuries it sometimes still rises without intermission and in considerable volume. Jets of vapor rush out from clefts in the sides and bottom of a crater with a noise like that made by the steam blown off by a locomotive. The number of these funnels is often so large, and the amount of vapor so abundant, that only now and then, when the wind blows the dense cloud aside, can a momentary glimpse be had of a part of the bottom of the crater; while at the same time the rush and roar of the escaping steam remind one of the din of some vast factory. Aqueous vapor rises likewise from rents on the outside of the volcanic cone. It issues so copiously from the molten lava which pours down the slopes of the cone that the stream of rock is almost concealed from view by the cloud; and it continues to escape from fissures of the lava, far below the point from which the molten matter proceeded, for a long time after the rock has solidified and come to rest. So saturated, as it were, are many crystalline lavas with the vapor of water that Mr. Scrope even suggested that they derive their mobility from this cause.

Probably in no case is the steam mere pure vapor of water. It is associated with other vapors and gases disengaged from the potent chemical laboratory underneath. Of these probably the most abundant is *sulphuretted-hydrogen*, readily traceable by its characteristic odor. Its liability to decomposition leads to the deposition of a yellow crust of sulphur about the orifices from which it rises; perhaps, also, in great part to the alteration of this gas must we attribute the *sulphuric acid* so frequently observed at volcanic vents. Another gas especially abundant at Vesuvius, but not detected in all volcanoes, is *hydrochloric acid*, which comes away with the steam, and gives it its pungent suffocating fumes. *Carbonic acid* appears in most volcanoes, partly as one of their usual products, but chiefly given off during the feebler conditions of activity and in the last stages of vulcanism. After an eruption of Vesuvius this gas has sometimes been discharged so copiously that hundreds of hares, pheasants, and partridges have been suffocated by it. In the ancient volcanic regions of the Eifel and Auvergne, it still rises in prodigious quantities. Bischof estimates that the quantity of carbonic acid evolved in the Brohl Thal amounts to five millions of cubic feet, or 300 tons of gas in one day. *Nitrogen*, derived doubtless from the decomposition of atmospheric air dissolved in the water which penetrates into the volcanic foci, has been frequently detected among the gaseous emanations.

With these gases and vapors are associated many substances which, sublimed by the volcanic heat, appear as deposits along crevices and surfaces wherein they reach the air and are cooled. Besides sulphur, which has been already mentioned, there are several chlorides (particularly that of sodium, and less abundantly those of iron, copper, and lead), sal-ammoniac, specular iron, oxide of copper (tenorite), boracic acid, and other substances. Sodium chloride sometimes appears so abundantly that wide spaces of a volcanic cone, as well as of the newly erupted lava, are crusted with salt, which can even be profitably removed by the inhabitants of the district. Considerable quantities of these chlorides may thus be buried between successive sheets of lava, and in long subsequent times may give rise to mineral springs, as has been suggested with reference to the saline waters which issue from volcanic rocks of Old Red Sandstone and Carboniferous age in Scotland. The iron-chloride forms a bright yellow and reddish crust on the crater walls, as well as on loose stones on the slopes of the cone. Specular iron forms abundantly as thin lamellæ in the fissures of Vesuvian lavas. Tenorite may be seen at the edge of the crater of Vesuvius, condensing into fine filaments which are blown away by the wind. An order of succession has been observed to take place in the appearance of the different volcanic gaseous discharges.

In connection with the aqueous vapor of volcanoes, reference may be made here to the abundant discharges of water which accompany volcanic explosions. Three sources of this water may be assigned:—(1) from the melting of snow by a rapid accession of temperature previous to or during an eruption,—this takes place from time to time on Etna, and still more markedly in Iceland and among the snowy ranges of the Andes; (2) from the condensation of the vast clouds of steam which are discharged during an eruption,—this undoubtedly is the chief source of the destructive torrents so frequently observed to form part of the phenomena of a great volcanic explosion; and (3) from the disruption of reservoirs of water filling subterranean cavities, or of lakes occupying crater-basins,—this has several times been observed among the South American volcanoes, where immense quantities of dead fish, which inhabited the water, have been swept down with the escaping torrents. The volcano of Agua, in Guatemala, has never been known to discharge anything but water. In the large crater of Idjèn, one of the volcanoes of Java, lay a hot steaming lake of acid water. In the beginning of the year 1817 an eruption took place, by which the water was discharged with frightful destruction down the slopes of the mountain. After the explosion the basin filled again with water, but its temperature was no longer high.

In many cases the water rapidly collects volcanic dust as it rushes down, and soon becomes a pasty mud, or it issues at first in this condition from the volcanic reservoirs, from which, after violent detonations, it is discharged. Hence arise what are termed mud-lavas or aqueous lavas, which in many respects behave like true igneous lavas. This mud eventually consolidates into one of the numerous forms of tuff,—a rock which, as has been already stated (p. 214), varies greatly in the amount of its coherence, in its composition, and its internal arrangement. Obviously, unless where subsequently altered, it can possess none of the crystalline structure of true lavas. As a rule it betrays its aqueous origin by more or less distinct evidence of stratification, by the multifarious pebbles, stones, blocks of rock, tree-trunks, branches, shells, bones, skeletons, which it has swept along in its course and preserved within its mass. Sections of this compacted tuff may be seen at Herculaneum. The *trass* of the Brohl Thal and other valleys in the Eifel district, referred to on p. 214, is another example of an ancient volcanic mud.

2. *Lavas.*—The term lava is applied generally to all the molten rocks which flow out from volcanoes.[1] The behavior of the lava as it issues and flows down the volcanic cones will be described in the next sub-section. It will be sufficient to refer here to some of the leading peculiarities of the lavas viewed as volcanic products. (1.) Their specific gravity ranges between 2·37 and 3·22. (2.) The heavier varieties contain much magnetic or titaniferous iron, with augite and olivine, their composition being basic, and their proportion of silica averaging about 45 or 50 per cent. In this group come the basalts, dolerites, nepheline-lavas, and leucite-lavas. The lighter varieties contain commonly a minor proportion of metallic bases, but are rich in silica, their percentage of that acid ranging between 60 and 80. They are thus not basic but acid rocks. Among their more important species, trachyte, rhyolite, obsidian, pitchstone, and pumice may be enumerated. (3.) They differ much in texture. (*a*) Some are entirely crystalline, consisting of nothing but an interlaced mass of crystals and crystalline particles, as in some dolerites. (*b*) Some show more or less of a half-glassy or stony matrix, in which the constituent crystals are imbedded; this is the most common arrangement. (*c*) Others are entirely vitreous, such crystals or crystalline particles as occur in them being quite subordinate, and, so to speak, accidental enclosures in the main glassy mass. Obsidian or volcanic glass is the type of this group. (*d*) They further differ in the extent to which their mass has been affected by the interstitial steam at the time of their eruption. Some show no outward signs of any influence from that cause; in others, however, the expansion of the imprisoned steam has been such as to expand the still molten stone into an open cellular texture, somewhat like that of open ill-baked bread. Such a vesicular arrangement very commonly appears on the upper surface of a lava current. (4.) They vary greatly in color and general external aspect. The heavy basic lavas are usually dark-grey, or almost black, though, on exposure to the weather, they usually acquire a brown tint from the oxidation and hydration of their iron. Their surface is commonly rough and rugged, until it has been sufficiently decomposed by the atmosphere to crumble into excellent soil which, under favorable circumstances, supports a luxuriant vegetation. The less dense lavas, such as phonolites and trachytes, are frequently paler in color, sometimes pale yellow or buff, and decompose into light soils; but the obsidians present rugged black sheets of rock roughened with ridges and heaps of froth-like pumice.

3. *Fragmentary Materials.*—Under this title we include all the substances which, driven up into the air by volcanic explosions, fall in solid form to the ground—the dust, ashes, sand, cinders, and blocks of every kind which are projected from a volcanic orifice. These materials must obviously differ greatly in composition, texture, and appearance, even during a single eruption, and still more in successive explosions of the same volcano. For the sake of convenience separate names are applied to some of the more distinct varieties. Of these the more important are the following. (1.) *Ashes and Sand.*—In many eruptions vast quantities of an exceedingly fine light-grey powder are ejected. As this substance greatly resembles what is left after a piece of wood or coal is burnt in an open fire, it has been popularly termed *ash*, and this name has been adopted by geologists. If, however, by the word ash the result of combustion is implied, its employment to denote any product of volcanic action must be regretted as apt to convey a wrong impression. The fine ashlike dust ejected by a volcano is merely lava in an extremely fine state of comminution. So minute are the particles that they find their way readily through the finest chinks of a closed room, and settle down upon floor and furniture as ordinary dust does when a house is shut up for a short time. From this finest form of material gradations may be traced through what is termed volcanic sand into the coarse varieties of ejected matter. In composition the ash and sand vary necessarily with the nature of the lava from which they are derived. (2.) When the fragments range from the size of a pea to that of a walnut they are called *lapilli.* These are pieces of lava, round, subangular, or angular in shape, and having the same indefinite range of composition as the finer dust. As a rule, the coarse fragments fall nearest the focus of eruption. Sometimes they are solid fragments of lava, but more usually they have a cellular texture, while sometimes they are so light and porous as to float readily on water, and, when ejected near the sea, to cover its surface over a large area. (3.) *Volcanic Blocks* are large pieces of stone, often angular in shape. In some cases they appear to be fragments loosened from already solidified rocks in the chimney of the volcano. Hence we find among them pieces of older tuffs, and of lavas recognizably belonging to early eruptions. But in other and numerous instances they are not volcanic rocks at all, but belong to earlier formations through which the volcanic chimney has been drilled. Blocks of a coarsely

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[1] "Alles ist lava was im Vulkane fliesst und durch seine Flüssigkeit neue Lagerstätter einnimmt" is Leopold Von Buch's comprehensive definition.

crystalline granitoid lava have been particularly observed both on Etna and Vesuvius. In the year 1870 a mass of that kind weighing several tons was to be seen lying at the foot of Vesuvius, within the entrance to the Atrio del Cavallo. Similar blocks occur among the Carboniferous volcanic pipes of central Scotland. In the older tuffs of Somma, blocks of altered limestone form the chief repositories of the Vesuvian minerals. (4.) *Volcanic Bombs and Slags.*—These have originally formed portions of the column of lava ascending the pipe of the volcano, and have been detached and hurled into the air by the successive explosions of steam. In the case of a bomb, we have a round, elliptical, or pear-shaped and often discoidal mass of lava, from a few inches to several feet in diameter. Sometimes it is tolerably solid throughout, more usually vesicular. Not unfrequently it consists of a hollow interior, with a shell which is vesicular towards the centre and becomes more close-grained towards the outside. There can be no doubt that, when torn by eructations of steam from the surface of the boiling lava, the material of these bombs was in as thoroughly molten a condition as the rest of the mass. From the rotatory motion imparted by its ejection, it took a circular form, and in proportion to its rapidity of rotation and fluidity would be the amount of its "flattening at the poles." The centrifugal force within would allow the expansion of the interstitial vapor, while the outer surface would rapidly cool and solidify; hence the solid crust, and the porous or even cavernous interior. Such bombs, varying from the size of an apple to that of a man's body, were found by Mr. Darwin abundantly strewed over the ground in the island of Ascension.[1] They have been found likewise in the tuff of Lower Carboniferous date at Dunbar, in Scotland. When the ejected fragment of lava has a rough irregular form, and a porous structure like the clinker of an iron-furnace, it is known as a *slag*.

The fragmentary materials erupted by a volcano and deposited around it acquire by degrees more or less consolidation partly from the mere pressure of the higher upon the lower strata, partly from the influence of infiltrating water. It has been already stated (part ii., p. 214) that different names are applied to the rocks thus formed. The coarse, tumultuous, unstratified accumulation of volcanic debris within a crater or funnel is called agglomerate. When the debris, though still coarse, is more rounded, and is arranged in a stratified form, it is a volcanic conglomerate. The finer-grained varieties, formed of dust and lapilli, are included in the general designation of tuffs. These are usually pale-yellowish, greyish, or brownish, sometimes black rocks, granular, porous, and often incoherent in texture. Organic remains sometimes occur in tuff. Where the volcanic debris has accumulated over the floor of a lake, or of the sea, the entombing and preserving of shells and other organic objects must continually take place. But even in the tuffs of a volcanic cone traces of animals and plants may be preserved. Professor Guiscardi of Naples has found about 100 species of marine shells of living species in the old tuffs of Vesuvius. Marine shells have been picked up within the crater of Monte Nuovo, and have been frequently observed in the old or marine tuff of that district. The showers of ash which fall on the outer slopes of a volcano, or the sheets of mud which sometimes are spread out there, cover over and often preserve the land-shells, insects, and vegetation living on the area at the time. The older tuffs of Vesuvius have yielded many remains of the shrubs and trees which at successive periods have clothed the flanks of the mountain.

§ 2. *Volcanic Action.*

We have now to consider the circumstances under which the various solid, liquid, and gaseous products of a volcano are emitted. Volcanic action may be either constant or periodic. Stromboli, in the Mediterranean, so far as we know, has been uninterruptedly emitting hot stones, steam, and lava, from the earliest period of history. Among the Moluccas the volcano Sioa, and in the Friendly Islands that of Tofua, have never ceased to be in eruption since their first discovery. The lofty cone of Sangay, among the Andes of Quito, is always giving off hot vapors; Cotopaxi, too, is ever constantly active. But, though examples of unceasing action may thus be cited from widely different quarters of the globe, they are nevertheless exceptional. The general rule is that a volcano breaks out from time to time with greater or less fury, and after longer or shorter intervals of quiescence.

To what particular cause or series of causes any special eruption may be due is a question to which at present no definite answer can be given. An attempt has been made to show that the explosions of a volcano are to some extent regulated by the conditions of atmospheric pressure over the area at the time. In the case of a volcanic funnel like Stromboli, where, as Mr. Scrope pointed out, the expansive subterranean force within, and the repressive effect of atmospheric pressure without, just balance each other, any serious disturbance of that pressure might be expected to make itself evident by a change in the condition of the volcano. Accordingly, it has long been remarked by the fishermen of the Lipari Islands that in stormy weather there is at Stromboli a more copious discharge of steam and stones than in fine weather. They make use of the cone as a weather-glass, the increase of its activity indicating a falling, and the diminution a rising barometer. In like manner Etna, according to S. von Waltershausen, is most active in the winter months. When we remember the connection now indubitably established between a more copious discharge of fire-damp in mines and a lowering of atmospheric pressure, we may be prepared to find a similar influence affecting the escape of vapors from the upper surface of the lava column of a volcano; for it must not be forgotten that it is not so much to the lava itself as to the expansive vapors accompanying it that the manifestations of volcanic activity are due. Among the Vesuvian eruptions since the middle of the 17th century, the number which took place in winter and spring was to that of those which broke out in summer and autumn as 7 to 4. But there may be other causes besides atmospheric pressure concerned in these differences; the preponderance of rain during the winter and spring may be one of these. At present we must wait for further data.

Kluge has sought to trace a connection between the years of maximum and minimum sun-spots and those of greatest and feeblest volcanic activity, and has constructed lists to show that years which have been specially characterized by terrestrial eruptions have coincided with those marked by few sun-spots and diminished magnetic disturbance.[2] Such a connection cannot be regarded as having yet been satisfactorily established. Again, the same author has called attention to the frequency and vigor of volcanic explosions about the middle of August, at or near the time of the yearly meteoric shower. But in this case, likewise, the cited examples can hardly yet be looked upon as more than coincidences.

The case of Kilauea, in Hawaii, seems to show a regular system of eruptive periods. Dana has pointed out that outbreaks of lava have taken place from that volcano at intervals of from eight to nine years, this being the time required to fill the crater up to the point of outbreak, or to a depth of 400 or 500 feet. But the great eruption of 1868 did not occur until after an interval of 18 years. The same author suggests that the missing eruption may have been submarine.

The approach of an eruption is not always indicated by any premonitory symptoms, for many tremendous explosions are recorded to have taken place in different parts of the world without any perceptible warning. Much in this respect would appear to depend upon the condition of liquidity of the lava, and the amount of resistance offered by it to the passage of the escaping vapors through its mass. In Hawaii, where the lavas are remarkably liquid, vast outpourings of lava have taken place quietly without earthquakes during the present century. But even there the great eruption of 1868 was accompanied by tremendous earthquakes.

The eruptions of Vesuvius are often preceded by a failure or diminution of the wells and springs in the district. But more frequent indications of an approaching outburst are conveyed by sympathetic movements of the ground beneath. Rumblings and groanings from a subterranean source are heard; slight tremors succeed, increasing in frequency and violence till they become distinct earthquake shocks. The vapors from the crater rise more abundantly into the air. All this time the lava column in the pipe or funnel of the volcano has been slowly ascending, forced upward and kept in perpetual agitation by the passage of the elastic vapors through its mass. If a long previous interval of quiescence has elapsed, there may be much solidified lava towards the top of the vent which will restrain the ascent of the still molten portion underneath. A vast pressure is thus exercised on the sides of the cone. Should these be too weak to resist, they will open in one or more rents, and the liquid lava will issue from the outer slope of the mountain; or the energies of the volcano will be directed towards clearing the obstruction in the chief throat, until, with tremendous explosions, and the rise of a vast cloud of dust and fragments, the bottom and sides of the crater are finally blown out, and the top of the cone disappears. The lava may now escape from the lowest part of the lip of the crater, while, at the same time, immense numbers of red-hot bombs, scoriæ, and stones are shot up into the air, most of them falling back into the crater, but many descending upon the outer slopes of the cone, and some even upon the country beyond the base of the mountain. The lava rushes down at first like one or more rivers of melted iron, but, as it cools, its rate of motion lessens. Clouds of steam rise from its surface, as well as from the central crater. Indeed, every successive paroxysmal convulsion of the mountain is marked, even at a distance, by the rise of huge ball-like wreaths or clouds of steam, mixed with dust and stones, forming a vast column which towers sometimes a couple of miles above the summit of the cone. By degrees these diminish in frequency and intensity. The lava ceases to flow, the showers of stones and dust dwindle down, and after a time, which may vary from hours to days or months, even in the *régime* of the same mountain, the volcano becomes once more tranquil.

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[1] *Geological Observations on Volcanic Islands*, 2d edit., p. 42.

[2] *Ueber Synchronismus und Antagonismus*, p. 72.

Let us now consider some of the aspects of this action which have more particular geological interest from the permanent changes with which they are connected, or from the way in which they enable us to detect and realize conditions of volcanic energy in former periods.

Fissures.—During the convulsions which culminate in the formation of a volcano, as well as in the subsequent progress of the mountain so formed, the ground at and around the focus of action is liable to be rent open by fissures. These tend to diverge from the focus; but around the vent where the rocks have been most exposed to concussion the fissures sometimes intersect each other in all directions. In the great eruption of Etna, in the year 1669, a series of six parallel fissures opened on the side of the mountain. One of these, with a breadth of two yards, ran for a distance of 12 miles, in a somewhat winding course, to within a mile of the top of the cone. Similar fissures, but on a smaller scale, have often been observed on Vesuvius; and they are recorded from many other volcanoes.

Two obvious causes may be assigned for the production of fissures:—(1) the enormous expansive force of the imprisoned vapors acting upon the walls of the funnel and convulsing the cone by successive explosions; and (2) the hydrostatic pressure of the lava-column in the funnel, amounting to about 125 lb per square inch, or 8 tons on the square foot, for each 100 feet of depth. Both of these causes may act simultaneously.

Into the rents thus formed the molten lava naturally finds its way. It is indeed forced into them, and solidifies there like iron in a mould. The cliffs of many an old crater show how marvellously they have been injected by such *veins* or *dykes* of lava. Those of Somma, and the Val del Bue on Etna, have long been known. The dykes project now from the softer tuffs like great walls of masonry. Such wedges of solid rock driven into the cone must widen its dimensions, and at the same time from their length and ramifications must bind the substance of the cone together, and thus strengthen it against the effects of future convulsions. We can understand, therefore, how there should be for a time an alternation in the character of the eruptions of a volcano, depending in great measure upon the relation between the height of the cone on the one hand and the strength of its sides on the other. When the sides have been well braced together by interlacing dykes, and further thickened by the spread of volcanic materials all over their slopes, they may resist the effects of explosion and of the pressure of the ascending lava-column. In this case the volcano may find relief only from its summit, and if the lava flows forth it will do so from the top of the cone. As the cone increases in elevation, however, the pressure from within upon its sides augments. Eventually egress is once more established on the flanks by means of fissures and a new series of lava-streams is poured out over the lower slopes.

Though lava very commonly issues from the lateral fissures on a volcanic cone, it may sometimes approach the surface without actually flowing out. The great fissure on Etna in 1669, for example, was visible even from a distance by the long line of vivid light which rose from the incandescent lava within. Again, it frequently happens that minor volcanic cones are thrown up on the line of a fissure. This may arise either from the congelation of the lava round the point of emission, or from the accumulation of ejected scoriæ round the fissure-vent. Of the former structure examples occur in Hawaii, where the lava is remarkably liquid, and rapidly hardens into tears or drops, like wax down the sides of a candle. Where in viscid lavas the steam tears off and throws up many scoriæ and bombs, a cone of such loose materials will naturally form round the orifice by which the lava escapes from the flank of the mountain.

Explosions.—Although volcanic materials may be erupted to a large extent without the appearance of visible fissures, they cannot in such cases reach the surface without some explosive action, and the consequent displacement and removal of previously existing rock. Vents are thus blown out of the solid crust, the volcanic energy being, as it were, concentrated on a given point, which we may suppose must usually be the weakest in the structure of that part of the crust. The operation has often been observed in volcanoes already formed, and has even been witnessed on ground previously unoccupied by a volcanic vent. The history of the cone of Vesuvius brings before us a long series of such explosions, beginning with that of 79—the greatest which has occurred within the times of human history—and coming down to the present day. Even now, in spite of all the lava and ashes poured out during the last eighteen centuries, it is easy to see how stupendous must have been that earliest explosion, by which the southern half of the ancient crater was blown out. At every successive important eruption, a similar but minor operation takes place within the present cone. The hardened cake of lava forming the floor is burst open, and with it there usually disappears much of the upper part of the cone, and sometimes, as in 1872, a large segment of the crater-wall. In the year 1538 a new volcano, Monte Nuovo, was formed in 24 hours on the margin of the Bay of Naples. A cavity was drilled by successive explosions, and such quantities of stones, scoriæ, and ashes were thrown out from it as to form a hill 440 English feet above the sea-level, and more than a mile and a half in circumference. Most of the fragments now to be seen on the slopes of the cone and inside its beautifully perfect crater are of various volcanic rocks, many of them being black scoriæ; but pieces of Roman pottery, together with fragments of the older underlying tuff, and some marine shells, have been obtained; and these doubtless formed part of the soil and subsoil dislocated and ejected during the explosions.

It is not necessary, and it does not always happen, that any actual solid or liquid volcanic rock is ejected even when explosions of considerable violence take place, whereby the rocks through which the funnel rises are much shattered. Thus among the cones of the extinct volcanic tract of the Eifel, some occur consisting entirely, or nearly so, of comminuted debris of the Devonian greywacke and slate which form the prevailing rocks there, and through which the various volcanic vents have been opened. Evidently in these cases elastic vapors only forced their way to the surface; and we see what probably often takes place in the early stages of a volcano's history, though the fragments of the underlying disrupted rocks are in most instances buried and lost under the far more abundant subsequent volcanic materials. Sections of ancient volcanic necks or pipes sometimes afford an excellent opportunity of observing that these orifices were originally opened by the blowing out of the solid crust and not by the formation of fissures. Many examples occur in Scotland among volcanic rocks of Old Red Sandstone, Carboniferous, and Permian age. The orifices are there filled with fragmentary materials wherein portions of the surrounding and underlying rocks form a noticeable proportion.

Showers of Dust and Stones.—A communication having been opened, either by fissuring or explosion, between the heated interior and the surface, fragmentary materials seldom fail to be ejected from it. These may consist at first mainly of the rocks through which the orifice has been opened, as has just been explained. But if eruptive energy continues, they soon appear in larger quantities, and consist of thoroughly volcanic substances. In a great eruption vast numbers of red-hot stones are shot up into the air, and fall back partly into the crater and partly on the outer slopes of the cone. But instances are known where large stones, ejected obliquely, have described huge parabolic curves in the air, and fallen at a great distance. Stones 8 ℔ in weight occur among the ashes which buried Pompeii. The volcano of Antuco in Chili is said to send stones flying to a distance of 36 miles, and Cotopaxi is reported to have hurled a 200-ton block 9 miles.

But in many great eruptions, besides a constant shower of stones and scoriæ, a vast column of exceedingly fine dust rises out of the crater, sometimes to a height of more than a mile, and then spreads outwards like a sheet of cloud. So dense sometimes is this dust-cloud that the sun is obscured, and for days together the darkness of night reigns for miles around the volcano. In 1822 this was the case at Vesuvius, the ashes not only falling thickly on the villages round the base of the mountain, but travelling as far as Ascoli, which is 56 Italian miles distant from the volcano on one side, and as Casano, 105 miles on the other. But probably the most stupendous outpouring of volcanic ashes on record was that which took place, after a quiescence of 26 years, from the volcano Coseguina, in Nicaragua, during the early part of the year 1835. On that occasion utter darkness prevailed over a circle of 35 miles radius, the ashes falling so thickly that, even 8 leagues from the mountain, they covered the ground to a depth of about 10 feet. It was estimated that the rain of dust and sand fell over an area at least 270 geographical miles in diameter. Some of the finer materials, thrown so high as to come within the influence of an upper air-current, were borne away eastward, and fell four days afterwards at Kingston, in Jamaica—a distance of 700 miles.

An inquiry into the origin of these showers of fragmentary materials brings vividly before us some of the essential features of volcanic action. We find that bombs, slags, and lapilli may be thrown up in comparatively tranquil states of a volcano, but that the showers of fine dust are discharged with violence, and only appear when the volcano becomes more energetic. Thus, at the constantly, but quietly, active volcano of Stromboli, the column of lava in the pipe may be watched slowly rising and falling with a slow rhythmical movement. At every rise the surface of the lava swells up into blisters several feet in diameter, which by and by burst with a sharp explosion that makes the walls of the crater vibrate. A cloud of steam rushes out, carrying with it hundreds of fragments of the glowing lava, sometimes to a height of 1200 feet. It is by the ascent of steam through its mass that a column of lava is kept boiling at the bottom of a crater, and by the explosion of successive larger bubbles of steam that the various bombs, slags, and fragments of lava are torn off and tossed into the air. It has often been noticed at Vesuvius that, after each great concussion, a huge ball-like cloud of steam rushes up from the crater. Doubtless it is the sudden escape of that steam which causes the explosion. The violence of the explosion will depend greatly upon the viscidity of the lava, and the consequent resistance offered to the upward passage of the steam. Explosions and accompanying scoriæ are abundant at Vesuvius, where the lavas are comparatively viscid; they are almost unknown at Kilauea, where the lava is remarkably liquid.

The steam, collecting into larger or smaller vesicles, works its way upwards through the substance of the molten lava. As the elasticity of this compressed vapor overcomes the pressure of the overlying lava, it escapes at the surface, and there the lava is thus kept in ebullition. But this comparatively quiet operation, which may be watched within the craters of many active volcanoes, does not produce clouds of fine dust. The friction of the millions of stones ascending and descending through the air in the dark column above the crater, though it must doubtless cause much dust and sand, can give rise to but an insignificant proportion of what is actually reduced to the condition of extreme subdivision necessary to produce widespread darkness and a thick far-reaching deposit of ashes. The explanation now accepted calls in the explosive action of steam as the immediate cause of the trituration. A sudden and powerful explosion of steam, it is maintained, will blow the top of the lava column into dust, like water shot out of a gun. We must remember that the aqueous vapor by which many lavas are so largely impregnated must exist interstitially far down in the lava-column, under an enormous pressure, and at a white heat. The sudden ascent of lava so constituted will relieve the pressure rapidly without sensibly affecting the temperature of the mass. Consequently the white-hot steam will at length explode, and reduce the molten mass containing it to the finest powder.

Evidently no part of the operations of a volcano has greater geological significance than the ejection of such enormous quantities of fragmentary matter. In the first place, the fall of these loose materials round the orifice of discharge is one main cause of the growth of the volcanic cone. The heavier fragments gather round the vent, and there too the thickest accumulation of finer dust takes place. Hence, though successive explosions may blow out the upper part of the crater-walls, and prevent the mountain from growing so rapidly in height, every eruption must add to the diameter of the cone. In the second place, as every shower of dust and sand adds to the height of the ground on which it falls, thick volcanic accumulations may be formed far beyond the base of the mountain. In these are entombed trees and other kinds of vegetation, together with the bodies of many animals, as well as the works of man. Hence new geological formations arise which, in their component materials, not only bear witness to the volcanic eruptions which produced them, but preserve a record of the land-surfaces over which they spread. In the third place, besides the distance to which the fragments may be hurled by volcanic explosions, or to which they may be diffused by the ordinary aerial movements, we have to take into account the vast spaces across which the finer dust is sometimes borne by upper currents in the atmosphere. An instance has already been cited where ashes from Coseguina fell 700 miles away, having been carried all that long distance by a high counter-current of air, moving apparently at the rate of about 7 miles an hour in an opposite direction to that of the wind which blew at the surface. On several occasions ashes from one of the Icelandic volcanoes have fallen so thickly between the Orkney and Shetland Islands that vessels passing there have had the unwonted deposit shovelled off their decks in the morning. In the year 1783, during an eruption of Skaptar-Jökull, so vast an amount of fine dust was ejected that the atmosphere over Iceland continued loaded with it for months afterwards. It fell in such quantity over parts of Caithness—a distance of 600 miles—as to destroy the crops; that year is still spoken of by the inhabitants as the year of "the ashie." Traces of the same deposit were observed even as far as Holland. Hence it is evident that volcanic deposits may be formed in regions many hundreds of miles distant from any active volcano. A single thin layer of volcanic detritus in a group of sedimentary strata would thus not of itself prove the existence of contemporaneous volcanic action in its neighborhood. It might be held to have been wind-borne from a volcano in a distant and separate region.

Lava-streams.—A microscopic examination of their intimate structure shows that lavas have been truly molten rocks. They usually consist fundamentally of a glass through which are diffused, in greater or less abundance, various microlites and crystals. Their degree of liquidity, at the time of emission, seems to depend on the extent to which the rock remains in the condition of glass, viscidity increasing with the development of the microlites and crystals out of the glassy menstruum in which, no doubt, originally their component molecules were diffused. The fluidity may also be governed in no small degree by the amount of vapor existing interstitially in the molten mass. Mr. Scrope indeed contended that aqueous vapor was the main cause of the mobility of such crystalline lavas as those of Vesuvius. But even where the lava pours forth with a liquidity like that of melted iron, it speedily assumes a more viscid motion, as the process of devitrification advances and the rock is exposed to the chilling effects of radiation and of contact with air and soil. An interesting fact, admirably shown by the microscope, but often easily observable with the naked eye, is that in lava still liquid and mobile well-defined crystals make their appearance. These sometimes are broken during the continued movement of the surrounding mass, the separated fragments becoming involved in the general glassy base, or portions of that base, are injected into the fractures of the crystals. Well-defined crystals of leucite may be seen in specimens of Vesuvian lava, which has been ladled out from a white-hot stream, impressed with a stamp, and thus suddenly congealed. On the other hand, the obsidians have solidified in the condition of complete glass, often without any trace of devitrification. The green pyroxenic lava of Hawaii exhibits so extreme a degree of fluidity that, during its ebullition in pools of the crater, jets not more than a quarter of an inch in diameter are tossed up, and, falling back on one another, make "a column of hardened tears of lava," while, in other places, the jets thrown up and blown aside by the wind give rise to long threads of glass which lie thickly together like mown grass, and are known by the natives under the name of Pele's Hair, after one of their divinities.[1]

It would be of the highest interest and importance to know accurately the temperature with which a lava stream issues. The difficulty of making any direct observation at the point of outflow has hitherto been insuperable. Measurements have been taken at various distances below the point where the moving lava could be safely approached; but these are not satisfactory, seeing that the outer crust of the lava cools rapidly, and gives no measure of the temperature even a short way underneath. Experiments made by Scacchi and Sainte-Claire Deville on the Vesuvian lava erupted in 1855, by thrusting thin wires of silver, iron, and copper into the lava, indicated a temperature of scarcely 700° C. Earlier observations of a similar kind, made in 1819, when a silver wire $\frac{1}{30}$th inch in diameter at once melted in the Vesuvian lava of that year, gave a greatly higher temperature. Evidence of the high temperature of lava has been adduced from the alteration it has affected upon refractory substances in its progress, as where, at Torre del Greco, it overflowed the houses, and was afterwards found to have fused the fine edges of flints, to have decomposed brass into its component metals, the copper actually crystallizing, and to have melted silver, and even sublimed it into small octohedral crystals. But such facts, though full of interest and importance, give us no clue to the absolute initial temperature of the lava, which must be greatly higher than that of the stream after several miles of descent on the mountain slopes, and after some hours or days of cooling.

In spite of this very high temperature, however, the lava issues abundantly charged with aqueous vapor, to the expansion of which, as we have seen, its ebullition and expulsion are mainly due. As this vapor at once begins to escape when the lava issues into the air, it shows itself by a dense white cloud hanging over the moving mass. The lava streams of Vesuvius sometimes appear with as large and dense a steam cloud at their lower ends as that which escapes at the same time from the main crater. Even after the molten mass has flowed several miles, steam continues to rise abundantly both from its end and from numerous points along its surface.

From the wide extent of basalt dykes, such as those of Britain, some of which rise to the surface at a distance of 200 miles and upwards from the main volcanic regions of their time, it is evident that the molten lava may sometimes occupy a far greater superficial area underneath than the mere circumference of the actual pipe or of the volcanic cone. We must conceive of a vast reservoir of melted rock impregnated with superheated steam, and impelled upwards by the elastic force of the vapor. The lava may be regarded rather as the sign than as the cause of volcanic action. It is the pressure of the imprisoned vapor, and its struggles to get free, which produce the subterranean earthquakes, the explosions, and the outpouring of lava. As soon as the vapor finds relief, the terrestrial commotion calms down again, and the quiescence continues until another accumulation of vapor demands a repetition of the same phenomena.

It is evident that the vapor may succeed in effecting its escape without driving molten rock up to the surface. There may be tremendous explosions without an actual outcome of lava. But, in most cases, so intimately are vapors and lava commingled in the subterranean reservoirs that they rise together, and the explosions of the one lead to the outflow of the other. The first point at which the lava makes its appearance at the surface will largely depend upon the structure of the ground. Two causes have been assigned in a foregoing section (p. 218) for the fissuring of a volcanic cone. As the molten mass rises within the chimney of the volcano, continued explosions of vapor take place from its upper surface, the violence of which may be inferred from the vast clouds of steam, of ashes, and of stones which are hurled to so great a height into the air. These explosions must at the same time powerfully affect the sides of the funnel, exposed as these are to the enormous pressure exerted by the imprisoned vapor. We cannot therefore be surprised that, when a volcano experiences shocks of such intensity as to be felt over a radius 100 miles or more, its sides should at last give way, and large divergent fissures should be opened down its cone. Again, the hydrostatic pressure of the column of lava must have a potent influence. At a depth of 1000 feet below the top of the column the pressure exerted on each square foot of the surrounding walls must amount to more than 80 tons. We may well believe that such a force, acting upon the walls of a funnel already shattered by a succession of terrific explosions, will be apt to prove too great for their resistance. When this happens, the lava pours forth from the outside of the cone. So fissured is the cone sometimes that the lava issues freely from many points. A volcano so affected has been graphically described as "sweating fire." More usually the lava issues only from one or two points. Should these lie well down on the cone, far below the summit of the lava-column, the lava, on its first escape, driven by hydrostatic pressure, will sometimes spout up high into the air—a fountain of molten rock. This was observed in 1794 on Vesuvius, and in 1832 on Etna. In the eruption of 1852 at Mauna Loa, an unbroken fountain of lava, from 200 to 700 feet in height and 1000 feet broad, burst out at the base of the cone. Similar "geysers" of molten rock have subsequently been noticed in the same region. Thus, in March and April, 1868, four fiery fountains, throwing the lava to heights varying from 500 to 1000 feet, continued to play for several weeks.

In a lofty volcano, therefore, the chances are always rather against the lava rising to the lip of the crater and flowing out there. It does so now and then; but more frequently it escapes from some fissure or orifice in a weak part of the cone. In minor volcanoes, on the other hand, where the explosions are less violent, and where the thickness of the cone in proportion to the diameter of the funnel is often greater, the lava very commonly rises in the crater. Should the crater walls be too weak to resist the pressure of the molten mass, they will give way, and the lava will rush out from the breach. This is seen to have happened in several of the puys of Auvergne, so well figured and described by Mr. Scrope. But if the crater be massive enough to withstand the pressure, the lava, if still impelled upward by the struggling vapor, will at last flow out from the lowest part of the rim.

It was at one time supposed that lava beds could not consolidate on such steep slopes as those of most volcanoes, and that their present inclined position was to be attributed to a central upheaval of each mountain. This idea formed the subject of the famous theory of elevation-craters (*Erhebungskratere*) of L. von Buch, E. de Beaumont, and other geologists. It was a matter of prime importance in the interpretation of volcanic action to have this question settled. To Constant Prevost belongs the merit of having completely exposed the fallacy of this theory. He pointed out that there was no more reason why lavas should not consolidate on steep slopes than that tears or drops of wax should not do so. Mr. Paulett Scrope also showed conclusively that the steep slope of the lava-beds of a volcanic cone was original. Sir Charles Lyell and Mr. Hartung subsequently obtained abundant additional evidence from the Canary Islands, Etna, and other volcanic districts, to disprove the elevation theory. Geologists are now agreed that thick sheets of lava, with all their characteristic features, can consolidate on slopes of even 35° and 40°. The lava in the Hawaii Islands has cooled rapidly on slopes of 25°, that from Vesuvius, in 1855, is here and there as steep as 30°. On the east side of Etna, a cascade of lava, which poured, in 1689, into the vast hollow of the Cava Grande, has an inclination varying from 18° to 48°, with an average thickness of 16 feet. On Mauna Loa some lava-flows are said to have congealed on slopes of 49°, 60°, and even 80°, though in these cases it could only be a layer of rock stiffening and adhering to the surface of the steep slope. Even when it consolidates on a steep slope, a stream of lava forms a sheet with parallel, upper, and under surfaces, a general uniformity of thickness, and often greater evenness of surface than where the angle of descent is low.

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[1] Dana, *Geol. U. S. Explor. Exped.*, p. 179.

At its first appearance, where it issues from the mountain, the lava glows with a white heat, and flows with a motion which has been compared to that of honey or of melted iron. It soon becomes red, and, like a coal fallen from a hot fireplace, rapidly grows dull as it moves along, until it assumes a black, cindery aspect. At the same time the surface congeals, and soon becomes solid enough to support a heavy block of stone. Its aspect depends, not merely on the composition and fluidity of the lava, but on the point of egress, whether from the crater or from a fissure, on the form of the ground, the angle of slope, and the rapidity of flow. Lavas which have been kept in ebullition within the central chimney are apt to acquire a rough cellular texture. The surface of the moving stream breaks up into rough brown or black cinder-like slags, and irregular rugged cakes, which, with the onward motion, grind and grate against each other with a harsh metallic sound, sometimes rising into rugged mounds or getting seamed with rents and gashes, at the bottom of which the red-hot glowing lava may be seen. When lava escapes from a lateral fissure it may have no scoriæ, but its surface will present froth-like, curving lines, as in the scum of a slowly flowing river, or will be arranged in curious ropy folds, as the layers have successively flowed over each other and congealed. These and many other fantastic coiled shapes were exhibited by the lava which flowed from the side of Vesuvius in 1858. A large area which has been flooded with lava is perhaps the most hideous and appalling scene of desolation anywhere to be found on the surface of the globe.

A lava stream at its point of escape from the side of a volcanic cone occupies a comparatively narrow breadth; but it usually spreads out as it descends, and moves more slowly. The sides of the moving mass look like huge embankments, or like some of the long mounds of "clinkers" one sees in a great manufacturing district. The advancing end of the mass is often much steeper, creeping onward like a great wall or rampart, down the face of which the rough blocks of hardened lava are ever rattling.

The rate of movement is regulated by the fluidity of the lava, by its volume, and by the form and inclination of the ground. Hence, as a rule, a lava-stream moves faster at first than afterwards, because it has not had time to stiffen, and its slope of descent is considerably steeper than further down the mountain. One of the most fluid and swiftly flowing lava-streams ever observed on Vesuvius was that erupted on 12th August, 1805. It is said to have rushed down a space of 3 Italian (3¾ English) miles in the first four minutes, but to have widened out and moved more slowly as it descended, yet finally to have reached Torre del Greco in three hours. A lava erupted by Mauna Loa in 1852 went as fast as an ordinary stage-coach, or 15 miles in two hours. Long after a current has been deeply crusted over with slags and rough slabs of lava it continues to creep slowly forward for weeks or even months.

It happens sometimes that, as the lava moves along, the pressure of the still molten mass inside bursts through the outer hardened and deeply seamed crust, and rushes out with, at first, a motion much more rapid than that of the main stream; but such an offshoot rapidly congeals and comes to rest, though sometimes not before doing much damage to vineyards, gardens, houses, or other property in its course. Any sudden change in the form or slope of the ground, too, will affect the flow of the lava. Thus, should the stream reach the edge of a steep defile or cliff, it will pour over it in a cataract of glowing molten rock, with clouds of steam, showers of fragments, and a noise utterly indescribable. Or if, on the other hand, the current should encounter a ridge or hill across its path, it will accumulate in front of it until it either finds egress round the side or actually overrides and entombs the obstacle. The hardened crust or shell within which the still fluid lava moves serves to keep the mass from spreading. We often find, however, that the lava has subsided here and there inside its crust, and has left curious cavernous spaces and tunnels. Into these, when the whole is cold, we may creep, and may find them sometimes festooned and hung with stalactites of lava.

As a rule a lava-stream shows three component layers. At its bottom lies a rough, slaggy mass, produced by the rapid cooling of the lava, and the breaking up and continued onward motion of the scoriform layer. The central and main portion of the stream consists of solid lava, often, however, with a more or less carious and vesicular texture. The upper part, as we have seen, is a mass of rough, broken-up slags, scoriæ, or clinkers. The proportions borne by these respective layers to each other vary continually. Some of the more fluid ropy lavas of Vesuvius have an inconstant and thin slaggy crust; others may be said to consist of little else than scoriæ from top to bottom. These divergences in texture seem to depend largely upon the amount of interstitial steam imprisoned within the lava, and the conditions under which it can effect its escape. Throughout the whole mass, but more especially along its upper surface, the steam under its diminished pressure expands, and pushing the molten rock aside, segregates into small bubbles or irregular cavities. Hence, when the lava solidifies, these steam-holes are seen to be sometimes so abundant that a detached portion of the rock containing them will float in water. They are often elongated in the direction of the motion of the lava-stream.

But, besides producing a general vesicular texture in the upper parts of the lava-stream, the aqueous vapor gives rise to much more striking features on the surface of the lava. If the outburst takes place from an orifice or fissure on the exterior of the volcanic cone, so vast an amount of steam will rush out there, with such boiling and explosion of the lava, that a cone of bombs, and slags, and irregular lumps of lava, will probably form round the spot—in fact a miniature or parasitic volcano, which will remain as a marked cone on its parent mountain long after the eruption which gave it birth has ceased. Moreover, even after such abundant discharge of steam, the lava-stream continues to exhale it, as it were, from every pore. Here and there on the surface of the moving mass a fissure opens, and a column of roaring hissing vapors rushes out from it, accompanied as before by an abundant discharge of lava-fragments, or even by the rise and outflow of the lava from beneath. Some lava-streams are thus dotted over with small cones a few feet or yards in height. Besides the steam which, in condensing, makes its presence so conspicuous, many other vapors entangled in the pores of the lava escape from its fissures. The points at which vapors are copiously disengaged are termed *fumarole*. Among the exhalations, chlorides may be mentioned as particularly prominent; chloride of sodium frequently shows itself, not only in fissures, but even over the cooled crust of the lava, in small crystals, in tufts, or as a granular and even glassy incrustation. Chloride of iron is deposited as a yellow coating at the *fumarole*, where also bright emerald-green films and scales of chloride of copper may be more rarely observed. Many chemical changes take place in the escape of the vapors through the lava. Thus specular iron, probably the result of the mutual decomposition of steam and iron chloride, forms abundant scales, plates, and small crystals in the *fumarole* and vesicles of the lava. Sal-ammoniac also appears in large quantity on many lavas, not merely in the fissures, but also on the upper surface of the current. This salt is not directly a volcanic product, but results from some decomposition, probably from that of the aqueous vapor, whereby a combination is formed with atmospheric nitrogen.

The hardened crust of a lava-stream is a bad conductor of heat. Consequently, when the surface of the mass has become cool enough to be walked upon, the red hot mass may be observed through the rents to lie only a few inches below. Many years therefore may elapse before the temperature of the whole mass has fallen to that of the surrounding soil. Eleven months after an eruption of Etna, Spallanzani could see that the lava was still red hot at the bottom of the fissures, and a stick thrust into one of them instantly took fire. The Vesuvian lava of 1785 was found by Breislak seven years afterwards to be still hot and steaming internally, though lichens had already taken root on its surface. The ropy lava erupted by Vesuvius in 1858 was observed in 1870 to be still so hot, even near its termination, that steam issued abundantly from its rents, many of which were too hot to allow the hand to be held in them. Hoffmann records that the lava which flowed from Etna in 1787 was still steaming in 1830. But still more remarkable is the case of Jorullo, in Mexico, which sent out lava in 1759. Twenty-one years later a cigar could still be lighted at its fissures; after 44 years it was still visibly steaming; and even in 1846, that is, after 87 years of cooling, two vapor columns were still rising from it.[1]

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[1] E. Schleiden, quoted by Naumann, *Geol.*, i. p. 160.

This extremely slow rate of cooling has justly been regarded as a point of high geological significance in regard to the secular cooling and probable internal temperature of our globe. Some geologists have argued indeed that, if so comparatively small a portion of molten matter as a lava-stream can maintain a high temperature under a thin, cold crust for so many years, we may, from analogy, feel little hesitation in believing that the enormously vaster mass of the globe may, beneath its relatively thin crust, still continue in a molten condition within. More legitimate deductions, however, might be drawn, if we knew more accurately and precisely in each case the rate of loss of heat, and how it varies in different lava-streams. Sir William Thomson, for instance, has suggested that, by measuring the temperature of intrusive masses of igneous rock in coal-workings and elsewhere, and comparing it with that of other non-volcanic rocks in the same regions, we might obtain data for calculating the time which has elapsed since these igneous sheets were erupted.

In its descent a stream of lava may reach a water-course, and, by throwing itself as a great embankment across the stream, may pond back the water and form a lake. Such is the origin of the picturesque Lake Aidat in Auvergne. Or the molten current may usurp the channel of the stream, and completely bury the whole valley, as has happened again and again among the vast lava-fields of Iceland. No change in physiography is so rapid and so permanent as this. The channel which has required, doubtless, many thousands of years for the water laboriously to excavate, is sealed up in a few hours under 100 feet or more of stone, and a still longer interval may elapse before this newer pile is similarly eroded.

By suddenly overflowing a brook or pool of water, molten lava sometimes has its outer crust shattered to fragments by a sharp explosion of the generated steam, while the fluid mass within rushes out on all sides. Numerous instances have occurred where the lavas of Etna and Vesuvius have protruded into the sea. Thus a current from the latter mountain entered the Mediterranean at Torre del Gréco in 1794, and pushed its way for 360 feet outwards, with a breadth of 1100 and a height of 15 feet. So quietly did it advance that Breislak could sail round it in a boat and observe its progress.

In passing from a fluid to a solid condition, and thus contracting, lava acquires different structures. Lines of divisional planes or joints traverse it, especially perpendicular to the upper and under surfaces of the sheet. These lines at various irregular distances cross each other so as to divide the rock into rude prisms. Occasionally another series of joints at a right angle to these traverses the mass parallel with its bounding surfaces, and thus the rock acquires a kind of fissile or bedded appearance. The most characteristic structure, however, among volcanic rocks is the prismatic, or, as it is incorrectly termed, "basaltic." Where this arrangement occurs, as it does so commonly in basalt, the mass is divided into tolerably regular pentagonal, hexagonal, or irregularly polygonal prisms or columns, set close together at a right angle to the main cooling surfaces. These prisms vary from 2 or 3 to 18 or more inches in diameter, and range up to 100 or even 150 feet in length.

Considerable discussion has arisen as to the mode in which this columnar structure has been produced. The experiments of Mr. Gregory Watt were supposed to explain it by the production of a number of spherical concretions in the cooling mass, and the gradual pressure of those soft balls into hexagonal columns, as the mass contracted in cooling. He melted a mass of basalt, and on allowing it to cool observed that, when a small portion was quickly chilled, it took the form of a kind of slag-like glass, not differing much in appearance from obsidian; a larger mass, more slowly cooled, returned to a stony state. He remarked that during this process small globules make their appearance, which increase in size by the successive formation of external concentric coats, like those of an onion. And he supposed, as each spheroid must be touched by six others, the whole, if exposed to the same pressure acting in every direction, must be squeezed into a series of hexagons. To account, however, for a long column of basalt, we should have to imagine a pile of balls standing exactly centrically one upon the other, an arrangement which seems hardly possible. The prismatic structure is a species of jointing, due to the contraction of the rock as a whole, and not to the production of any internal peculiarities of texture. The concretionary structure associated with the columnar arises from a common tendency to weather out into nodular forms, and may be observed even where the rock is not columnar. Prismatic forms have been superinduced upon rocks by a high temperature and subsequent cooling, as where coal and sandstone have been invaded by basalt. They may likewise be observed to arise during the consolidation of a substance, as in the case of starch. In that substance the columnar structure is apt to radiate from certain centres, as may also be seen sometimes in basalt and other igneous rocks.

Mr. Mallet has recently investigated this subject, and concludes that "all the salient phenomena of the prismatic and jointed structure of basalt can be accounted for upon the admitted laws of cooling, and contraction thereby, of melted rock possessing the known properties of basalt, the essential conditions being a very general homogeneity in the mass cooling, and that the cooling shall take place slowly, principally from one or more of its surfaces."[1]

In the more perfectly columnar basalts the columns are sometimes articulated, each prism being separable into vertebræ, with a cup and ball socket at each articulation. This peculiarity is traced by Mr. Mallet to the contraction of each prism in its length and in its diameter, and to the consequent production of transverse joints, which, as the resultant of the two contracting strains, are oblique to the sides of the prism, but, as the obliquity lessens towards the centre, assume necessarily, when perfect, a cup-shape, the convex surface pointing in the same direction as that in which the prism has grown. This explanation, however, will hardly account for cases, which are not uncommon, where the convexity points the other way, or where it is sometimes in one direction, sometimes in the other.[2] The remarkable spheroids which appear in many weathered igneous rocks besides basalts may probably be due to some of the conditions under which the original contractions took place. They are quite untraceable on a fresh fracture of the rock. It is only after some exposure to the weather that they begin to appear, and then they gradually crumble away by the successive formation and disappearance of external weathered crusts or coats, which fall off into sand and clay. Almost all augitic or hornblendic rocks, even granite, exhibit the tendency to decompose into rounded spheroidal blocks.

By the outpouring of lava two important kinds of geological change are produced. In the first place, the surface of a country is thereby materially changed. Stream-courses, lakes, ravines, valleys, in short all the minor features of a landscape, may be completely overwhelmed under a sheet of lava, 100 feet or more in thickness. The drainage of the district is thus effectually altered, and all the numerous changes which flow from the operations of running water over the land are arrested and made to begin again in new channels. In the second place, considerable alterations may likewise be caused by the effects of the heat and vapors of the lava upon the subjacent or contiguous ground. Instances have been observed in which the lava has actually melted down opposing rocks, or masses of slags, on its own surface. Interesting observations, already referred to, have been made at Torre del Greco under the lava stream which overflowed part of that town in 1794. It was found that the window-panes of the houses had been devitrified into a white, translucent, stony substance, that pieces of limestone had acquired an open, sandy, granular texture, without loss of carbonic acid, and that iron, brass, lead, copper, and silver objects had been greatly altered, some of the metals being actually sublimed. We can understand therefore that, retaining its heat for so long a time, a mass of lava may induce many crystalline structures, rearrangements, or decompositions in the rocks over which it comes to rest, and proceeds slowly to cool. This is a question of considerable importance in relation to the behavior of ancient lavas which have been intruded among rocks beneath the surface, and have subsequently been exposed, as will be referred to in the sequel.

But, on the other hand, the exceedingly trifling change produced even by a massive sheet of lava has often been remarked with astonishment. On the flank of Vesuvius we may see vines and trees still flourishing on little islets of the older land-surface completely surrounded by a flood of lava. Professor Dana has given an instructive account of the descent of a lava-stream from Kilauea in June, 1840. Islet-like spaces of forest were left in the midst of the lava, many of the trees being still alive. Where the lava flowed round the trees the stumps were usually consumed, and cylindrical holes or casts remained in the lava, either empty or filled with charcoal. In many cases the fallen crown of the tree lay near, and so little damaged that the epiphytic plants on it began to grow again. Yet so fluid was the lava that it hung in pendent stalactites from the branches, which nevertheless, though clasped round by the molten rock, had barely their bark scorched. Again, for nearly 100 years there has lain on the flank of Etna a large sheet of ice which, originally in the form of a thick mass of snow, was overflowed by the molten flood, and has thereby been protected from the evaporation and thaw which would certainly have dissipated it long ago, had it been exposed to the air. The heat of the lava has not sufficed to melt it. There seems reason to suspect, however, that in other cases snow and ice have been melted in large quantities by overflowing lava. The great floods of water which rushed down the flank of Etna, after an eruption of the mountain in the spring of 1755, have been thus explained.

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[1] See an abstract of his paper, *Proc. Roy. Soc.*, January, 1875.

[2] Mr. Scrope pointed this out (*Geol. Mag.*, September, 1875), though Mr. Mallet (*Ibid.*, November, 1875) replied that in such cases the articulations must be formed just about the dividing surface between the part of the rock which cooled from above, and that which cooled from below.

One further aspect of a lava-stream may be noticed here —the effect of time upon its surface. While all kinds of lava must, in the end, crumble down under the influence of atmospheric waste and, where other conditions permit, become coated with soil and support some kind of vegetation, yet extraordinary differences may be observed in the facility with which different lava-streams yield to this change, even on the flank of the same mountain. Every one who ascends the slopes of Vesuvius remarks this fact. After a little practice it is not difficult there to trace the limits of certain lavas even from a distance, in some cases by their verdure, in others by their barrenness. Five hundred years have not sufficed to clothe with green the still naked surface of the Catanian lava of 1381; while some of the lavas of the present century have long given footing to bushes of furze. Some of the younger lavas of Auvergne, which certainly flowed in times anterior to those of history, are still singularly bare and rugged. Yet, on the whole, where lava is directly exposed to the atmosphere, without receiving protection from occasional showers of volcanic ash, or being liable to be washed bare by heavy torrents of rain, its surface decays in a few years sufficiently to afford soil for a few plants in the crevices. When these have taken root they help to increase the disintegration. At last, as a more or less continuous covering of vegetation spreads over the rock, the traces of its volcanic origin one by one fade away from its surface. Some of the Vesuvian lavas of the present century already support vineyards.

Torrents of Water and Mud.—We have seen that large quantities of water accompany many volcanic eruptions. In some cases, where ancient crater-lakes or internal reservoirs have been shaken by repeated detonations, and finally disrupted, the mud which has thus been produced issues at once from the mountain. Such "mud-lavas," on account of their liquidity and swiftness of motion, are more dreaded for their destructiveness than even the true melted lavas. On the other hand, rain or melted snow, rushing down the cone and taking up loose volcanic dust, is converted into a kind of mud that grows more and more pasty as it descends. The mere sudden rush of such large bodies of water down the steep declivity of a volcanic cone cannot fail to effect much geological change. Deep trenches are cut out of the loose volcanic slopes, and sometimes large areas of woodland are swept away, the debris being strewn over the plains below.

During the great Vesuvian eruption of 1622 a torrent of this kind poured down upon the villages of Ottajano and Massa, overthrowing walls, filling up streets, and even burying houses with their inhabitants. It was by similar streams from the same volcano that some of the Roman cities on its flanks were overwhelmed in the first century. Many of the volcanoes of Central and South America discharge large quantities of mud directly from their craters. Thus in the year 1691 Imbaburu, one of the Andes of Quito, emitted floods of mud, so largely charged with dead fish that pestilential fevers arose from the subsequent effluvia. Seven years later (1698), during an explosion of another of the same range of lofty mountains, Carguairazo (14,706 feet), the summit of the cone is said to have fallen in, while torrents of mud, containing immense numbers of the fish *Pymelodus Cyclopum*, poured forth and covered the ground over a space of four square leagues. The carbonaceous mud (locally called *moya*) emitted by the Quito volcanoes sometimes escapes from lateral fissures, sometimes from the craters. Its organic contents, and notably its siluroid fish, which are the same as those found living in the streams above ground, prove that the water is derived from the surface, and accumulates in craters or underground cavities until discharged by volcanic action. Similar but even more stupendous and destructive outpourings have taken place from the volcanoes of Java, where wide tracts of luxuriant vegetation have at different times been buried under masses of dark grey mud, sometimes 100 feet thick, with a rough hillocky surface from which the top of a submerged palm-tree might have been seen protruding.

Between the destructive effects of mere water-torrents and that of these mud-floods there is, of course, the notable difference that, whereas in the former case a portion of the surface is swept away, in the latter, while sometimes considerable demolition of the surface takes place at first, the main result is the burying of the ground under a new tumultuous deposit by which the surface is greatly changed, not only as regards its temporary aspect, but in its more permanent features, such as the position and form of its water-courses.

Mud-volcanoes.—Though probably seldom if ever strictly volcanic in the proper sense of that term, certain remarkable orifices of eruption may be noticed here to which the names of mud-volcanoes, salses, air-volcanoes, and macalubas have been applied. These are conical hills formed by the accumulation of fine and usually saline mud, which, with various gases, is continuously or intermittently given out from the orifice or crater in the centre. They occur in groups, each hillock being sometimes less than a yard in height, but ranging up to elevations of 100 feet, or even sometimes, as in the plains of the lower Indus, to 400 feet. Like true volcanoes, they have their periods of repose, when either no discharge takes place at all, or mud oozes out tranquilly from the crater, and their epochs of activity, when large volumes of gas, and sometimes columns of flame, rush out with considerable violence and explosion, and throw up mud and stones to a height of several hundred feet.

The gases play much the same part therefore in these phenomena that steam does in those of true volcanoes. They consist of carbonic acid gas, carburetted hydrogen, sulphuretted hydrogen, and nitrogen. The mud is usually cold. In the water occur various saline ingredients, among which common salt generally appears. Naphtha is likewise frequently present. Large pieces of stone, differing from those in the neighborhood, have been observed among the ejections, indicative doubtless of a somewhat deeper source than in ordinary cases. Heavy rains may wash down the minor mud cones and spread out the material over the ground, but gas-bubbles again appear through the sheet of mud, and by degrees a new series of mounds is once more thrown up.

There can be little doubt that these phenomena are to be traced to chemical changes in progress underneath. Dr. Daubeny explained them in Sicily by the slow combustion of beds of sulphur. The frequent occurrence of naphtha and of inflammable gas points, in other cases, to the disengagement of hydrocarbons from subterranean strata.

Mud volcanoes occur in Iceland, in Sicily (Macaluba), in many districts of northern Italy, at Tamar and Kertch, at Baku on the Caspian, over an area of about 1000 square miles near the mouth of the Indus, and in other parts of the globe.

Gaseous Discharges.—Some of these belong to true volcanic phenomena, others are closely associated with the mud-volcanoes. To the former class we may assign the copious emanations of carbonic acid which so frequently take place in districts where volcanic activity has been long dormant or extinct. The gas either comes out directly from fissures of the rock, or rises dissolved in the water of springs. The old volcanic districts of Europe furnish many examples. Thus on the shores of the Laacher See—an ancient crater lake of the Eifel—carbonic acid gas issues from numerous openings called *moffette*, round which dead insects, and occasionally mice and birds may be found. In the same region occur hundreds of springs more or less charged with the gas. The famous Valley of Death in Java contains one of the most remarkable gas-springs in the world. It is a deep, bosky hollow, from one small space on the bottom of which carbonic acid issues so copiously as to form the lower stratum of the atmosphere. Tigers, deer, and wild-boar, enticed by the shelter of the spot, descend and are speedily suffocated. Many of their skeletons, together with those of man himself, have been observed.

In the second class of gas-springs we may group the emanations of carburetted hydrogen, which, when they take fire, are known as Fire-wells. They occur in many of the districts where mud-volcanoes appear, as in northern Italy, on the Caspian, in Mesopotamia, in southern Kurdistan, and in many parts of the United States. It has been observed that they rise especially in regions where beds of rock-salt lie underneath, and as that rock has been ascertained often to contain compressed carburetted hydrogen, the solution of the rock by subterranean water, and the consequent liberation of the gas, has been offered as an explanation of these fire-wells.

Geysers.—In various regions where volcanic action still continues, or where it has long been dormant, there occur eruptive fountains of hot water and steam, to which the general name of geysers is given, from the well-known examples in Iceland, which were the first to be seen and described. Besides the Great and Little Geysers, the Strokkr, and other minor springs of hot water in Iceland, other, perhaps still more striking, examples have in recent years been brought to light in that tract of the western territories of the United States set aside as the "Yellowstone National Park," and good illustrations are also found in New Zealand. A geyser possesses a vertical pipe in the ground, terminating at the surface in a basin which is formed of siliceous sinter, and may rise some feet or yards above the general level. At more or less regular intervals rumblings and sharp detonations occur underneath, followed by an agitation of the water in the basin, and then by the violent expulsion of a column of water and steam to a considerable height in the air. The hot water contains silica in solution, which, on cooling and evaporating, is deposited at the surface; and thus the geyser builds up its basin, sometimes raising it into a long, solitary, finger-like pillar.

Bunsen and Descloiseaux spent some days experimenting at the Icelandic geysers, and ascertained that in the Great Geyser, while the surface temperature is about 212° Fahr. that of the lower portions of the tube is much higher—a thermometer giving as high a reading as 266° Fahr. The water there must consequently be 48° above the normal boiling-point, but is kept in the fluid state by the pressure of the overlying column. At the basin, however, the water cools quickly. After an explosion it accumulates there, and eventually begins to boil. The pressure on the column below being thus relieved, a portion of the superheated water flashes into steam, and as the change passes down the pipe, the whole column of water and steam rushes out with great violence. The water thereafter gradually collects again in the pipe, and after an interval of some hours the operation is renewed. The experiments made by Bunsen proved the cause of the eruption to lie in the high temperature of a portion of the pipe. He hung stones by strings to different depths in the funnel of the geyser, and found that only those in the higher part were cast out by the rush of water, sometimes to a height of 100 feet, while at the same time the water at the bottom was hardly disturbed at all.[1]

These observations give an additional interest and importance to the phenomena of geysers in relation to those of volcanic action. They show that the eruptive force is steam; that the water column, even at a comparatively small depth, has a temperature considerably above 212°; that this high temperature is local; and that the eruptions of steam and water take place periodically, and with such vigor as to eject large stones to a height of 100 feet.

§ 3. *Structure of Volcanoes.*

It is now admitted that a volcano is due to the accumulation of material round the vent of eruption, and not to any blister-like expansion of the ground. The structure of a volcanic cone necessarily depends in great measure upon the nature of the substances ejected. The following are the more important and interesting types of this kind of structure:—

(1.) *Cones of Non-volcanic Materials.*—These are due to the discharge of steam or other aeriform product through the solid crust without the emission of any true ashes or lava. The materials ejected from the cavity are wholly, or almost wholly, parts of the surrounding rocks through which the volcanic pipe has been drilled. Some of the cones surrounding the crater-lakes or *maare* of the Eifel consist chiefly of fragments of the underlying Devonian slates.

(2.) *Tuff-Cones, Cinder-Cones.*—Successive eruptions of fine dust and stones, often rendered pasty by getting mixed with the water so copiously condensed during an eruption, form a cone in which the materials are solidified by pressure into tuff. Sometimes the cones are made up only of loose cinders, like Monte Nuovo in the Bay of Baiæ. Cones consisting entirely of loose volcanic materials often arise on the flanks or round the roots of a great volcano, as happens to a small extent on Vesuvius, and on a larger scale upon Etna. They likewise occur by themselves apart from any lava-producing volcano, though usually they afford indications that columns of lava have risen in their funnels, and even now and then that this lava has reached the surface. Admirable examples are furnished by the cones of the Phlegræan fields near Naples. Ancient cones of a similar character occur among the Carboniferous rocks of Scotland. The materials of the cone are arranged in more or less regular beds which dip away from the funnel, their inclination corresponding with that of the cone. Inside the crater they slope steeply inward towards the crater-bottom.

(3.) *Mud-Cones* or *Salses* are formed by the accumulation and consolidation of mud round the vents of mud-volcanoes. They sometimes reach a height of 400 feet.

(4.) *Lava-Cones.*—These are comparatively rare, since, in most cases, the emission of lava is accompanied by the discharge of ashes. Owing to its liquidity, the lava flows off quickly, and the cones have very gentle slopes. The most remarkable examples are those in the Hawaii Islands described by Professor Dana. They attain a great height, but so small is their angle of inclination, that they may be described as only gently-sloping mounds, and their craters have been compared to vast open quarries on a hill or moor.

(5.) *Cones of Tuff and Lava.*—These are by far the most frequent. They may be taken, indeed, as the typical form of volcanoes. Around the central vent the successive showers of scoriæ and ashes gather, with occasional streams of lava, which from time to time descend different sides of the growing cone. The component strata have thus the usual inclination outwards, though, when seen in section along the crater walls, they look approximately horizontal. By continued explosions fissures are formed in the sides of the cone. These are injected with lava, producing a network of dykes which strengthen the cone, or they serve as channels of escape for lava, and give rise to lateral eruptions and minor or parasitic cones. As the main cone increases in diameter by the accumulation of fragmentary and molten ejections, it rises also in height, until at last few or no eruptions take place from its summit, but only from openings on its flanks.

(6.) *Submarine Volcanoes.*—It is not only on the surface of the land that volcanic action shows itself. It takes place likewise under the sea, and as the geological records of the earth's past history are chiefly marine formations, the characteristics of submarine volcanic action have no small interest to the geologist. Unfortunately, the phenomena of recent volcanic eruptions under the sea are for the most part inaccessible. Here and there, as among the islands of the Greek Archipelago and at Tahiti, elevation of the sea-bed has taken place, and brought to the surface beds of lava, which had been erupted and had consolidated under water. There does not appear to be any appreciable difference either in external aspect or in internal structure between such submarine lavas and those erupted on the land. Some of them are highly scoriaceous. There is no reason indeed why slaggy lava and loose scoriæ should not accumulate under the pressure of a deep column of the ocean. At the Hawaii Islands, on 25th February, 1877, masses of pumice during a submarine volcanic explosion, were ejected to the surface, one of which struck the bottom of a boat with considerable violence, and then floated. At the same time, when we reflect to what a considerable extent the bottom of the great ocean basins is dotted over with volcanic cones, rising often solitary from profound depths, we can understand how large a proportion of the actual eruptions may take place under the sea. The foundations of these volcanic islands doubtless consist of submarine lavas and fragmentary materials, which, in each case, continued to accumulate to a height of two or three miles, until the pile reached the surface of the water and the phenomena became subaerial. The immense abundance and wide diffusion of volcanic detritus over the bottom of the Pacific and Atlantic Oceans, even at distances remote from land, as has been made known by the voyage of the "Challenger," may indicate the prevalence and persistence of submarine volcanic action, though, at the same time, it must be admitted that an extensive diffusion of volcanic debris from the islands is effected by winds and ocean-currents.

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[1] Bunsen, *Ann. der Chemie und Pharmacie*, lxii. (1847), p. 1.

§ 4. *Geographical Distribution of Volcanoes.*

The chief facts under this head may thus be summarized. (1.) Volcanoes occur along the margins of the ocean basins, particularly along lines of dominant mountain ranges. The vast hollow of the Pacific is girdled with a wide ring of volcanic foci. (2.) They rise as a striking feature in the heart of the ocean basins. Most of the oceanic islands are volcanic. Even the coral islands have in all likelihood been built upon the tops of submarine volcanic cones. (3.) Volcanoes are thus situated, as a rule, close to the sea. When they occur inland they sometimes appear in the neighborhood of a large sheet of water. Yet so many instances have been observed where volcanoes have appeared at great distances from any sheet of water that the proximity of a lake or of the sea cannot be regarded as necessary for the evolution of volcanic phenomena. (4.) The dominant arrangement of volcanoes is in lines along subterranean lines of weakness, as in the chain of the Andes, the Aleutian Islands, and the Malay Archipelago. (5.) Where the linear arrangement does not hold, it gives place to one in groups, as in Italy, Iceland, and the volcanic islands of the great oceans.

§ 5. *Distribution of Volcanic Action in Time.*

Besides the existence of what are called extinct volcanoes, the geologist can adduce proofs of the former presence of active volcanoes in many countries where cones and craters and all ordinary aspects of volcanic mountains have long disappeared. Sheets of lava, beds of tuff, dykes, and necks representing the sites of volcanic vents have been recognized abundantly. These manifestations of volcanic action, moreover, have as wide a range in geological time as they have in geographical area. Every great geological period, back at least as far as the lower Silurian, has had its volcanoes. In Britain, for instance, there were active volcanic vents in the lower Silurian period, whence the lavas and tuffs of Snowdon, Aran Mowddwy, and Cader Idris were ejected. The Lower Old Red Sandstone epoch was one of prolonged volcanic activity in central Scotland. The earlier half of the Carboniferous period likewise witnessed the outburst of innumerable small volcanoes over the same region. During the Permian period a few scattered vents existed in the south-west of Scotland, and in the time of the New Red Sandstone some similar points of eruption appeared in the south of England. The older Tertiary ages were distinguished by the outpouring of the enormous basaltic plateaus of Antrim and the Inner Hebrides.

Thus it can be shown that, within the same comparatively limited geographical space, volcanic action has been rife at intervals during a long succession of geological ages. The existing active volcanoes of Iceland rise from amid Tertiary lavas and tuffs, which form part of a great volcanic ridge, extending down through the Faroe Islands into the west of Britain. Volcanic action, which now manifests itself so conspicuously along certain lines, seems to have continued in that linear development for protracted periods of time. The actual vents have changed, dying in one place and breaking out in another, yet keeping on the whole along the same lines.

§ 6. *Causes of Volcanic Action.*

Volcanoes depend, of course, upon the internal heat of the planet as their prime source of energy. But the *modus operandi* whereby that internal heat manifests itself in volcanic action is a problem by no means of easy solution. Were this action merely an expression of the intensity of the heat, we might expect it to have manifested itself in a far more powerful manner in former periods, and to exhibit a regularity and continuity commensurate with the exceedingly slow diminution of the earth's temperature. But there is no geological evidence in favor of greater volcanic intensity in ancient times than in more recent periods; on the contrary, it may be doubted whether any of the Palæozoic volcanoes equalled in magnitude those of the Tertiary period, or whether any of the latter ever produced such stupendous changes as have been effected by modern volcanoes still active. On the other hand, no feature of volcanic action is more conspicuous than its spasmodic fitfulness.

The mere presence of a high internal temperature, therefore, would probably not of itself produce the phenomena of volcanoes, at least in the present condition of the planet. There can be no doubt that one essential exciting cause of volcanic action is the descent of water from the surface. It has already been pointed out how invariably steam plays a chief part in volcanic eruptions, how it issues in vast clouds from the crater, and continues to rise copiously from the lava even after the molten rock has travelled for some miles, and has assumed a solid surface. The quantity of water which descends into the interior must be enormous. The floor of the sea, the beds of rivers and lakes, are all leaky. Of the annual rain which sinks beneath the surface of the land, we cannot tell what proportion is detained and prevented from rising again in springs. Not only does this subterranean water percolate down cracks and joints, it infiltrates through the very pores of the rocks, and can do so even against the pressure of steam on the further side.

Accordingly, there has arisen a very prevalent belief among geologists, that it is to the enormous expansive force of perhaps white-hot water finding access to, and imprisoned in, some of the heated empty spaces at the roots of volcanoes that the explosion of a crater and the subsequent rise of a lava-column are due. It has been supposed that, somewhat like the reservoirs in which the hot water and steam accumulate under the Icelandic geysers, these volcanic spaces receive a constant influx of water from the surface, which cannot escape by other channels, but is in great part converted into vapor or retained in the fluid state at an enormously high temperature and under vast pressure. In the course of time, the materials filling up the chimney are unable to withstand the upward expansion of this imprisoned vapor and water, so that, after some premonitory rumblings, the whole opposing mass is blown out, and the vapor rushes up in the well-known masses of cloud. Meanwhile, the removal of the overlying column relieves some of the pressure from the water-charged lava, which therefore begins to rise in the funnel until it forces its way through some weak part of the cone, or pours over the top of the crater. After a time the vapor is expended, the energy of the volcano ceases, and there comes a variable period of repose, until a renewal of the same phenomena brings on another eruption. By such successive paroxysms it is supposed that the form of the internal reservoirs and tunnels becomes changed; new spaces for the accumulation of superheated water are formed, whence in time new volcanic vents issue, while the old ones gradually die out.

As physical considerations negative the idea of a comparatively thin crust surmounting a molten interior whence volcanic energy might be derived, geologists have found themselves involved in great perplexity to explain volcanic phenomena for the production of which a source of no great depth would seem to be necessary. They have supposed the existence of pools or lakes of liquid lava lying beneath the crust, and at an inconsiderable depth from the surface. They have sometimes appealed to the influence of the contraction of the earth's mass, assuming that the contraction is greater in the outer than in the inner portions, and that the effect of this must be to squeeze out some of the internal molten matter through weak parts of the crust. Cordier, for example, calculated that a contraction of only a single millimetre (about $\frac{1}{25}$th of an inch) would suffice to force out of the surface lava enough for 500 eruptions, allowing 1 cubic kilometre (about 1300 million cubic yards) for each eruption.

The influence of contraction as the grand source of volcanic energy has recently been insisted upon on quite different grounds by Mr. Mallet, who has developed the theory that all the present manifestations of hypogene action are due directly to the more rapid contraction of the hotter internal mass of the earth, and the consequent crushing in of the outer cooler shell. He points to the admitted difficulties in the way of connecting volcanic phenomena with the existence of internal lakes of liquid matter, or of a central ocean of molten rock. Observations made by him on the effects of the earthquake shocks accompanying the volcanic eruptions of Vesuvius and of Etna, showed that the focus of disturbance could not be more than a few miles deep,—that, in relation to the general mass of the globe, it was quite superficial, and could not possibly have lain under a crust of 800 miles or upwards in thickness. The occurrence of volcanoes in lines, and especially along some of the great mountain chains of the planet, is likewise dwelt upon by him as a fact not satisfactorily explicable on any previous hypothesis of volcanic energy. But he contends that all these difficulties disappear when once the simple idea of cooling and contraction is adequately realized. "The secular cooling of the globe," he remarks, "is always going on, though in a very slowly descending ratio. Contraction is therefore constantly providing a store of energy to be expended in crushing parts of the crust, and through that providing for the volcanic heat. But the crushing itself does not take place with uniformity; it necessarily acts *per saltum* after accumulated pressure has reached the necessary amount at a given point, where some of the pressed mass, unequally pressed as we must assume it, gives way, and is succeeded perhaps by a time of repose, or by the transfer of the crushing action elsewhere to some weaker point. Hence, though the magazine of volcanic energy is being constantly and steadily replenished by secular cooling, the effects are intermittent." He offers an experimental proof of the sufficiency of the store of heat produced by this internal crushing to cause all the phenomena of existing volcanoes. The slight comparative depth of the volcanic foci, their linear arrangement, and their occurrence along lines of dominant elevation becom he contends, intelligible under this hypothesis. For, since the crushing in of the crust may occur at any depth, the volcanic sources may vary in depth indefinitely; and as the crushing will take place chiefly along lines of weakness in the crust, it is precisely in such lines that crumpled mountain-ridges and volcanic funnels should appear. Moreover, by this explanation it is sought to harmonize the discordant observations regarding the variations in the rate of increase of temperature downward within the earth. In some parts of the crust the crushing must be much greater than in other parts; and since the heat "is directly proportionate to the local tangential pressure which produces the crushing and the resistance thereto," it may vary indefinitely up to actual fusion. So long as the crushed rock remains out of reach of a sufficient access of subterranean water, there would, of course, be no disturbance. But if, through the weaker parts, water enough should descend and be absorbed by the intensely hot crushed mass, it would be raised to a very high temperature, and, on sufficient diminution of pressure, would flash into steam and produce the commotion of a volcanic eruption.

This ingenious theory requires the operation of sudden and violent movements, or at least that the heat generated by the crushing should be more than can be immediately conducted away through the crust. Were the crushing slow and equable, the heat developed by it would doubtless be tranquilly dissipated through the crust, the temperature of which might not be sensibly affected in the process, or not to such an extent as to cause any appreciable molecular rearrangement of the particles of the rock. Moreover, as the action is general throughout the whole mass of the outer shell, there does not seem in the theory any valid reason why volcanic action should be limited to particular lines, and why it should continue so long persistently on these lines. The existence of weak parts of the crust is postulated; but the successive crushings and consequent fusions might be expected to strengthen these weaker parts and to make volcanic conditions less easy.

It cannot indeed be denied that there exists the most convincing geological evidence in favor of the secular contraction of the globe, that during the process masses of sedimentary strata, many thousands of feet in thickness, have been crumpled and crushed, and that the crumpling has often been accompanied by such an amount of heat and evolution of chemical activity as to produce a movement and rearrangement of the elements of the rocks,—this change sometimes advancing to the point of actual fusion. There is reason to believe that some at least of these periods of intense terrestrial disturbance have been followed by periods of prolonged volcanic action in the disturbed areas. Mr. Mallet's theory is thus, to some extent, supported by independent geological testimony. The existence, however, of large reservoirs of fused rock, at a comparatively small depth beneath the surface, may be conceived as probable, apart altogether from the effects of the subsidence of the outer shell upon the inner nucleus. The connection of volcanoes with lines of elevation, and consequent weakness in the earth's crust, is precisely what might have been anticipated on the view that the nucleus, though practically solid, is at such a temperature and pressure that any diminution of the pressure, by corrugation of the crust or otherwise, will cause the subjacent portion of the nucleus to melt. It is along the lines of elevation that the pressure must be relieved, and it is there that the consequent melting will take place. On these lines of tension and weakness, therefore, the conditions for volcanic excitement must be best developed. Water is there able soonest to reach the intensely-heated materials underneath the crust, and to give rise to the volcanic explosions. The periodicity of eruptions will thus depend upon the length of time required for the storing up of sufficient steam, and on the amount of resistance in the crust to be overcome. In some cases the intervals of activity, like those of the geysers, return with considerable regularity. In other cases, the shattering of the crust, or the upwelling of vast masses of lava, or the closing of subterranean passages for the descending water, or other causes may vary the conditions so much, from time to time, that the eruptions may follow each other at very unequal periods, and with very discrepant energy. Each great outburst exhausts for a while the vigor of the volcano, and an interval is needed for the renewed accumulation of vapor.

Section II.—Earthquakes.

The phenomena of earthquake-motion having been discussed in the article EARTHQUAKES, we shall notice here only those which have a marked geological importance from the way in which they affect the crust or surface of the earth, briefly describing the effects of earthquakes upon the surface of the land, and upon terrestrial and oceanic waters, the permanent changes of level occasioned by them, their distribution and geological relations, and their causes.

1. *Effects upon the Soil and General Surface of a Country.*—The earth-wave or wave of shock underneath a country may traverse a wide region and affect it violently at the time without leaving any trace of its passage. Loose objects, however, are apt to be displaced. Thus blocks of rock, already disengaged from their parent masses, may be rolled down into the valleys below. Large landslips are thus produced, and these may give rise to very considerable subsequent changes in the drainage of the localities where they take place. It has often been observed that the soil is rent by the passage of the earthquake. Fissures appear, varying in size from mere cracks, like those due to desiccation, up to deep and wide chasms. Where these cracks are numerous, and where, consequently, the ground has been much disturbed, permanent modifications of the landscape may be produced. Trees are thrown down and buried, wholly or in part, in the rents. These superficial effects may, in a few years, be effaced by the gradually levelling power of the atmosphere. Where, however, the chasms are wide and deep enough to intercept any rivulets, or to serve as channels for heavy rain-torrents, they are sometimes further excavated, so as to become gradually enlarged into ravines and valleys. As a rule, each rent is only a few yards long. Sometimes it may extend for half a mile or even more. In the earthquake which shook the South Island of New Zealand in 1848, a fissure was formed averaging 18 inches in width and traceable for a distance of 60 miles parallel to the adjacent axis of the mountain-chain. The subsequent earthquake of 1855, in the same region, gave rise to a fracture which could be traced along the base of a line of cliff for a distance of about 90 miles.

Remarkable circular cavities are sometimes formed in the ground during the passage of the earth-wave. In many cases these holes serve as funnels of escape for an abundant discharge of water, so that when the disturbance ceases they appear as pools. They are believed to be caused by the sudden collapse of subterranean water-channels and the consequent forcible ejection of the water to the surface.

2. *Effects upon Terrestrial Waters.*—Springs are temporarily affected by earthquake movements, becoming greater or smaller in volume, sometimes muddy or discolored, and sometimes increasing in temperature. Brooks and rivers have been observed to flow with an interrupted course, in-

creasing or diminishing in size, stopping in their flow so as to leave their channels dry, and rolling forward with increased rapidity. Lakes are still more sensitive to the tremors of the ground beneath. Their waters occasionally rise and fall for several hours, even at a distance of many hundred miles from the centre of disturbance. Thus, on the day of the great Lisbon earthquake, many of the lakes of central and north-western Europe were so affected as to maintain a succession of waves rising to a height of 2 or 3 feet above their usual level. Cases, however, have been observed where, owing to excessive subterranean movement, lakes have been emptied of their contents and their beds left permanently dry. On the other hand, areas of dry ground have been depressed, and have become the sites of new lakes.

Some of the most important changes in the fresh water of a region, however, are produced by the fall of masses of rock and earth. Landslips, by damming up a stream, may so arrest its water as to form a lake. The barrier, if of sufficient strength, may be permanent, and the lake will then remain. Owing, however, to the usually loose, incoherent character of its materials, the dam thrown across the pathway of a stream runs a great risk of being undermined by the percolating water. When this is the case, a sudden giving way of the barrier will allow the confined water to rush with great violence down the valley, and produce perhaps tenfold more havoc there than may have been caused by the original earthquake. When the landslip is of sufficient dimensions to divert the stream from its previous course, the new channel thus taken may become permanent, and a valley may be cut out or widened.

3. *Effects upon the Sea.*—The great sea-wave propagated outward from the centre of a sub-oceanic earthquake, and reaching the land after the earth-wave has arrived there, gives rise to much destruction along the maritime parts of the disturbed region. As it approaches the shore, the littoral waters retreat seawards, sucked up, as it were, by the advancing wall of water, which, reaching a height of sometimes 60 feet, rushes over the bare beach and sweeps inland, carrying with it everything which it can dislodge and bear away. Loose blocks of rock are thus lifted to a considerable distance from their former position, and left at a higher level. Deposits of sand, gravel, and other superficial accumulations are torn up and swept away, while the surface of the country, as far as the limit reached by the wave, is strewn with debris. If the district has been already shattered by the passage of the earth-wave, the advent of the great sea-wave augments and completes the devastation.

4. *Permanent Changes of Level.*—It has been observed, after the passage of an earthquake, that the level of the disturbed country has been changed. Thus after the terrible earthquake of 19th November, 1822, the coast of Chili for a long distance was found to have risen from 3 to 4 feet, so that along the shore the littoral shells were exposed adhering still to the rocks amid multitudes of dead fish. The same coast-line has since been further upraised by subsequent earthquake shocks. On the other hand, many instances have been observed where the effect of the earthquake has been to depress permanently the disturbed ground. For example, by the Bengal earthquake of 1762 an area of 60 square miles on the coast, near Chittagong, suddenly went down beneath the sea, leaving only the top of the higher eminences above water. The succession of earthquakes which in the years 1811 and 1812 devastated the basin of the Mississippi gave rise to widespread depressions of the ground, over some of which the river spread so as to form new lakes, with the tops of the trees still standing above the surface of the water.

5. *Distribution and Geological Relations of Earthquakes.*—While no large space of the earth's surface seems to be free from at least some degree of earthquake-movement, there are regions more especially liable to the visitation. As a rule, earthquakes are most frequent in volcanic districts, the explosions of a volcano being very generally preceded or accompanied by tremors of greater or less intensity. In the Old World the great belt of earthquake disturbance stretches in an east and west direction, along that tract of remarkable depressions and elevations lying between the Alps and the mountains of northern Africa, and spreading eastward so as to enclose the basins of the Mediterranean, Black Sea, Caspian, and Sea of Aral, and to rise into the great mountain-ridges of Central Asia. In this zone lie numerous volcanic vents, both active and extinct or dormant, from the Azores on the west to the basaltic plateaus of India on the east. The Pacific Ocean is surrounded with a vast ring of volcanic vents, and its borders are likewise subject to frequent earthquake shocks. Some of the most terrible earthquakes within human experience have been those which have affected the western seaboard of South America.

6. *Causes of Earthquakes.*—An earthquake shock has been defined by Mr. Mallet as the transit of a wave of elastic compression through the crust and surface of the earth, generated by some sudden impulse within the crust. The passage of such a wave has been imitated experimentally, and some of its characteristic features have been illustrated by accidental explosions at powder-works. But though the phenomena point to some sudden and violent blow inflicted upon the solid crust, it is impossible to do more than speculate on the probable nature of this blow. In some cases it may arise from the sudden flashing into steam of water in the spheroidal state, from the sudden condensation of steam, from the explosions of a volcanic orifice, from the falling in of the roof of a subterranean cavity, or from the sudden snap of subterranean rocks subjected to prolonged and intense strain. But we are still in ignorance as to the actual immediate cause of any earthquake in regions remote from active volcanoes. So much, at least, is certain, that the shock must arise from some sudden and violent impulse, whereby a wave or undulation is propagated in all directions through the solid substance of the crust.

Section III.—Secular Upheaval and Depression.

Besides the sudden movements due to earthquake-shocks, the crust of the earth undergoes in many places oscillations of an extremely quiet and uniform character, sometimes of an elevatory, sometimes of a subsiding nature. So tranquil are these changes that they produce from day to day no appreciable alteration in the aspect of the ground affected. Only after the lapse of several generations, and by means of careful measurements, can they really be proved. Indeed, in the interior of a country nothing but a series of accurate levellings from some unchanged datum-line might detect the change of level, unless the effects of this terrestrial movement showed themselves in altering the drainage. It is only along the sea-coast that a ready measure is afforded of any such movement. In popular language it is usual to speak of the sea as rising or sinking relatively to the land. But so long as the volume of the ocean remains the same, the general sea-level can neither rise nor fall, unless by some movement of the solid globe underneath it. And, as we cannot conceive of any possible augmentation of the oceanic waters, nor of any diminution save what may be due to the extremely slow process of abstraction by the hydration of minerals, or absorption into the earth's interior, we are compelled to regard the sea-level as practically a constant datum-line, any deviation from which, in the apparent heights of sea and land, must be due to movement of the land and not of the sea.

There are indeed certain cosmical causes which may affect the relative levels of sea and land. Thus the accumulation of large masses of snow and ice as an ice-cap at one of the poles would, as has been above pointed out (*ante*, p. 194), tend to displace the earth's centre of gravity, and as a consequence to raise the level of the ocean in the hemisphere so affected, and to diminish it in a corresponding measure elsewhere. The return of the ice into the state of water would produce an opposite effect. Dr. Croll has also drawn attention to the fact that, as a consequence of the diminution of centrifugal force owing to the retardation of the earth's rotation caused by the tidal wave, the sea-level must have a tendency to subside at the equator and rise at the poles. A larger amount of land need not ultimately be laid bare at the equator, for the change of level resulting from this cause would be so slow that the general degradation of the surface of the land might keep pace with it, and diminish the terrestrial area as much as the retreat of the ocean tended to increase it. Dr. Croll has further pointed out that the waste of the equatorial land, and the deposition of the detritus in higher latitudes, must still further counteract the effects of retardation and the consequent change of ocean-level.[1]

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[1] Croll, *Phil. Mag.*, 1868, p. 382; Sir W. Thomson, *Trans. Geol. Soc. Glasgow*, iii. 223.

Such widespread general causes of change must produce equally far-reaching effects. But in examining the changes of level between land and sea, we find them to be eminently local and variable in character, pointing to some local and unequally acting cause,—so that, while admitting these cosmical and widespread influences to be part of the general system of geological change, we must yet hold the sea-level, for all practical purposes, to be invariable, any apparent oscillations of that level upon the land being due to terrestrial movements.

§ 1. *Movements of Upheaval.*

Various maritime tracts of the land have been ascertained to have undergone in recent times, or to be still undergoing, a gradual elevation above the sea. Thus, the coast of Siberia, for 600 miles to the east of the river Lena, the western tracts of South America, and the Scandinavian peninsula, with the exception of a small area at its southern apex, have been proved to have been recently upheaved. The proofs of this change of level chiefly to be relied on are the following[1]:—

(1.) The position of rocks covered with barnacles or other littoral adherent animals, or pierced by lithodomous shells. A single stone with these creatures on its surface would not necessarily prove anything, for it might be cast up by a storm; but a line of large boulders, which had evidently not been moved since the cirripedes and molluscs lived upon them, and still more a solid cliff with these marks of littoral or sub-littoral life upon its base, now raised above high-water mark, would be sufficient to demonstrate a rise of land. The amount of the upheaval might be pretty accurately determined by measuring the vertical distance between the upper edge of the barnacle zone upon the upraised rock, and the limit of the same zone on the present shore.

(2.) A line of sea-caves, now standing at a distance above high-water mark beyond the reach of the sea, would afford evidences of recent uprise, since caves of this kind are only hollowed out by the waves between tide-marks.

(3.) One of the most striking proofs of upheaval is furnished by what are termed *raised beaches.* A beach is the space between tide-marks, where the sea is constantly busy producing sand and gravel, mingling with them the remains of shells and other organisms, sometimes piling the deposits up, sometimes sweeping them away out into opener water. The terrace or platform thus formed is a well-marked feature of coast-lines skirting tidal seas. When the land rises with sufficient rapidity to carry up the line of littoral deposits above the reach of the waves, the flat terrace thus elevated is known as a raised beach. The former high-water mark then lies inland, and while its sea-worn caves are in time hung with ferns and mosses, it furnishes itself an admirable platform, on which meadows, fields, and gardens, roads, houses, villages, and towns spring up, while a new beach is made below the margin of the uplifted one. Raised beaches abound around many parts of the coast-line of Britain. Some excellent examples occur in Cornwall and Devon. The coast-line on both sides of Scotland is fringed with raised beaches, sometimes four or five occurring above each other, at heights of 25, 40, 60, 75, and 100 feet above the present high-water mark. Each terrace marks a former lower level of the land with regard to the sea, and probably a lengthened stay of the land at that level, while the intervals between them represent the vertical amount of each successive uplift of the land, and show that the land in its upward movement did not remain long enough at intermediate points for the formation of terraces. A succession of raised beaches, rising above the present sea-level, may therefore be taken as pointing to a former prolonged upheaval of the country, interrupted by long pauses, during which the general level did not materially change.

(4.) Any stratum of rock containing marine organisms, which have manifestly lived and died where their remains now lie, must be held to prove upheaval of the land. In this way it can be shown that most of the solid land now visible to us has once been under the sea. Even high on the peaks of the cliffs and the flanks of the Himalaya mountains, undoubted marine shells occur in the solid rocks.

(5.) In countries which have been long settled by a human population, it is sometimes possible to prove, or at least to render probable, the fact of recent uprise of the land by reference to tradition, to local names, and to works of human construction. Piers and harbors, if now found to stand above the upper limit of high-water, furnish indeed indisputable evidence of a rise of land since their erection.

§ 2. *Movements of Subsidence.*

It is more difficult to trace the downward movement of the land, for the evidence of each successive sea-margin is carried down and washed away or covered up. Nevertheless, the fact of subsidence can be satisfactorily established by the following kinds of proof[2]:—

(1.) The results of mere erosion by the sea and those of actual depression of the level of the land cannot always be distinguished without some care. The encroachment of the sea upon the land, involving, it may be, the disappearance of successive fields, roads, houses, villages, and even whole parishes, does not necessarily indicate a sinking of the land. Such destruction of the coast-line may, indeed, be in progress without any actual change of level. Should the sea, however, rise to the level of roads and buildings which it never used to touch, should former half-tide rocks cease to show even at low water, and should rocks, previously above the reach of the highest tide, be turned first into shore reefs, then into skerries and islets, we infer that the coast-line is sinking. Such kind of evidence is found in Scania, the most southerly part of Sweden. Streets, built of course above high-water mark, now lie below it, with older streets lying beneath them, so that the subsidence is of some antiquity. A stone, the position of which had been exactly determined by Linnæus in 1749, was found after 87 years to be 100 feet nearer the water's edge. The west coast of Greenland, for a space of more than 600 miles, is perceptibly sinking. It has there been noticed that, over ancient buildings on low shores, as well as over entire islets, the sea has risen. The Moravian settlers have been more than once driven to shift their boat-poles inland, some of the old poles remaining visible under water.

(2.) As the land is brought down within reach of the waves, its characteristic surface-features are, of course, apt to be effaced, so that the submerged area, which passes down beneath the sea, may retain little or no evidence of its having been a land-surface. It will be covered, as a rule, with sea-worn sand or silt. Hence, no doubt, the reason why, among the marine strata which form so large a part of the stratified portion of the earth's crust, and where there are many proofs of depression, actual traces of land-surfaces are comparatively rare. It is only under very favorable circumstances, as, for instance, where the area is sheltered from prevalent winds and waves, and where, therefore, the surface of the land can sink tranquilly under the sea, that fragments of that surface may be completely preserved under overlying marine accumulations. It is in such places that "submerged forests" occur. These are stumps or roots of trees still in their positions of growth in their native soil. Beds of peat, full of tree-stumps, hazel-nuts, branches, leaves, and other indications of a terrestrial surface, are often found in similar situations. Sir Henry de la Beche has described, round the shores of Devon, Cornwall, and western Somerset, a vegetable accumulation, consisting of plants of the same species as those which now grow freely on the adjoining land, and occurring as a bed at the mouths of valleys, at the bottoms of sheltered bays, and in front of and under low tracts of land, the seaward side of which dips beneath the present level of the sea. Over this submerged land-surface sand and silt containing estuarine shells have generally been deposited, whence we may infer that in the submergence the valleys first became estuaries, and then sea-bays. If now, in the course of ages, a series of such submerged forests should be formed one over the other, and if, finally, they should, by upheaval of the sea-bottom, be once more laid dry, so as to be capable of examination by boring, well-sinking, or otherwise, they would prove a former long continued depression, with intervals of rest. In such a case, the intervals of pause would be marked by the buried forests, and the progress of the depression by the strata of sand and mud lying between them. In short, the evidence would be strictly on a parallel with that furnished by a succession of raised beaches as to a former protracted elevation with long pauses.

(3.) An interesting kind of proof of an extensive depression of the north-west of Europe is furnished by the deep fjords or sea-lochs by which that region is indented. A fjord is a long, narrow, and often singularly deep inlet of the sea, which terminates inland at the mouth of a glen or valley. The word is Norwegian, and in Norway fjords are characteristically developed. The English word "firth," however, is the same, and the western coasts of the British Isles furnish many excellent examples of fjords. In Scotland they are usually called lochs, as Loch Hourn, Loch Nevis, Loch Fyne, Gareloch; in Ireland they are sometimes known by the name of loughs, as Lough Foyle, but more commonly by that of bays, as Dingle Bay, Bantry Bay. There can be little doubt that, though now filled with salt water, fjords have been originally land valleys. The long inlet was first excavated as a land-valley or glen. This valley exactly corresponds in form and character with the hollow of the fjord, and must be regarded as merely its inland prolongation. That the glens have been excavated by subaerial agents is a conclusion borne out by a great weight of evidence. If, therefore, we admit the subaerial origin of the glen, we must also grant a similar origin to its seaward prolongation. Every fjord will thus mark the site of a submerged valley. This inference is confirmed by the fact that fjords do not, as a rule, occur singly. Like the glens on the land they lie in groups; so that when they are found intersecting a long line of coast like that of the west of Norway, or the west of Scotland, we conclude that the land has there sunk down so as to permit the sea to run far up and fill the submerged glens.

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[1] "Earthquakes and Volcanoes," by A. Geikie, Chambers's *Miscellany of Tracts.*

[2] *Ibid.*

(4.) Evidence of widespread depression over the area of the Pacific Ocean is furnished by the numerous atolls or coral islands scattered throughout that vast expanse of water. Mr. Darwin ascertained that the reef-building corals do not live at a greater depth than about 15 or 20 fathoms. Yet reefs and circular islets of coral rise with nearly perpendicular sides from a depth of 2000 feet and upwards, until they reach the surface of the sea. As the corals could not have begun to grow upwards from such vast depths, Mr. Darwin first suggested that the sites of these coral reefs had undergone a progressive subsidence, the rate of upward growth of the reefs keeping pace, on the whole, with the depression. A fringing reef would first be formed fronting the land within the limit of the 20 fathom line. Growing upward until it reached the surface of the water, it would be exposed to the dash of the waves, which would break off pieces of the coral and heap them upon the reef. In this way islets would be formed which, by successive accumulations of materials thrown up by the breakers or brought by winds, would remain permanently above water. On these islets palms and other plants, whose seeds might be drifted from the adjoining land, would take root and flourish. Inside the reef there would be a shallow channel of water, communicating, through gaps in the reef, with the main ocean outside. Fringing reefs of this character are of common occurrence at the present time. In the case of a continent they front its coast for a long distance, but they may entirely surround an island. If the site of a fringing reef undergoes depression at a rate sufficiently slow to allow the corals to keep pace with it, the reef will grow upward as the bottom sinks downward. The lagoon channel inside will become deeper and wider, while, at the same time, the depth of the water outside will increase. In this way a barrier reef will be formed. Continued slow depression must continually diminish the area of the land enclosed within one of these rings of coral-reef, while the reef itself retains much the same size and position. At last the final peak of the original island disappears under the lagoon, and an atoll or true coral island is formed. Should any more rapid or sudden downward movement take place, it might carry the atoll down beneath the surface, as seems to have happened at the Great Chagos bank in the Indian Ocean, which is a submerged atoll. It has recently been suggested that barrier reefs do not necessarily prove subsidence, seeing that they may grow outward from the land upon the top of a talus of their own debris broken down by the waves, and may thus appear to consist of solid coral which had grown upward from the bottom during depression, although only the upper layer, 20 fathoms or thereabouts in thickness, is composed of solid, unbroken, coral growth. The explanation may doubtless account for some barrier-reefs, and for the way in which the steep seaward face of all such reefs is formed and maintained But it does not elucidate the existence of submerged atolls, the presence of gaps in atolls answering to gaps in the fringing reefs opposite to the mouths of rivers; and the difficulty of supposing that, in a coral archipelago, there should have been scores of submerged peaks so nearly of the same height as to rise within 20 fathoms of the surface, and yet so seldom actually to tower above it. According to the simple and luminous theory of Mr. Darwin, every stage in the progress of the changes is open to observation, from the incipient fringing reef to the completed and submerged atoll. Every observed fact fits in harmoniously with the others, and we reach the impressive conclusion that a vast area of the Pacific Ocean, fully 6000 geographical miles from east to west, has undergone a recent subsidence, and may be slowly sinking still.

It by no means follows, however, as some writers have imagined, that the present Pacific Ocean occupies the site of a vast submerged continent. All the coral islands seem to have been built on volcanic peaks. Wherever any non-calcareous rock appears it is of volcanic origin. We must therefore conceive of these oceanic islands as detached volcanic eminences rising out of a wide area of subsidence, and doubtless as deriving their existence from the results of that subterranean movement.

§ 3. *Causes of Secular Upheaval and Depression.*

These movements, without question, we must again trace back to consequences of the original internal heat of the earth. There are various ways in which the heat may have acted. Thus a considerable accession of heat expands rocks. and, on the other hand, a loss of heat causes them to contract. We may suppose therefore that, during the subterranean changes, a great extent of the crust underneath a tract of land may have its temperature slowly raised. The effect of this increment would be to cause a slow uprise of the ground above. The gradual transference of the heat to another quarter might produce a steady subsidence. Such variations in subterranean temperature, however, could give rise at the most to but very insignificant elevations or depressions.

A far more important and generally effective cause is to be sought in the secular contraction of the globe. If our planet has been steadily losing heat by radiation into space, it must have progressively diminished in volume. The cooling implies contraction. According to Mr. Mallet, the diameter of the earth is less by at least 189 miles since the time when the planet was a mass of liquid.[1] But the contraction has not manifested itself uniformly over the whole surface of the planet. The crust varies much in structure, in thermal resistance, and in the position of its isogeo-thermal lines. As the hotter nucleus contracts more rapidly by cooling than the cooled and hardened crust, the latter must sink down by its own weight, and in so doing requires to accommodate itself to a continually diminishing diameter. The descent of the crust gives rise to enormous tangential pressures. The rocks are crushed, crumpled, and broken in many places. Subsidence must have been the general rule, but every subsidence would doubtless be accompanied with upheavals of a more limited kind. The direction of these upheaved tracts would largely depend upon the original structure of the crust. It would be apt to occur in lines which, once taken as lines of weakness or relief from the intense strain, would probable be made use of again and again at successive paroxysms or more tranquil periods of contraction. Mr. Mallet, in the paper already cited, has ingeniously connected these movements with the linear direction of mountain chains, volcanic vents, and earthquake shocks.

Though the origin of the present surface configuration of the land will be more conveniently discussed in a subsequent part of this article, after the structure of the earth's crust has been described, a few words may be inserted here, where some allusion to the subject might be looked for. Mountains may arise from three causes—(1) from the corrugation of the earth's crust due to the effects of secular contraction; (2) from the accumulation of materials poured out of volcanic orifices; and (3) from the isolation of elevated masses of ground, owing to the removal, by denudation, of the materials originally connecting them, and to the consequent formation of valleys. Mountains formed in the volcanic way are almost always conical, and are either solitary, as Etna, or occur in linear groups, like the volcanoes of Java. Those formed by denudation are of minor dimensions, and rather deserve the name of hills.

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[1] *Phil. Trans.*, 1873, p. 250.

Mountain-chains, on the other hand, which are the dominant features of the earth's surface, though they may have lines of volcanic vents along their crests, are not formed essentially of volcanic materials, but of the sedimentary and crystalline rocks of the crust which have been ridged up into vast folds. If the continental lands may be compared to great undulations of the solid surface of the globe, the mountain-chains may be likened to the breaking crests of such wave-like undulations. In their internal structure mountain-chains bear witness to the intense crumpling of the rocks during the process of upheaval. As a consequence of the uprise of two or more parallel ranges of mountain, lines of longitudinal valley must be produced. But no sooner is a mass of land raised above the sea than it is exposed to the attacks of air, rain, frost, springs, glaciers, or other meteoric agents of disintegration. Its surface is then worn down, the flow of water down its slopes cuts out gulleys, ravines, and valleys, so that eventually a very rugged surface is produced, on which, probably, no portion of the original surface of upheaval may remain, but where new lines of minor ridge and valley may appear as the combined result of internal geological structure and atmospheric denudation. The reader, however, is referred to part vii. of this article for a fuller treatment of this interesting subject.

During the movements by which mountain masses have been upheaved, the stratified rocks have been so compressed as to occupy, in many cases, but a small proportion of the horizontal extent over which they originally extended. They have adjusted themselves to this diminished area by undergoing intense plication, and thus acquiring a much greater vertical depth. On the other hand, they have been abundantly fractured, some portions of their mass being pushed up, others being let down, so that the crust is traversed with a kind of complicated network of fissures. The discussion of these features of geological structure, however, must likewise be postponed to part iv., where the facts regarding their occurrence will be described.

Section IV.—Hypogene Causes of Changes in the Texture, Structure, and Composition of Rocks.

The phenomena of hypogene action hitherto under consideration have related almost wholly to the effects produced at the surface. It is evident, however, that these phenomena must be accompanied by very considerable changes in the rocks which form the earth's outer crust. These rocks, as just stated, have been subjected to enormous pressure; they have been contorted, crumpled, and folded back upon themselves, as if thousands of feet of solid limestones, sandstones, and shales had been merely a few layers of carpet; they have been shattered and fractured everywhere; they have in one place been pushed far above their original position, in another depressed far beneath it: so great has been the compression which they have undergone that their component particles have in many places been rearranged, and even crystallized. They have here and there actually been reduced to fusion, and have been abundantly invaded by masses of molten rock from below.

In the present section of this article we shall consider chiefly the nature of the agencies by which such changes have been effected; the results achieved, in so far as they constitute part of the architecture or structure of the earth's crust, will be discussed in part iv. At the outset, it is evident that we can hardly hope to detect many of these processes of subterranean change actually in progress and watch their effects. The very vastness of some of them places them beyond our direct reach, and we can only reason regarding them from the changes which we see them to have produced. But a good number are of a kind which we can in some measure imitate in our laboratories and furnaces. It is not requisite, therefore, to speculate wholly in the dark on this subject. Since the original and classic researches of Sir James Hall, the founder of experimental geology, great progress has been made in the investigation of hypogene processes by experiment. The conditions of nature have been imitated as closely as possible, and varied in different ways, with the result of giving us an increasingly clear insight into the physics and chemistry of subterranean geological changes. The succeeding portions of this section of the article will therefore be chiefly devoted to an illustration of the nature of hypogene action, in so far as that can be inferred from the results of actual experiment. The subject may be conveniently treated under three heads—(1) the effects of heat; (2) the effects of pressure and contraction; (3) the influence of water in effecting changes in minerals and rocks.

§ 1. *Effects of Heat.*

The importance of heat among the transformations of the rocks has been fully admitted by geologists, since it used to be the watchword of the Huttonian or Vulcanist school at the end of last century. Two sources of subterranean heat may have at different times and in different degrees cooperated in the production of hypogene changes—(1) the internal heat of the globe, of which some account has already been given, and (2) the heat due to the transformation of mechanical energy in the crumpling, fracturing, and crushing of the rocks of the crust, as these have been from time to time compelled to adjust themselves to the diminishing diameter of the more rapidly cooling and contracting interior. From which of these two sources, or from what combination of them, the heat was derived by which any given change in the rocks was produced, is a problem which admits in the mean time of only very partial solution. Leaving this question for the present, let us examine the effects which are clearly referable to the influence of heat. It is evident that the conditions under which these effects are produced must vary almost infinitely. We have to consider (1) the temperature, from the lowest at which any change is possible up to that of complete fusion; (2) the nature of the rock operated upon, some materials being much more susceptible of change from heat than others; (3) the pressure under which the heat acts, the potency of this agency being much increased with increase of pressure; (4) the presence of water, whereby chemical changes take place which would not be possible in dry heat.

In an interesting series of experiments the illustrious De Saussure (1779) fused some of the rocks of Switzerland and France and inferred from them, contrary to the opinion previously expressed by Desmarest,[1] that basalt and lava have not been produced from granite, but from hornstone (pierre de corne), varieties of "schorl," calcareous clays, marls, and micaceous earths, and the cellular varieties from different kinds of slate.[2] He observed, however, that the artificial products obtained by fusion were glassy and enamel-like, and did not always recall volcanic rocks, though some exactly resembled porous lavas.

Sir James Hall, about the year 1790, began an important investigation, in which he succeeded in reducing various ancient and modern volcanic rocks to the condition of glass, and in restoring them, by slow cooling, to a stony state. Since that time many other researches of a more complicated kind have been undertaken, especially by Delesse, Daubrée, Deville, Bunsen, Bischof, H. and W. Rogers. By these observations it has been abundantly proved that all rocks undergo molecular changes when exposed to high temperature, that when the heat is sufficiently raised they become fluid, that if the glass thus obtained is rapidly cooled it remains vitreous, and that, if allowed to cool slowly, a more or less distinct crystallization sets in, the glass is devitrified, and a lithoid product is the result.

Illustrations of the influence of different degrees of heat upon rocks of different kinds may often be very instructively observed at lime-kilns, especially those roughly-built kilns or pits which may still be met with in outlying districts. Some of the stones lining such cavities will be found with no sensible change, others show a somewhat cellular texture, others have acquired a rudely prismatic structure, while some have had their surfaces fused into a rough glaze or enamel. The bricks or stones used for lining furnaces present similar illustrations, the columnar or prismatic structure being occasionally very perfectly developed in these materials. Mere contact with a highly-heated surface, and subsequent gradual cooling, have often produced this prismatic arrangement in rocks of the most diverse kinds. Thus, in Scotland, beds of sandstone and seams of coal have acquired the most perfect prismatic structure from the intrusion of basalt dykes or sheets through them. To these and other effects of intruded igneous rocks reference will be made in the sequel. In these cases the alteration is merely local, and has obviously been produced by contact with a highly heated surface. But, besides such minor effects due merely to contact, others of a more general kind affect large masses of rock or whole districts of country.

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[1] *Mém. Acad. Scien.*, 1771, p. 273.

[2] De Saussure, *Voyages dans les Alps*, edit. 1803, tome i. p. 178.

When rocks are exposed to temperatures as high as their melting-points, they fuse into glass which, in the great majority of cases, is of a bottle-green or black color, the depth of the tint depending mainly on the proportion of iron. In this respect they resemble the natural glasses—pitchstones and obsidians. They almost always contain minute cells or bubbles, arising probably from the disengagement of water or of oxygen during the fusion. But after the most thorough fusion which has been found possible, minute granules usually appear in the solidified glass. Sometimes these consist of specks of quartz, which is especially apt to remain unmelted when the rock is very siliceous, or of other minerals of the original rock. But a microscopic investigation of fused rock shows that, even in what seems to be a tolerably homogeneous glass, there are abundant minute hair-like, feathered, needle-shaped, or irregularly-aggregated bodies diffused through the glassy paste. These *crystallites* are in some cases colorless silicates, in others they are opaque metallic oxides, particularly oxides of iron. They precisely resemble the crystallites which are observed in many volcanic rocks, such as obsidian, pitch-stone, and basalt. They may be obtained even from the fusion of a granitic or granitoid rock, as in the well-known case of the Mount Sorrel syenite near Leicester, which, being fused and slowly cooled, yielded abundant crystallites, including exquisitely grouped octohedra of magnetite.

According to the observations of Delesse, volcanic rocks, when reduced to a molten condition, attack briskly the sides of the Hessian crucibles in which they are contained, and even eat them through. This is an interesting fact, for it helps to explain how some intrusive igneous rocks have come to occupy positions previously filled by sedimentary strata, and why, under such circumstances, the composition of the same mass of rock should be found to vary considerably from place to place.[1]

It would appear that, in passing from a crystalline into a vitreous condition, rocks undergo a diminution of density, which, on the whole, is greater the more silica and alkali are present, and is less as the proportion of iron, lime, and alumina increases. According to Delesse, granites, quartziferous porphyries, and such highly silicated rocks lose from 8 to 11 per cent. of their density when they are reduced to the condition of glass, basalts lose from 3 to 5 per cent., and lavas, including the vitreous varieties, from 0 to 4 per cent. This diminution of density (and consequent increase of volume) may account for minor oscillations of the ground so often observed in volcanic regions. If we suppose a subterranean mass of lava 500 feet thick to pass from the fluid to the crystalline condition, this might cause a subsidence of the ground above to the extent of about 20 or 25 feet. The transition of a similar mass of rock from the solid to the fluid condition would cause an uprise to a like amount.

So far as experiments have yet been conducted, it has been found impossible to obtain from a piece of fused rock a crystalline substance exactly resembling the original mass. Externally it may appear quite stony, but its internal structure, as revealed by the microscope, shows it to be essentially a slag or glass, and not a truly crystalline rock. There is another fundamental difference between the natural and artificial products. When a compound containing substances of different fusibilities is artificially melted, and allowed thereafter to cool in such a way that the various ingredients may separate from each other, they appear in their order of fusibility, the most refractory coming first, and the most fusible being the last to take a solid form. But in rocks which have crystallized naturally from a fluid condition, it is often to be observed that the component minerals have been far from obeying what might have been supposed to be their invariable law. Thus in all parts of the world, granite presents the very striking fact that its quartz, which we call an infusible mineral, has actually solidified after the more fusible felspar. In the Vesuvian lavas the difficultly fusible leucite may be seen to have enclosed crystals already formed of the fusible augite. In many ancient crystalline rocks the pyroxenic constituents, which offer a less resistance to fusion, have assumed a crystalline form before the more refractory triclinic felspars. From these facts it is clear that, in the fusion of rocks and in their subsequent consolidation, there must have been conditions under which the normal order of appearance of the minerals was disturbed or reversed. Yet another fact may be mentioned to show further the difference between the kind of fusion which has frequently obtained in nature and that of the ordinary operations of a glass-work or iron-furnace. As far back as the year 1846 Scheerer showed that there exist in granite various minerals which could not have consolidated save at a comparatively low temperature. He instanced especially several gadolinites, orthites, and allanites, which cannot endure a higher temperature than a dull-red heat without altering their physical characters; and he concluded that granite, though it may have possessed a high temperature, cannot have solidified from simple igneous fusion.

We may conclude, therefore, that the manner in which rocks have been melted within the crust is not that mere simple fusion which we can accomplish artificially, but that it has involved conditions which have not been successfully imitated in any laboratory or furnace. Two obvious differences must occur to the reader between the natural and artificial operations. In the first place, rocks which have undoubtedly once been in a fluid or at least pasty condition, and which have been injected as veins and dykes into previously consolidated masses, contain water imprisoned within their component crystals. This is not water which has been subsequently introduced. It is contained in minute cells, which it usually does not now completely fill, but which it no doubt did occupy completely at the time and temperature at which the rock was consolidated. We have seen (*ante*, p. 223) how abundant are the discharges of water-vapor from volcanic fires, how the molten lava-streams issue from their vents, saturated, as it were, with steam, and how the steam continues to rise from them long after they have congealed and come to rest. In the solid crystals of lava which were erupted only recently, as well as in those of early geological periods, the presence of water in minute cavities may be readily detected. It is in the quartz of such rocks, and still more in that of granite, that the detection of water-cavities is most easily made. The quartz of granite is usually full of them. "A thousand millions," says Mr. J. Clifton Ward, "might easily be contained within a cubic inch of quartz, and sometimes the contained water must make up at least 5 per cent. of the whole volume of the containing quartz." Thus microscopic investigation confirms the conclusion arrived at by Scheerer in the memoir already cited, that at the time of its eruption granite must have been a kind of pasty mass containing a considerable proportion of water. It is common now to speak of the "aquo-igneous" origin of some eruptive rocks, and to treat their production as a part of what is termed the "hydro-thermal" operations of geology. We may conclude that, while some rocks, like obsidian and pitchstone, which so closely resemble artificial glasses, may have been derived from a simple igneous fusion such as can be imitated in a furnace (though even in these the presence and influence of water may be traced), the great majority of rocks have had a more complex origin, and in a great number of cases can be proved to have been mingled with more or less water while they were still fluid.

In the second place, there can be no question that, in the great hypogene laboratory of nature, rocks have been softened and fused under enormous pressure. Besides the pressure due to their varying depth from the surface, they must have been subject to the enormous expansion of the superheated water or vapor which filled all their cavities. Mr. Sorby has ingeniously estimated the probable pressure under which granite consolidated by taking the ratio between the size of the liquid cavities in the quartz and that of the contained bubble or vacuity. Assuming the temperature of consolidation to have been 680° Fahr. (360° Cent.), or a dull-red heat, he inferred that in many cases the pressure under which the granite consolidates must have been equal to that of an overlying mass of rock 50,000 feet, or more than 9 miles, in thickness. It is not probable that any such thick overlying mass ever did cover the granite; the pressure, even if it be allowed to have been so great, must have been due partly to other causes, such as the compression due to secular contraction.

It would appear therefore that perfect anhydrous fusion, or the reduction of a rock to the state of a completely homogeneous glass, has been a comparatively rare process in nature, or at least that such glasses, if originally formed, have in the vast majority of cases undergone devitrification and crystallization, until the glassy base has been reduced to a smaller or larger fraction of the total mass of the rock, or has entirely passed into a stony condition. In many volcanic rocks the original vitreous base or ground-mass can be readily observed with the microscope between the definitely-formed crystals. Crystallites, or arrested stages in the crystallization of iron oxides and of silicates, can often be detected in these rocks, more especially where it is evident that they must have cooled with comparative rapidity, as where they have been thrust into narrow fissures to form dykes. But in rocks such as granite, where no glass exists, but where the mineral constituents are all crystalline, no trace of the crystallites occurs. Doubtless such differences point to original distinctions in the kind and degree of fusion of the rocks. It seems reasonable to suppose that those rocks which show a glassy ground-mass, and the presence of crystallites, have been fused under conditions more nearly resembling those of the simple igneous fusion of experiment.

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[1] *Bull. Soc. Géol. France*, 2d ser., iv. 1382.

It has long been known that many mineral substances can be obtained in a crystalline form from the condensation of vapors. This process, called sublimation, may be the result of the mere cooling and reappearance of bodies which have been vaporized by heat and solidify on cooling, or from the solution of these bodies in other vapors or gases, or from the reaction of different vapors upon each other. These operations are of common occurrence at volcanic vents, and in the crevices of recently erupted and still hot lava-streams. They have been successfully imitated by experiment. In the early researches of Sir James Hall on the effects of heat modified by compression, he obtained by sublimation "transparent and well-defined crystals," lining the unoccupied portion of a hermetically-sealed iron tube, in which he had placed and exposed to a high temperature some fragments of limestone (*Trans. Roy. Soc. Edin.*, vi. 110). Numerous experiments have been made by Messrs. Delesse, Daubrée, and others, in the production of minerals by sublimation. Thus many of the metallic sulphides found in mineral veins have been produced by exposing to a comparatively low temperature (between that of boiling water and a dull-red heat) tubes containing metallic chlorides and sulphide of hydrogen. By varying the materials employed, corundum, quartz, apatite, and other minerals have been obtained. It is not difficult, therefore, to understand how, in the crevices of lava-streams and volcanic cones, as well as in some mineral veins, sulphides and oxides of iron and other minerals may have been formed by the ascent of heated vapors. Superheated steam is endowed with a remarkable power of dissolving that intractable substance, silica; artificially heated to the temperature of the melting point of cast-iron, it rapidly attacks silica, and deposits the mineral in snow-white crystals as it cools.

§ 2. *Effects of Pressure and Contraction.*

Besides the influence of pressure in raising the melting point of subterranean rocks, and in permitting water to remain fluid among them at temperatures far above the boiling point, even at a red or perhaps a white heat, we have to consider the effects produced by the same cause upon rocks already solidified. The simplest and most obvious result of pressure upon such rocks is their consolidation, as where a mass of loose sand is gradually compacted into a more or less coherent stone, or where a layer of vegetation is compressed into peat, lignite, or coal. In many cases the cohesion of a sedimentary rock is due merely to the pressure of the superincumbent strata. But it usually happens that some cementing material has contributed to bind the component particles together. Of these natural cements the most frequent are peroxide of iron, silica, and carbonate of lime.

Pressure equally distributed over a rock presenting everywhere nearly the same amount of resistance will promote consolidation, but may produce no further internal change. If, however, the pressure becomes extremely unequal, or if the rock subjected to it can find escape from the influence in one or more directions, there will be a disturbance or rearrangement of the particles, which by this means are made to move upon each other. Five consequences of these movements may be noticed here.

(1.) *Cleavage.*—When a mass of rock, owing to subsidence or any other cause, is subjected to powerful lateral compression, its innate particles, which in all rocks have almost invariably a longer and shorter axis, tend, under the intense strain, to rearrange themselves in the line of least resistance, that is, with their long axes perpendicular to the direction of the pressure. The result of this readjustment is that the rock affected by it acquires a facility for splitting along the lines in which its component particles have placed themselves. Fine-grained argillaceous rocks show most characteristically this internal change; but in coarse materials it becomes less conspicuous, or even disappears. Rocks which have been thus acted on, and have acquired this superinduced fissility, are said to be *cleaved*, and the fissile structure is termed *cleavage*. This has been proved experimentally by Sorby, who produced perfect cleavage in pipeclay through which scales of oxide of iron had previously been mixed. Dr. Tyndall superinduced cleavage on bees-wax and other substances by subjecting them to severe pressure. Cleavage among rocks occurs on a great scale in countries where the strata have been greatly plicated, that is, where they now occupy much less horizontal surface than they once did, and consequently where, in accommodating themselves to their diminished area, they have had to undergo much powerful lateral compression. The structure of districts with cleaved rocks is described in part iv.

(2.) Further evidence of the compression to which rocks have been subjected is furnished by the way in which contiguous pebbles in a conglomerate may be found to have been squeezed into each other, and even sometimes to have been elongated in a certain general direction. It is doubtless the coarseness of the grain of such rocks which permits the effects of compression to be so readily seen. Similar effects must take place in fine-grained rocks, though they escape observation. Organic remains both of plants and animals may often be found to have undergone considerable distortion from this cause. M. Daubrée has imitated experimentally the indentations produced by the contiguous portions of conglomerate pebbles.[1]

(3.) The ingenious experiments of M. Tresca on the flow of solids have proved that, even at ordinary atmospheric temperatures, solid resisting bodies like lead, cast-iron, and ice, may be so compressed as to undergo an internal motion of their parts which is closely analogous to that of fluids. Thus, a solid jet of lead has been produced by placing a piece of the metal in a cavity between the jaws of a powerful compressing machine. Iron, in like manner, has been forced to flow in the solid state into cavities and take their shape. On cutting sections of the metals so compressed, their particles or crystals are found to have ranged themselves in lines of flow which follow the contour of the space into which they have been squeezed. Such experiments are of considerable geological interest, for they show that in certain circumstances, under great pressure, the unequally mixed particles of rocks within the earth's crust may have been forced to move upon each other, and thus to acquire a "fluid structure" resembling that which is seen in rocks which have possessed true liquidity. No large sheet of rock can be expected, however, to have undergone this internal change; the effects could only be produced exceptionally at places where there was an escape from the pressure, as, for instance, along the sides of fissures, or in other cavities of rocks. The explanation cannot be applied to the case of rocks like schists, which display a kind of rude foliation or fluid structure over areas many thousands of square miles in extent.

(4.) *Plication.*—Reference has already been made to the fact that, owing to the more rapid contraction of the inner portion of the globe, the outer layer or crust is from time to time forced to adjust itself to this change by subsiding. As a consequence of the subsidence, the descending area requires to occupy less horizontal space, and must therefore suffer powerful lateral compression. The rocks are thus crumpled up, as, in the classic experiment of Sir James Hall, folds of cloth are folded when a weight is placed upon them and they are squeezed from either side. The mere subsidence of such a curved surface as that of our globe must thus necessarily produce much lateral compression. Mr. J. M. Wilson has calculated that, if a tract of the earth's surface, 345 miles in breadth, be depressed one mile, it will undergo compression to the extent of 121 yards; at two miles the compression will be 189 yards; at eight miles 598 yards. The observed amount of compression in districts of contorted rocks, however, far exceeds these figures. Another cause of the compression and contortion of rocks is the injection into them of igneous masses from below, but this is probably a minor source of disturbance. The character of plicated rocks is described in part iv. p. 266.

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[1] *Comptes Rendus*, xliv. 823.

(5.) *Faults.*—Closely connected with the disturbances which have produced contortions come those by which the crust of the earth has been fractured. But in this case the movement is one of elevation rather than of subsidence; for, instead of having to occupy a diminished diameter, the rocks get more room by being pushed up, and as they cannot occupy the additional space by any elastic expansion of their mass, they can only accommodate themselves to the new position by a series of dislocations. Some portions will be pushed up farther than others, and this will happen more particularly to those which have a broad base. These will rise more than those with narrow bottoms, or the latter will seem to sink relatively to the former. Each broad-bottomed segment will thus be bounded by two sides sloping towards the upper part of the block. This is found to be almost invariably the case in nature. A fault or dislocation is nearly always inclined from the vertical, and the side to which the inclination rises, and from which it "hades," is the upthrow side. The details of these features of geological structure are discussed in part iv. section v.

§ 3. *Influence of Water.*

In the great geological contest fought at the beginning of the century between the Neptunists and the Plutonists, the two great battle-cries were, on the one side, Water, on the other, Fire. The progress of the science since that time has shown that each of the parties had truth on its side, and had seized one aspect of the problems touching the origin of rocks. If subterranean heat has played a large part in the construction of the materials of the earth's crust, water, on the other hand, has performed a hardly less important share of the task. They have often co-operated together, and in such a way that the result must be regarded as their joint achievement, wherein the respective share of each can hardly be exactly apportioned. In the following brief *résumé* of this subject we shall consider the changes produced by pure water, by water charged with substances in solution, and by water raised above ordinary temperatures.

By numerous observations it has been proved that all rocks within the accessible portion of the earth's crust contain interstitial water, or, as it is sometimes called, quarry-water (*eau-de-carrière*). This is not chemically combined with their mineral constituents, but merely retained in their pores. Most of it evaporates when the stone is taken out of the parent rock and freely exposed to the atmosphere. The absorbent powers of rocks vary greatly, and chiefly in proportion to their degree of porosity. Gypsum absorbs from about 0·50 to 1·50 per cent. of water by weight; granite, about 0·37 per cent.; quartz from a vein in granite, 0·08; chalk, about 20·0; plastic clay, from 19·5 to 24·5. These amounts may be increased by exhausting the air from the specimens and then immersing them in water.

The water enclosed within the interstices and crystals of igneous rocks may be either an original constituent, deriving its origin, like any of the component minerals, from molten reservoirs within the earth's crust, or it may have descended from the surface to the incandescent rocks. Many facts may be adduced in support of the greater probability of the second view. Besides the general proximity of volcanic orifices to large sheets of water, we have abundant evidence of the actual descent of water from the surface, both through fissures, and also by permeation through the solid substance of rocks. All surface rocks contain water, and no mineral substance is strictly impervious to the passage of liquid. The well-known artificial coloring of agates proves that even the mineral substances apparently most homogeneous and impervious can be traversed by liquids. M. Daubrée has instituted a series of experiments to illustrate the power possessed by water of penetrating rocks, in virtue of their porosity and capillarity, even against a considerable counter-pressure of vapor; and, without denying the presence of original water, he concludes that the interstitial water of igneous rocks may all have been derived by descent from the surface.

The presence of interstitial water must affect the chemical constitution of rocks. It is now well understood that there is probably no terrestrial substance which, under proper conditions, is not to some extent soluble in water. By an interesting series of experiments, made many years ago by Messrs. Rogers, it was ascertained that many of the ordinary mineral constituents of rocks could be dissolved to an appreciable extent even by pure water, and that the change was accelerated and augmented by the presence of carbonic acid.[1] Silica, alkaliferous silicates, and iron oxides can be taken up and held in solution by pure water even at ordinary temperatures, in considerable quantities. The mere presence of pure water therefore within the pores of subterranean rocks cannot but give rise to changes in the composition of these rocks. Some of the more soluble materials must be dissolved, and, as the water evaporates, must be redeposited in a new form.

But water in a natural state is never chemically pure. In its descent through the air it absorbs oxygen and carbonic acid, besides other impurities (see p. 237), and as it filters through the soil it abstracts more carbonic acid, as well as other results of decomposing organic matter. It is thus enabled to effect numerous decompositions of the rocks underneath. The nature of these changes may be inferred from the composition of spring water, to which reference will subsequently be made (p. 240). For the present it will be sufficient to remark that two important kinds of chemical decomposition must evidently arise from the action of such infiltrating water. (1.) The presence of the organic matter must exercise a reducing power on oxides. This will be more especially the case with those of iron, the nearly insoluble hæmatite being reduced to the protoxide, which, converted into carbonate, is readily removable in solution. There can be little doubt that by this means a vast amount of ferruginous matter is extracted from subterranean rocks and carried to the surface. (2.) The presence of carbonic acid enables the water to attack vigorously the mineral constituents of rocks. Alkaline carbonates, with carbonates of lime and magnesia, and protoxides of iron and manganese, are produced, and these substances borne onward in solution give rise to further reactions among the rocks through which they are carried. "In the decomposition of rocks," says Bischof, "carbonic acid, bicarbonate of lime, and the alkaline carbonates bring about most of the decompositions and changes in the mineral kingdom."

The microscopic study of rocks has thrown much light upon the mineralogical alterations in rocks due to the influence of percolating water. Even the most solid-looking, unweathered rocks, are found to have been affected by such metamorphism. Their hydrous magnesian silicates, for example, are partially or wholly converted into such hydrous forms as serpentine, chlorite, or delessite. The process of conversion may often be watched. It can be seen to have advanced along the fissures or cleavage-planes of the minerals leaving the intervening sections still fresh; or it may be observed to have proceeded in such a way that diffused alteration-products are dispersed in filaments or irregular patches through the base of the rock, or gathered together and even recrystallized in cavities; or the whole rock, as in many serpentines, has undergone an entire transformation. Much information regarding such internal alterations of rocks may be obtained from the study of *pseudomorphs*, that is, crystals having the external form of the mineral of which they originally consisted, with the internal structure and composition of the mineral which has replaced it. Serpentine representing olivine, clay taking the place of rock-salt, silica that of wood, and marcasite that of molluscan shell, are familiar examples. There is no reason to doubt that these changes may, in the course of ages, have been effected at ordinary temperatures by water descending from the surface of the ground.

But two other considerations require to be taken into account in the discussion of the internal transformations of rocks by subterranean water. (1.) In the first place, the water has often been at a high temperature. Mere descent into the crust of the earth will raise the temperature of the water until, if this descent be prolonged, a point far above 212° Fahr. may be reached. Experiments have shown that the chemical action of water is vastly increased by heat. Thus M. Daubrée exposed a glass tube containing about half its weight of water to a temperature of about 400° C. At the end of a week he found the tube so entirely changed into a white, opaque, powdery mass as to present not the least resemblance to glass. The remaining water was highly charged with an alkaline silicate containing 63 per cent. of soda and 37 per cent. of silica, with traces of potash and lime. The white solid substance was ascertained to be composed almost entirely of crystalline materials. These consisted partly of minute perfectly limpid bipyramidal crystals of quartz, but chiefly of very small acicular prisms of wollastonite. It was found, moreover, that the portion of the tube which had not been directly in contact with the water was as much altered as the rest, whence it was inferred that at these high temperatures and pressures the vapor of water acts chemically like the water itself. (2.) In the second place, the effect of pressure must be recognized as most important in enabling water, especially when heated, to dissolve and retain in solution a larger quantity of mineral matter than it could otherwise do. In M. Daubrée's experiments just cited, the tubes were hermetically sealed and secured against fracture, so that the pressure of the greatly super-heated vapor had full effect. By this means, with alkaline water, he not only produced the two minerals above mentioned, but also felspar and diopside.

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[1] *American Journ. Science* (2), v. 401.

It is important to observe that the three conditions required for these changes—the presence of alkaline water, a high temperature, and considerable pressure—are precisely those which it can be affirmed must exist abundantly within the crust of the earth. We must admit the possibility of rocks originally at the surface being depressed so as to come within the influence of internal heat, and to contain within their pores abundant interstitial water more or less charged with alkaline carbonates. Rocks under these conditions, so far as we can judge, can hardly escape internal decomposition and recomposition. Mere descent to a great depth beneath the surface will not necessarily result in metamorphism, as has been shown in the case of the Nova Scotian and of the South Welsh coal-fields, where sandstones, shales, clays, and coal-seams can be proved to have been once depressed 14,000 to 17,000 feet below the sea-level, under an overlying mass of rock, and yet to have sustained no serious alteration. Perhaps the failure of change may be explicable on the supposition that these Carboniferous strata were comparatively dry. But where rocks possess sufficient interstitial water, and are depressed within the crust so as to be exposed to a considerable temperature and to great pressure, they must be metamorphosed,—the extent of the metamorphism depending partly upon the vigor of the attack made upon them by the water, partly on their own composition and proneness to chemical change, and partly upon the length of time during which the process is continued.

A metamorphosed rock must thus be one which has suffered a mineralogical rearrangement of its substance. It may or may not have been a crystalline rock originally. Any rock capable of alteration (and all rocks must be so in some degree) will, when subjected to the required conditions, become a metamorphic rock. The resulting structure, however, will, in most cases, bear witness to the original character of the mass. A sedimentary rock, for example, consisting of alternate layers of different texture and composition will doubtless retain, even in its metamorphosed condition, traces of that fundamental structure. The water will travel more easily along certain layers than along others; some laminæ will be more readily affected, or will give rise to a set of reactions different from those of contiguous layers. Hence the rearrangement and recrystallization due to metamorphism will take place along the predetermined lines of stratification, so long as these lines have not been effaced or rendered inoperative by any other geological structure. It is doubtless to this cause that the foliated character of gneiss, mica-schist, and so many other metamorphic rocks is to be ascribed.

In the process of metamorphism, therefore, as well as in that of fusion, to which reference has already been made, the influence of water would seem to have been always conspicuous. Indeed, as will be shown in part iv., it is extremely difficult in many cases to draw a line between the results of metamorphism and igneous fusion, or to decide whether a rock should be called igneous or metamorphic. It has been pointed out above, for example, that in many rocks which have undoubtedly been in a fluid condition, as proved by their injected veins and dykes, the constituent minerals have not appeared in the order of their respective fusibilities. Scheerer, Élie de Beaumont, and Daubrée have shown how the presence of a comparatively small quantity of water in such rocks has contributed to suspend their solidification, and to promote the crystallization of their silicates at temperatures considerably below the point of fusion. In this way the solidification of quartz in granite after the crystallization of the silicates, which would be unintelligible on the supposition of mere dry fusion, becomes explicable. The phenomena of metamorphism in the architecture of the earth's crust are discussed in part iv.

DIVISION II.—EPIGENE OR SURFACE ACTION.

It is on the surface of the globe and by the operation of agents working there that at present the chief amount of visible geological change is effected. In considering this branch of inquiry, we are not involved in the same preliminary difficulty regarding the very nature of the agencies as we found to be the case in the investigation of plutonic action. On the contrary, the surface agents are carrying on their work under our very eyes. We can watch it in all its stages, measure its progress, and mark in many ways how accurately it represents similar changes which for long ages previously must have been effected by the same means. But in the systematic treatment of this subject we encounter a difficulty of another kind. We discover that while the operations to be discussed are numerous and often complex, they are so interwoven into one great network that any separation of them under different subdivisions is sure to be more or less artificial, and to convey an erroneous impression. While, therefore, under the unavoidable necessity of making use of such a classification of subjects, we must bear always in mind that it is employed merely for convenience, and that in nature superficial geological action must be continually viewed as a whole, since the work of each agent has constant reference to that of the others, and is not properly intelligible unless that connection be kept in view.

The movements of the air; the evaporation from land and sea; the fall of rain, hail, and snow; the flow of rivers and glaciers; the tides, currents, and waves of the ocean; the growth and decay of organized existence, alike on land and in the depths of the sea;—in short, the whole circle of movement, which is continually in progress upon the surface of our planet, are the subjects now to be examined. It would be desirable to adopt some general term to embrace the whole of this range of inquiry. For this end the word epigene may be suggested as a convenient term, and antithetical to hypogene or subterranean action.

The simplest arrangement of this part of Geological Dynamics will be into three sections:—

I. Air.—The influence of the atmosphere in destroying and forming rocks.
II. Water.—The geological functions of the circulation of water through the air and between sea and land, and the action of the sea.
III. Life.—The part taken by plants and animals in preserving, destroying, or reproducing geological formations.

The words destructive, reproductive, and conservative, employed in describing the operations of the epigene agents, do not necessarily imply that anything useful to man is destroyed, reproduced, or preserved. On the contrary, the destructive action of the atmosphere may turn barren rock into rich soil, while its reproductive effects sometimes turn rich land into barren desert. Again, the conservative influence of vegetation has sometimes for centuries retained as barren morass what might otherwise have become rich meadow or luxuriant woodland. The terms, therefore, are used in a strictly geological sense, to denote the removal and re-deposition of material, and its agency in preserving what lies beneath it.

Section I.—Air.

Its composition having been already treated of (*ante*, p. 197), we shall consider here (1) the motions, and (2) the geological action of the air, which arises partly from its composition, and partly from its movements.

I. Movements of the Air.

These are due to differences in the pressure or density of the atmosphere, the law being that the air always moves from where the pressure is high to where it is low. Atmospheric pressure is understood to be determined by two causes, temperature and aqueous vapor.

1. *Temperature.*—Warm air, being less dense than cold air, ascends, while the latter flows in to take its place. The unequal heating of the earth's surface, by causing upward currents from the warmed portions, produces horizontal currents from the surrounding cooler regions inwards to the central ascending mass of heated air. To this cause the trade winds and the familiar land and sea breezes are due.

2. *Aqueous Vapor.*—In proportion as the quantity of watery vapor increases, the density of the air lessens. Consequently moist air tends to rise as warmed air does, with a corresponding but often very violent inflow of the drier and consequently heavier air from the surrounding tracts. The ascent of the moist air lessens the atmospheric pressure, which is indicated by the fall of the barometer. When the up-streaming vapor rises into the higher regions of the atmosphere, it expands and cools, condensing into visible form, and descending in copious showers to the earth. Unequal and rapid heating of the air, or accumulation of aqueous vapor in the air, and possibly some other influences not yet properly understood, give rise to extreme disturbances of pressure, and consequently to storms and hurricanes. For instance, the barometer sometimes indicates in tropical storms a fall of an inch and a half in an hour, showing that somewhere about a twentieth part of the whole mass of the atmosphere has in that short space of time been displaced over a certain area of the earth's surface. No such sudden change can occur without resulting in the most destructive tempest or tornado. In Britain the tenth of an inch of barometric fall in an hour is regarded as a large amount, such as only accompanies great storms.[1] When the pressure of the air at one place is shown by the barometer to differ from that at a neighboring locality at the same time, the wind will be observed to move on the whole from the area of high to the area of low pressure; and if the difference be great or sudden, the movement of the air may rise to the force of a hurricane until the equilibrium of pressure is restored.

The meteorological conditions of the atmosphere do not belong to the scope of this article (see Atmosphere, Climate, Meteorology). The reader, however, may note as of interest from a geological point of view the ascertained velocity and pressure exercised by the air in motion across the surface of the earth as expressed in the subjoined table:—

	Velocity in miles per hour.	Pressure in pounds per square foot.
Calm	0	0
Light breeze	14	1
Strong breeze	42	9
Strong gale	70	25
Hurricane	84	36

II. Geological Influences of the Air.

The paramount importance of the atmosphere as the vehicle for the circulation of temperature and moisture over the globe, and consequently as powerfully influencing the distribution of climate and the growth of plants and animals, must be fully recognized by the geologist. Attention will be confined at present to the direct changes produced on the surface of the earth by the air—(1) on land, and (2) on water.

1. *Its Influence on Land.*

I. Destructive Influences.—These are either (α) chemical or (β) mechanical, though in nature the two kinds of action are often inseparably interwoven.

(α) Under the denomination of *chemical* changes we include the oxidation of those minerals which can contain more oxygen, as in the peroxidation and precipitation of protosalts of iron; likewise the absorption of carbonic acid by rocks, and the production of alkaline and earthy carbonates and bicarbonates, which still further promote the process of decomposition. In the one case the active agent of change is the oxygen of the air, or rather of the aqueous vapor in the air, for perfectly dry air seems to have little or no oxidizing effect. A familiar illustration is afforded by the rust, or oxide, which forms on iron when exposed to moisture, though this iron may be kept long bright if allowed to remain screened from moist air. In the other case, the active agent is the carbonic acid of the air, though here again it appears to be requisite that moisture should intervene as the medium of introducing the acid to the substance which is to be altered by it. The occurrence of sulphuric and nitric acids in the air, especially noticeable in large towns, likewise leads to considerable corrosion of metallic surfaces, as well as of stones and lime. The mortar of walls may often be observed to be slowly swelling out and dropping off, owing to the conversion of the lime into sulphate. Great injury is likewise done from a similar cause to marble monuments in exposed graveyards.

As a rule, the changes effected by the air lead to many subsequent transformations. For example, the oxidation of the bisulphide of iron produces sulphuric acid, which decomposes silicates, carbonates, and other compounds with which it comes in contact. These changes, however, are more appropriately noticed under the head of rain (p. 237).

(β) Among the more recognizable *mechanical* changes of a destructive kind, brought about by the atmosphere, we may notice the following influences:—

1. *Expansion and Contraction.*—The effect of heat is to expand rocks, of cold to contract them. Strictly speaking, these results on the surface of the earth are due, not to the air, but to the heat-rays of the sun which reach the rocks through the air. In countries with a great annual range of temperature considerable difficulty is sometimes experienced in selecting building materials liable to be little affected by the alternate expansion and contraction which prevents the joints of masonry from remaining close and tight. In the United States, for example, with an annual thermometric range of more than 90° Fahr. this difficulty led to some experiments by Colonel Totten on the amount of expansion and contraction in different kinds of building-stones, caused by variations of temperature. It was found that in fine-grained granite the rate of expansion was ·000004825 for every degree Fahr. of increment of heat; in white crystalline marble it was ·000005668; and in red sandstone ·000009532, or about twice as much as in granite. If the daily variations in temperature are large, the effects are still more striking. In tropical climates with intensely hot days and extremely cold nights, the rapid nocturnal contraction produces sometimes a strain so great as to rival frost in its influence upon the surface of exposed rocks, disintegrating them into sand, or causing them to crack or peel off in skins or irregular pieces. Dr. Livingstone found in Africa (12° S. lat., 34° E. long.) that surfaces of rock which during the day were heated up to 137° Fahr. cooled so rapidly by radiation at night that, unable to sustain the strain of contraction, they split and threw off sharp angular fragments from a few ounces to 100 or 200 ℔ in weight.[2]

2. *Frost.*—Though properly belonging to the subject of the geological behavior of water to be afterwards described in more detail, the disintegrating action of frost may be noticed here. In freezing water expands, and thereby exerts an enormous strain upon any enclosed cavities or walls which may confine it. The consequence of this action is that in countries exposed to frost a continual disintegration of the surface of rocks goes on. This superficial decay combines with the chemical and mechanical operations of the atmosphere to produce considerable modifications in the forms of rocks and cliffs.

3. *Wind.*—By driving loose sand over rocks, prevalent winds produce on them a scratched and polished surface, as has happened with ancient monuments buried in the sands of the African deserts.[3] It is said that at Cape Cod holes have even been drilled in window glass by the same agency.[4] Cavities are now and then hollowed out of rocks by the gyration in them of little fragments of stone or grains of sand kept in motion by the wind. Hurricanes form important geological agents upon land in uprooting trees, and thus sometimes impeding the drainage of a country, and giving rise to the formation of peat mosses.

Weathering of Rocks.—Under the term "weathering" are included all the superficial changes which rocks undergo in consequence of the action of atmospheric processes upon them. The nature and rapidity of the disintegration depend partly on the one hand upon the climate, and partly on the other upon the composition, texture, and exposure of the rocks. In very dry countries, where the range of temperature is not extreme, weathering is reduced to a minimum. But even if the climate be dry, considerable disintegration may be caused, as has been already explained, by rapid changes of temperature between day and night. It is where moisture prevails, however, that weathering chiefly takes place. The nature of the changes will be more properly considered in the section which is devoted to the action of rain.

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[1] Buchan's *Meteorology*, p. 266.

[2] Livingstone's *Zambesi*, pp. 492, 516.

[3] For an account of this action of drifting sand in North America see Blake in *Pacific Railroad Report*, v. 92, 230.

[4] Dana's *Manual*, p. 631.

II. Reproductive Influences.—These arise partly from the result of the chemical and mechanical disintegration involved in weathering, and partly from the transporting power of winds and aerial currents. Under the former head is the formation of soil; under the latter may be noticed the production of sand-hills, the fall of dust-showers and colored rain, and the transport of seeds.

Soil.—Of the detritus produced by the action of the air on rocks, and washed away by rains and streams, part remains on the land and forms soil. All soil may be considered as the result of the decomposition of rocks, mingled with decayed vegetable and animal matter. Were it not for the action of rain in washing the loose materials to a greater or less distance from their source, the soil of every locality ought to be merely the decayed upper surface of the rocks underneath. But wherever rain falls, the soil is moved from higher to lower levels. Hence in some cases a good soil is laid down upon rocks which of themselves would only produce a poor one. This action of rain in the formation of soil is further alluded to on p. 240, and the cooperative influence of plant and animal life on p. 256.

Sand-hills or Dunes.—Winds blowing continuously upon loose materials, such as sand, drive them onward, and pile them into irregular heaps and ridges, called "dunes." This takes place more especially on windward coasts either of the sea or of large inland lakes, where the shores are sandy; but similar effects may be seen even in the heart of a continent, as in the sandy deserts of the Sahara and of Arabia. The dunes travel inland in parallel, irregular, and often confluent ridges, between which rain-water is sometimes arrested to form pools (*étangs* of the French coasts), where formations of peat occasionally take place. On the coast of Gascony the sea for 100 miles is so barred by sand-dunes that in all that distance only two outlets exist for the discharge of the drainage of the interior. As fast as one ridge is driven away from a beach another forms in its place, so that a series of huge sandy billows, as it were, is continually on the move from the sea margin towards the interior. A stream or river may temporarily arrest their progress, but eventually they push the obstacle aside or in front of them. In this way the river Adour, on the west coast of France, has had its mouth shifted two or three miles. Occasionally, as at the mouths of estuaries, the sand is blown across so as gradually to exclude the sea, and thus to aid the fluviatile deposits in adding to the breadth of the land.[1] The coast of Norfolk is fringed with sand-hills 50 to 60 feet high. On parts of the coast of Cornwall, the sand consists mainly of fragments of shells and corallines, and through the action of rain becomes sometimes indurated into a compact stone by carbonate of lime or oxide of iron. Long tracts of blown sand are likewise found along many parts of the Scottish and Irish coast-lines.

On the western border of the European continent extensive sand-dunes exist. They extend for many leagues along the French coast, and thence, by Flanders and Holland, round to the shores of Courland and Pomerania. In Denmark they are said to cover an area of 260 square miles. On the coast of Holland they are sometimes, though rarely, 260 feet high,—a common average height being 50 to 60 feet. The breadth of this maritime belt of sand varies considerably. On the east coast of Scotland it ranges from a few yards to 3 miles; on the opposite side of the North Sea it attains on the Dutch coast sometimes to as much as 5 miles. The rate of progress of the dunes towards the interior depends upon the wind, the direction of the coast, and the nature of the ground over which they have to move. On the low and exposed shores of the Bay of Biscay, when not fixed by vegetation, they travel inland at a rate of about 16½ feet; in Denmark at from 3 to 24 feet per annum. In the course of their march they envelop houses and fields; even whole parishes and districts once populous have been overwhelmed by them.[2]

Along the margins of large lakes and inland seas many of the phenomena of an exposed sea-coast are repeated, and on no inferior scale. Among these must be included sand-dunes, such as occur at the south-eastern end of Lake Michigan and on the eastern borders of the Caspian Sea. The shifting of vast waves of sand by the wind is exemplified on the grandest scale in the sandy deserts of Africa, Arabia, and Central Asia. Such arid wastes of loose sand, situated far inland and far distant from any sheet of fresh water, suggest curious problems in physical geography. Their sites may have been at a comparatively recent geological period covered by the sea; or, lying in rainless climates and having their surfaces exposed to the disintegrating effects of great extremes of temperature, the tracts may have become sandy and barren through atmospheric disintegration. The desert of the Sahara furnishes a good illustration of a dried-up sea-bed. In the rainless tract to the east of the Red Sea lie the great sandy deserts and hills of Arabia, of which Mr. Palgrave has given so graphic a narrative. Captain Sturt found vast deserts of sand in the interior of Australia, with long lines of dunes 200 feet high, united at the base and stretching in straight lines as far as the eye could reach. In the south-east of Europe great tracts of sandy desert occur in Poland, and run through the southern provinces of Russia.

Dust-Showers, Blood-rain.—In tropical countries, where great droughts are succeeded by violent hurricanes, the dust or sand of dried lakes or river-beds is sometimes borne away into the upper regions of the atmosphere, where, meeting with strong aerial currents which transport it for hundreds and even thousands of miles, it may descend again to the surface, in the form of "red-fog," "sea-dust," or "sirocco-dust." This transported material, usually of a brick-dust or cinnamon color, is occasionally so abundant as to darken the air and obscure the sun, and to cover the decks, sails, and rigging of vessels which may even be hundreds of miles from land. Rain falling through such a dust-cloud mixes with it, and descends either on sea or land as what is popularly called "blood-rain." This is frequent on the north-west of Africa, about the Cape Verd Islands, in the Mediterranean, and over the bordering countries. A microscopic examination of this dust by Ehrenberg led him to the belief that it contains numerous diatoms of South American species; and he inferred that a dust-cloud must be swimming in the atmosphere, carried forward by continuous currents of air in the region of the trade-winds and anti-trades, but suffering partial and periodical deviations. But much of the dust must come from the sandy plains and desiccated pools of the north of Africa. Daubrée recognized in 1865 some of the Sahara sand which fell in the Canary Islands. On the coast of Italy a film of sandy clay, identical with that in parts of the Libyan desert, is occasionally found on windows after rain. In the middle of last century an area of northern Italy, estimated at about 200 square leagues, was covered with a layer of dust which in some places reached a depth of one inch. Should the travelling dust encounter a cooler temperature, it may be brought to the ground by snow, as has happened in the north of Italy, and more notably in the east and south-east of Russia, where the snows are sometimes rendered dirty by the dust raised by the winds on the Caspian steppes. It is easy to see that a prolonged continuance of this action must give rise to widespread deposits of dust, mingled with the soil of the land, and with the silt and sand of lakes, rivers, and the sea; and that the minuter organisms of tropical regions may thus come to be preserved in the same formations with the terrestrial or marine organisms of temperate latitudes.[3]

Transportation of Seeds.—Besides the transport of dust and minute organisms for distances of many thousands of miles, the same agency may come into play also in the transport of living seeds, which, finally reaching a congenial climate and soil, may take root and spread. We are yet, however, very ignorant as to what extent this cause has actually operated in the establishment of any given local flora. With regard to the minute forms of vegetable life, indeed, there can be no doubt as to the efficacy of the wind to transport them across vast distances on the surface of the globe. Upwards of 300 species of diatoms have been found in the deposits left by dust-showers. Among the millions of organisms thus transported it is hardly conceivable that some should not fall into a fitting locality for their continued existence and the perpetuation of their species.

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[1] For accounts of sand-dunes, their extent, progress, structure, and the means employed to arrest their progress, the reader may consult Andersen's *Klitformationem*, 1 vol. 8vo, Copenhagen, 1861; Laval in *Annales des Ponts et Chaussées*, 1847, 2me sem.; and Marsh's *Man and Nature*, 1864, and the works cited by him. See also Élie de Beaumont, *Leçons de Géologie*, vol. i.

[2] This destruction has been, during the last quarter of a century, averted to a great extent by the planting of pine forests, the turpentine of which has become the source of a large revenue.

[3] See Humboldt on dust whirlwinds of the Orinoco, *Aspects of Nature;* also Maury, *Phys. Geog. of Sea*, chap. vi.; and Ehrenberg's *Passat-Staub und Blut-Regen*, 1847.

2. *Influence of the Air on Water.*

The action of the air upon water will be more fitly noticed in the section devoted to water (p. 253). It will be enough to notice here—

1. *Ocean Currents.*—The in-streaming of air from cooler latitudes towards the equator causes a drift of the sea-water in the same direction. Owing to the rotation of the earth, these aerial currents tend to take a more and more westerly trend as they approach the equator. This they communicate to the marine currents, which, likewise moving into regions having a greater velocity of rotation than their own, are all the more impelled in the same westerly direction. Hence the westerly belt or equatorial current, which flows across the great ocean. Owing to the position of the continents across its path, this great current cannot move uninterruptedly round the earth. It is split into branches which turn to right and left, and, bathing the shores of the land, carry some of the warmth of the tropics into more temperate latitudes.

2. *Waves.*—The impulse of the wind upon a surface of water throws that surface into pulsations which range in size from mere ripples to huge billows. Long-continued gales from the seaward upon an exposed coast indirectly effect much destruction, by the formidable battery of billows which they bring to bear upon the land. Wave-action is likewise seen in a marked manner when wind blows strongly across a broad inland sheet of water, such as Lake Superior (see p. 247).

3. *Alteration of the Water-level.*—When the wind blows freshly for a time down a lake or into a bay or arm of the sea, it drives the water before it, and keeps it temporarily at a higher level at the further or windward side. In a tidal sea, such as that which surrounds Great Britain, and which sends abundant long arms into the land, this action can often be studied. It is no infrequent occurrence that a high tide and a gale should happen at the same time. Whenever that takes place, then at those bays or firths which look windward the high tide rises to a greater height than elsewhere. With this conjunction of wind and tide, considerable damage to property has sometimes been done by the flooding of warehouses and stores, while even a sensible destruction of cliffs and sweeping away of loose materials may be chronicled by the geologist. On the other hand, a wind from the opposite quarter will drive the water out of the inlet, and thus make the water-level lower than it should otherwise be.

Section II.—Water.

Of all the terrestrial agents by which the surface of the earth is geologically modified, by far the most important is water. When following hypogene changes in a foregoing part of this article, we found how large a share is taken by water in the phenomena of volcanoes and other subterranean movements. When we returned to the surface of the earth and began to watch the operations of the atmosphere, we saw how impossible it is to consider these apart from the action of the aqueous vapor by which the atmosphere is pervaded. We must now study in detail the working of this wonderful geological agent itself.

The substance which we term water exists on the earth in three well-known forms—(1) gaseous, as invisible vapor; (2) liquid, as water; and (3) solid, as ice. The gaseous form has already been noticed in our inquiry into the geological characteristics of the air. It is in the air that this condition of the water-substance prevails. By the sun's heat vast quantities of vapor are continually raised from the surface of the seas, rivers, lakes, snow-fields, and glaciers of the world. This vapor remains invisible until the air containing it is cooled down to below its dew-point, or point of saturation,—a result which follows upon the union or collision of two aerial currents of different temperatures, or the rise of the air into the upper cold regions of the atmosphere, where it is chilled by expansion, by radiation, and by contact with cold mountains. At first minute particles appear, which either remain in the liquid condition, or, if the temperature is sufficiently low, are at once frozen into ice. As these changes take place over considerable spaces of the sky, they give rise to the phenomena of clouds. Further condensation augments the size of the cloud-particles, and at last they fall to the surface of the earth, if still liquid, as rain; if solid, as snow or hail; and if partly solid and partly liquid, as sleet. As the vapor is largely raised from the ocean surface, so in great measure it falls back again directly into the ocean. A considerable proportion, however, descends upon the land, and it is this part of the condensed vapor which we have now to follow. Upon the higher elevations it falls as snow, and gathers there into snow-fields, which by means of glaciers, send their drainage down towards the valleys and plains. Elsewhere it falls chiefly as rain, some of which sinks underground to gush forth again in springs, while the rest pours down the slopes of the land, feeding brooks and torrents, which, swollen further by the springs, gather into broader and yet broader rivers, whereby the drainage of the land is carried out to sea. Thence once more the vapor rises to reappear in clouds, and feed the innumerable water-channels by which the land is furrowed from mountain-top to sea-shore.

Here then is a vast system of circulation, ceaselessly renewed. And in that system there is not a drop of water which is not busy with its allotted task of changing the face of the earth. When the vapor ascends into the air it is almost chemically pure. But when, after being condensed into visible form, and working its way over or under the surface of the land, it once more enters the sea, it is no longer pure, but more or less loaded with material taken by it out of the air, rocks, or soils through which it has travelled. Day by day the process is advancing. So far as we can tell, it has never ceased since the first shower of rain fell upon the earth. We may well believe, therefore, that it must have worked marvels upon the surface of our planet in past time, and that it may effect vast transformations in the future. As a foundation for such a belief let us now inquire what it can be proved to be doing at the present time.

The subject of the geological operation of water upon the globe may be conveniently studied under the following subdivisions:—

A. Terrestrial Waters.—Under this head are to be considered—(1) the liquid state, including rain, underground water, brooks, rivers, and lakes; and (2) the solid state—frost, river-ice, snow, hail, glaciers.

B. Oceanic Waters.—Including the influence of marine currents, tides, and waves, and the part taken by the sea in the general geological *régime* of the earth.

A. TERRESTRIAL WATERS.

I. IN THE LIQUID STATE.

§ 1. *Rain.*

Rain effects two kinds of changes upon the surface of the land. (1.) It acts *chemically* upon soils and stones, and sinking under ground continues, as we shall find, a great series of similar reactions there. (2.) It acts *mechanically*, by washing away loose materials, and thus powerfully affecting the contours of the land.

I. Chemical Action.—This depends mainly upon the nature and proportion of the substances abstracted by rain from the air in its descent to the earth. Rain always absorbs a little air, and as we have already seen (p. 197) air always contains carbonic acid as well as other ingredients, in addition to its nitrogen and oxygen. If rain be regarded as an agent washing the air and taking impurities out of it, we may the better realize how by means of these it is enabled to work many chemical changes which, were it to reach the earth as pure water, it could not accomplish.

Composition of Rain-Water.—Numerous analyses of rain-water show that it contains in solution about 25 cubic centimetres of gases per litre. An average proportional percentage is by measure—nitrogen, 66·4; oxygen, 31·2; carbonic acid, 2·4,—the oxygen being in greater proportion than in air, owing to its greater solubility in water. Common salt, ammonia, sulphates, nitric acid, inorganic dust, and organic matter are usually present in minute quantities in rain water. So far as we know at present, the three ingredients which are chiefly effective in the chemical reactions due to rain are the oxygen, carbonic acid, and organic matter.[1]

Permeability of all Rocks by Water.—Though minerals and rocks differ vastly in their degree of porousness, there is none known which is not in some degree permeable by water. Even such hard and apparently impenetrable substances as flint and agate are found to be permeable. For, in fact, rocks and minerals when examined with the microscope are seen to be made up of variously-shaped grains, crystals, or particles, and it is in the minute channels and interstices between these particles, or even through the particles themselves, that the water works its way. Evidently, the smaller the interstices the less easily will the water force a passage into or through the stone. This permeability, though well marked upon the surface of the land, becomes still more so underground, where the rocks are sometimes quite saturated with water.

Liability of all Rocks to alteration by Water.—There is probably no known substance which is not, under some condition, soluble in water containing carbonic acid or other natural reagent. Rain-water, descending with the gases, acids, and organic matter it has abstracted from the air and soil, effects a chemical disintegration of the rocks. This action was referred to in the description of the air as partly due to atmospheric moisture, but it is chiefly carried on by rain. And as rain is so widely and almost universally distributed over the globe, this chemical action must be of very general occurrence.

Nature of the Changes effected.—Confining our attention to its three chiefly active ingredients, we find that rain water reacts chemically upon rocks by—1. *Oxidation.*—The prominence of oxygen in rain-water, and its readiness to unite with any substance which can contain more of it, render this a marked feature of the passage of rain over rocks. A thin oxidized pellicle is formed on the surface, and this, if not at once washed off by the rain, sinks deeper until a crust is formed over the stone. As already remarked, this process is simply a rusting of those minerals which, like metallic iron, have no oxygen, or have not their full complement of it. 2. *Deoxidation.*—Organic matter having an affinity for more oxygen decomposes peroxides by depriving them of some part of their share of that element, and reducing them to protoxides. These changes are especially noticeable among the iron oxides so abundantly diffused among rocks. Hence rain-water, in sinking through soil and obtaining such organic matter, becomes thereby a reducing agent. 3. *Solution.*—This may take place either by the simple action of the water, as in the solution of rock-salt, or by the influence of the carbonic acid present in the rain. Of the latter (*Carbonation*) a familiar example is the corrosion of marble slabs down which rain has trickled for a time. The carbonic acid dissolves some of the lime, which as a bicarbonate is held in solution in the carbonated water, but is deposited again when the water loses its carbonic acid or evaporates. It is not merely carbonates, however, which are liable to this kind of destruction. Even silicates of lime, potash, and soda, combinations existing abundantly as constituents of rocks, are attacked; their silica is liberated, and their alkalies or alkaline earths, becoming carbonates, are removed in solution. 4. *Hydration.*—Some minerals, containing little or no water, and therefore called anhydrous, when exposed to the action of the atmosphere, absorb water, or become hydrous, and are then usually more prone to further change. Hence the rocks of which they form part become disintegrated.

Weathering.—The weathering of rocks is dependent upon two sets of conditions—(1) meteorological, as the range of temperature, abundance of moisture, height above the sea, and exposure, and (2) lithological,—the composition and texture of the rocks themselves. As regards the composition of rocks, those which consist of particles liable to little chemical change from the influence of moisture are best fitted to resist weathering, provided their particles have sufficient cohesion to withstand the mechanical processes of disintegration. Siliceous sandstones are excellent examples of this permanence. Consisting wholly or mainly of the durable mineral quartz, they are sometimes able so to withstand decay that buildings made of them still retain, after the lapse of centuries, the chisel-marks of the builders. Some rocks which yield with comparative rapidity to the chemical attacks of moisture show no marks of disintegration on their surface, which remains clean and fresh. This is particularly the case with limestones. The reason lies obviously in the fact that limestone when pure is wholly soluble in acidulous water. Rain falling on this rock removes some of it in solution, and will continue to do so until the rock is dissolved away. It is only where the limestone contains impurities that a weathered crust of more or less insoluble particles remains behind. Hence the relative purity of limestones may be roughly determined by comparing their weathered surfaces, where, if they contain much sand, the grains will be seen projecting from the calcareous matrix, and where should the rock be very ferruginous, the yellow hydrous peroxide or ochre will be found as a powdery crust. In limestones containing abundant encrinites, shells, or other organic remains, the weathered surface commonly presents the fossils standing out in relief. This seems to arise from the crystalline arrangement of the lime in the organic structures, whereby they are enabled to resist disintegration better than the general mechanically aggregated matrix of the rock. An experienced fossil collector will always search well those weathered surfaces, for he often finds there, delicately picked out by the weather, minute and frail fossils which are wholly invisible on a freshly broken surface of the stone. Many rocks weather with a thick crust or even decay inwards for many feet or yards. Basalt, for example, often shows a yellowish-brown ferruginous layer on its surface, formed by the conversion of its felspar into kaolin and the removal of its silicate of lime as carbonate, by the hydration of its olivine and augite and their conversion into serpentine, saponite, or some other hydrous magnesian silicate, and by the conversion of its magnetite into limonite. Granite sometimes shows in a most remarkable way the distance to which weathering can reach. It may often be dug into for a depth of 20 or 30 feet, the quartz crystals and veins retaining their original positions, while the felspar is completely kaolinized.

It is to the effects of weathering that the abundant fantastic shapes assumed by crags and other rocky masses are due. Most varieties of rock have their own characteristic modes of weathering, whereby they may be recognized even from a distance. To some of these features reference will be made in a subsequent section.

II. MECHANICAL ACTION.—When a rock has been so corroded by weathering that the cohesion of the particles on its exposed surface is destroyed, these particles are washed off by rain. This detritus is either held in suspension in the little runnels into which the rain-drops gather as they begin to flow over the land, or is pushed by them along the surface. In this way the rain carries off by mechanical movement what it has already loosened by chemical action.

III. RESULTS OF RAIN-ACTION.—It is evident that the general result of the fall of rain upon a land-surface must be a disintegration and consequent lowering of that surface. At first we may be inclined to imagine that this waste must be so slow and slight as to be hardly appreciable. But a little observation will suffice to furnish many proofs of its existence and comparatively rapid progress in some places. We are familiar, for example, with the pitted channelled surface of the ground lying immediately under the drip of the eaves of a house. We know that the fragments of stone and gravel are left sticking up prominently because the earth around and above them has been washed away, and because, being hard, they resist the action of the falling drops and screen the earth below them. On a far larger scale we may notice the same kind of operation in districts of conglomerate, where the larger blocks, serving as a protection to the rock underneath, come to form as it were the capitals of slowly-deepening columns of rock. In the same way in certain valleys of the Alps a stony clay is cut by the rain into pillars, each of which is protected by, and indeed owes its existence to, a large block of stone which lay originally in the heart of the mass. These columns are of all heights, according to the positions in which the stones may have originally lain. There are instances, however, where the disintegration has been so complete that only a few scattered fragments remain of a once extensive stratum, and where it may not be easy to realize that these fragments are not transported boulders. In Dorsetshire and Wiltshire, for example, the surface of the country is in some parts so thickly strewn with fragments of sandstone and conglomerate "that a person may almost leap from one stone to another without touching the ground. The stones are frequently of considerable size, many being four or five yards across, and about four feet thick."[1] They have been used for the huge blocks of which Stonehenge and other of the so-called druidical circles have been constructed, hence they have been termed Druid Stones. Other names are Sarsen Stones (supposed to indicate that their accumulation has been popularly ascribed to the Saracens), and Grey Wethers, from their resemblance in the distance to flocks of (wether) sheep. They are found lying abundantly on the chalk, suggestive at first of some former agent of transport by which they were brought from a distance. It is now, however, generally admitted that they are simply fragments of some of the sandy Tertiary strata which once covered the districts where they occur, and that while the softer portions of these strata have been carried away, the harder parts (their hardness perhaps increasing by exposure) have remained behind as Grey Wethers, and have subsequently suffered from the inevitable splitting and crumbling action of the weather.

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[1] The organic matter is revealed by the putrid smell which long-kept rain water gives out. The reader who wishes to pursue this subject may consult the elaborate tables of analyses in Dr. Angus Smith's *Air and Rain*. See also the section on air, *ante*, p. 196.

But it is not from any single example, however striking, that the real importance of rain as a geological agent can be adequately realized. To form a true conception of this momentous action, we need to watch what takes place over a wide region. The whole land-surface over which rain falls is exposed to waste. As Hutton long ago insisted, the superficial covering of decayed rock or soil is constantly, though slowly, travelling outward and downward to the sea. In this ceaseless transport rain acts as the great carrying agent. The particles of rock loosened by atmospheric waste, by frost or the chemical disintegration of the rain itself, are washed off to form new soil. But they as well as the particles of the soil are step by step moved downward over the face of the land till they reach the nearest brook or river, whence their seaward progress may be rapid. A heavy rain discolors the water-courses of a country, because it loads them with the fine debris which it removes from the general surface of the land. In this way rain serves as the means whereby the work of the other disintegrating forces is made conducive to the general degradation of the land. The decomposed crust produced by weathering, which would otherwise accumulate over the solid rock and protect it from further decay, is removed by rain so as to expose a fresh surface to further decomposition. This decay is general and constant, but not uniform. In some places, from the nature of the rock, from the flatness of the ground, or from other causes, rain works under great difficulties. There the rate of waste must consequently be extremely slow. In other places, again, the rate may be rapid enough to be readily appreciable from year to year. A survey of this department of geological activity shows how the unequal wasting by rain has helped to produce the details of the present relief of the land, those tracts where the destruction has been greatest forming hollows and valleys, others, where it has been less, rising into ridges and hills.

Rain-action is not always merely destructive. Usually it is accompanied by reproductive effects, and, as already remarked, the mouldered rock which it washes off furnishes materials for the formation of soil. In favorable situations it has gathered together accumulations of loam and earth from neighboring higher ground—the "brick-earth," "head," and "rain-wash" of the south of England—earthy deposits, sometimes full of angular stones, derived from the subaerial waste of the rocks of the neighborhood.[2]

§ 2. *Underground Water.*

When rain falls upon the land its further progress becomes twofold. The greater part of it sinks into the ground and apparently disappears; the rest flows off into runnels, brooks, and rivers, and in this way moves downward to the sea. It is most convenient to follow first the course of the subterranean water.

We have seen that all rocks are more or less porous. They are moreover traversed by abundant joints and cracks. Hence, from the bed of the ocean, from the bottoms of lakes and rivers, as well as from the surface of the land on which rain falls, water is continually filtering downward into the rocks beneath. To what depth this descent of the surface water may go is not known. It may reach as far as the intensely heated interior of the planet, for, as the researches of M. Daubrée have shown, capillary water has the capacity of penetrating rocks even against a high counter-pressure of vapor. The water at extreme depths may be under such pressure as to retain its liquid condition at a red or even at a white heat. Probably the depth to which the water descends varies indefinitely according to the varying nature of the rocky crust. Some shallow mines are practically quite dry, while others of great depth require large pumping engines to keep them from being flooded by the water which pours into them from the surrounding rocks. As a rule, however, the upper layers of rock are fuller of moisture than those deeper down.

The water which in this way sinks into the earth is not permanently removed from the surface, though there may perhaps be a slight loss due to absorption and chemical alteration of the rocks. It accumulates underneath, until by the pressure of the descending column it is forced to find a passage through joints or fissures upward to the surface. The points at which it issues are termed *springs*. In most districts the rocks underneath are permeated with water below a certain limit which is termed the *water-level*. This line is not a strictly horizontal one like that of the surface of a lake. Moreover it is liable to rise and fall according as the seasons are wet or dry. In some places it lies quite near, in others far below, the surface. A well is an artificial hole dug down below the water-level, into which the water percolates. Hence, when the water-level happens to be at a small depth the wells are shallow, when at a great depth they require to be deep.

Since the rocks underneath the surface vary greatly in porosity, some contain far more water than others. It often happens that, percolating along some porous bed, the subterranean water finds its way downward until it passes under some more impervious[3] rock. Hindered in its progress, it accumulates in the porous bed, from which it may be able to find its way up to the surface again only by a tedious circuitous passage. If, however, a bore-hole be sunk through the upper impervious bed down to the water-charged stratum below, the water will eagerly avail itself of this artificial channel of escape, and will rise in the hole, or even rush up and gush out as a *jet d'eau* above ground. Wells of this kind are now largely employed. They bear the name of *Artesian*, from the old province of Artois in France, where they have long been in use.

That the water really circulates underground, and passes not merely between the pores of the rocks but in crevices and tunnels which it has no doubt to a large extent opened for itself along numerous natural joints and fissures, is proved by the occasional rise of leaves, twigs, and even live fish, in the shaft of an Artesian well. Such evidences are particularly striking when found in districts without surface waters, and even perhaps with little or no rain. They have been met with, for instance, in sinking wells in some of the sandy deserts on the southern borders of Algeria. In these and similar cases it is clear that the water may, and sometimes does, travel for many leagues underground away from the district where it fell as rain or snow, or where it leaked from the bed of a river or lake.

The temperature of springs affords a convenient but not always quite reliable indication of the relative depth from which they have risen. Some springs are just one degree or less above the temperature of ice. Others in volcanic districts issue with the temperature of boiling water. Between these two extremes every degree may be registered. Very cold springs may be regarded as probably deriving their supply from cold or even snow-covered mountains. Certain exceptional cases, however, occur where ice forms in caverns (*glacières*) even in warm and comparatively low districts. Water issuing from these ice caves is of course cold.[1] On the other hand, springs whose temperature is much higher than the mean temperature of the places at which they emerge must have descended far enough to be warmed by the internal heat of the earth. The hottest springs are found in volcanic districts. But even at a great distance from any active volcano, *thermal springs*, as they are called, appear with a temperature of 120° Fahr. (which is that of the Bath springs) or even more. These have probably risen from a great depth. If we could assume a progressive increase of 1° Fahr. of subterranean heat for every 60 feet of descent, the water at 120° issuing at a locality whose ordinary temperature is 50°, should have been down at least 4200 feet below the surface. But from what has been stated in a previous section (p. 200) regarding the irregular stratification of temperature within the earth's crust, such estimates of the probable depth of the sources of springs are liable to various errors.

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[1] See *Descriptive Catalogue of Rock Specimens in Jermyn Street Museum*, 3d ed.; Prestwich, *Quart. Journ. Geol. Soc.* x., p. 123; Whitaker, *Geological Survey Memoir on parts of Middlesex*, etc., p. 71.

[2] See Austen, *Quart. Journ. Geol. Soc.*, vi. 94, vii. 121; Foster and Topley, *Quart. Journ. Geol. Soc.*, xxi. 446.

[3] This term *impervious* must evidently be used in a relative and not in an absolute sense. A stiff clay is practically impervious to the trickle of underground water; hence its employment as a material for puddling (that is, making water-tight) canals and reservoirs. But it contains abundant interstitial water, on which indeed its characteristic plasticity depends.

Apart from its vast importance in a social point of view, the underground circulation of water has a profound interest for the geologist, from the light which it affords as to the changes that rocks undergo, and the manner in which these changes are effected. For, like all the other geological agents, it does not move on its course without doing work. We have now to inquire what is the nature of that work. A convenient arrangement will be to group its study under two heads—(1) chemical action, and (2) mechanical action.

(1.) Every spring, even the most clear and sparkling, contains mineral matter in chemical solution, obtained from the rocks through which the water travels in its journey from the surface into the interior, and back to the surface again. The nature of the mineral ingredients depends partly upon the composition of the rocks traversed, partly upon the gases, acids, or other reagents which may have been present in the rain, or may have been obtained by the water in its subterranean journey, and partly upon the depth to which the water may have reached and the temperature to which it may have been raised.

We have already (*ante*, p. 238) considered the substances extracted by rain from the air and used by it in the disintegration of rocks. The same reagents are of course carried underneath the ground, when the rain-water sinks out of sight, and continue there the processes of decomposition and alteration which they are seen to effect at the surface. But other sources are open to the subterranean water for the augmentation of its chemical reagents. (1.) In descending through the soil the meteoric water encounters abundant organic matter, which abstracts its oxygen and replaces it by carbonic acid. This interchange probably in many cases far more than compensates for the expenditure of these gases employed in subaerial disintegration. In so far as the water carries down from the soil any oxidizable organic substance, its action must be to reduce the oxides it encounters among rocks. It is remarkable that ordinary vegetable soil possesses the power of removing from the water which permeates it potash, silica, phosphoric acid, ammonia, and organic matter, elements which had been already in great measure abstracted from it by living vegetation, and which are again taken up by the same organic agents. (2.) Carbonic acid gas is sometimes largely evolved within the earth's crust, especially in regions of extinct or dormant volcanoes. Subterranean water coming in the way of this gas greedily dissolves it, and thereby obtains an enormously increased power of attacking even the most obdurate rocks. (3.) Whenever the water has its temperature considerably raised, its solvent capacity, especially for silica, is largely augmented. Hot springs often contain a large proportion of that substance in solution. (4.) The production of some of the compounds which are due to decompositions effected by the water, and are carried along with it in solution, increases its ability to accomplish further decompositions. Thus the alkaline carbonates, which are among the earliest products of the action of the water, enable it to dissolve silica and decompose silicates.

The study of these alterations belongs to the subject of Metamorphism, of which some account has already been given (*ante*, p. 233). Let us look at the results achieved by them, as shown in the composition of the water which issues from different springs. Considered from this point of view, springs may be treated as (1) common or ordinary springs, that is, those which contain only such average proportions of mineral matter as occur in ordinary potable water, and (2) mineral springs, or those where the proportion of foreign ingredients is large enough to give a marked character to the water. These two groups, however, merge insensibly into each other.

Common Springs.—The materials ordinarily present in common spring water are, besides atmospheric air and its gases, carbonate and sulphate of lime, common salt, with chlorides of calcium and magnesium, and sometimes organic matter. The amount of dissolved contents in ordinary drinking water does not exceed ·5 or at most 1·0 gramme per litre; the best waters contain even less.

Mineral Springs.—These may be roughly but conveniently classified according to the prevailing mineral substance contained in them, which may range in amount from 1 to 300 grammes per litre.[2]

Calcareous—containing so much lime that it is deposited as a white crust as the water evaporates. Spring water when saturated with carbonate of lime contains about 105 parts in 100,000. Springs of this kind are common in limestone countries. As the water flows away from its point of exit, it throws down a deposit of calcareous tufa or travertine, which, as it encrusts moss, twigs, and other objects, gives them the appearance of having been turned into stone, whence the springs are popularly termed "petrifying." Enormous accumulations of this kind have been formed in some parts of Italy, where the rock so produced is extensively quarried as a building material.

Ferruginous or Chalybeate—containing a large proportion of iron in the total mineral ingredients. Such waters have an inky taste, and often deposit along their course a yellow, brown, or red ochry deposit, consisting mainly of hydrated peroxide of iron. They may be frequently observed in those districts where beds or veins of ironstone occur, or where the rocks contain much iron in combination.

Siliceous—depositing silica or flint. Although silica may be dissolved and retained in solution even in cold water, it is in the hot water issuing in volcanic countries that it occurs most abundantly, and where true siliceous springs exist. The geysers of Iceland, New Zealand, the Yellowstone region, and other districts are illustrations. When the heated water of these thermal springs cools and evaporates, the silica is deposited as siliceous sinter round their basins, or in picturesque mounds at the point of escape. One of the sinter beds in the geyser region of Iceland is said to be two leagues long, a quarter of a league wide, and a hundred feet thick. As already stated (*ante*, p. 234), the effect of pressure is to enable water at great depths to retain a larger amount of mineral matter in solution. Hence, when the water ascends, it deposits its mineral contents, not only because it cools, but because the pressure is removed. There must in many cases be a copious deposit along the walls of the fissures up which the water flows on its way to the surface. Doubtless in this way many mineral veins have received their successive coatings of quartz, jasper, gypsum, calcite, and other minerals.

Brine—bringing to the surface a solution, more or less nearly saturated, of chloride of sodium. Springs of this kind appear where beds of solid rock-salt exist underneath. The water in its passage encounters the salt, dissolves it, and brings it to the surface. The brine springs of Cheshire in England, the Salzkammergut in Austria, Bex in Switzerland, etc., have long been well known. Some of the English brines contain about one per cent. of salts, of which the chloride of sodium may range from a half to three-fourths or more. Other brines, however, yield a far larger amount; one at Clemenshall, Würtemburg, gave upwards of 26 per cent. of salts, of which almost the whole was chloride of sodium. The other substances contained in solution in the water of brine springs are usually such as exist also in sea-water, such as sulphate and carbonate of lime, chlorides of magnesium and potassium, etc.

Medicinal—a vague term applied to mineral springs which have or are believed to have curative effects in different diseases. Medical men recognize various qualities, distinguished by the particular substance most conspicuous in each—as *Alkaline Waters*, containing lime or soda and carbonic acid, as those of Vichy or Saratoga; *Bitter Waters*, with sulphate of magnesia and soda—Sedlitz, Kissingen; *Salt* or *Muriated Waters*, with common salt as the leading mineral constituent —Wiesbaden, Cheltenham; *Earthy Waters*, lime, either a sulphate or carbonate, being the most marked ingredient—Bath, Lucca; *Sulphurous Waters*, with sulphur as sulphuretted hydrogen and in sulphides—Aix-la-Chapelle, Harrogate.

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[1] The most remarkable example of a glacière yet observed is that of Dobschau, in Hungary, of which an account, with a series of interesting drawings, was published in 1874 by Dr. J. A. Krenner, keeper of the national museum in Buda-Pesth.

[2] Paul in Watt's *Chem. Dict.*, v., 1016.

Oil.—Mineral oil is carried up by some ordinary springs, and floats in dark drops on the surface of the water. But in some parts of the world, as in a wide region in the Northern States of the American Union and in Canada, the oil ascends with little or no water, and forms the oil-springs which in recent years have become so remarkable and abundant a source of illuminating oils, paraffin, and other hydrocarbon compounds.

Results of Chemical Action of Underground Water.—Since every spring is busily engaged in bringing mineral substances from below ground to the surface, there must evidently be a vast amount of subterranean waste, and many tunnels, channels, and caverns must in consequence be formed. To take one illustration: the warm springs of Bath, with a mean temperature of 120° Fahr., are impregnated with sulphates of lime and soda, and chlorides of sodium and magnesium. Professor Ramsay has estimated their annual discharge of mineral matter to be equal to a square column 9 feet in diameter and 140 feet in height. It is in calcareous regions that the extent of the subterranean loss can be most strikingly seen. Sometimes a district of limestone is drilled with vertical cavities (*swallow-holes* or *sinks*) formed by the solution of the rock by the descent of carbonated rain-water. Surface-drainage is there intercepted, and passes at once under ground, where, in course of time, an elaborate system of channels may be dissolved out of the solid rock. Such has been the origin of the Peak caverns of Derbyshire, the intricate grottoes of Antiparos and Adelsberg, and the vast labyrinths of the Mammoth Cave of Kentucky. In the course of time the underground rivers open out new courses, and leave their old ones dry. By the falling in of the roofs of caverns near the surface, brooks and rivers are occasionally engulfed, which, after a long subterranean course, may issue to the surface again in a totally different surface area of drainage to that in which they took their rise, and sometimes, as in Florida, with volume enough to be navigable almost up to their outflow. In such circumstances lakes may be formed over the sites of the broken-in caverns; and valleys may thus be deepened, or perhaps even formed. Mud, sand, and gravel, with the remains of plants and animals, are swept below ground, and sometimes accumulate in deposits there. This has been the origin of ossiferous caverns, and of the loam and breccia so often found in them.

These wonderful results of the subterranean circulation of water appeal to the imagination, and are those usually most dwelt upon as evincing the potency of this kind of geological agency. And yet the thoughtful observer who reflects upon this subject will perhaps be led to perceive that even more important than these visible caverns and grottoes are the silent unobtrusive changes so constantly in progress in the solid heart of rocks. As far down as percolating water reaches there is not a particle of mineral matter safe from its attacks. And as we have seen, it is hardly possible to find any rock which does not bear throughout its minute grains and pores evidence that water has filtered through it, removing some substances and putting others in their place.

(2.) *Results of Mechanical Action.*—In its passage along fissures and channels of the rocks, the underground water not merely dissolves materials chemically and removes them in solution, it likewise loosens some of the finer particles from the sides of these subterranean conduits and carries them along in mechanical suspension. We may occasionally observe, where a spring gushes forth at the surface, that grains of sand are brought up in the clear sparkling water. This removal of material sometimes produces remarkable surface changes when it takes place along the side of a steep slope or cliff, such as occur in river valleys, or by the sea-coast. Let us suppose a thin layer of some porous material, like loose sand or ill-compacted sandstone, to lie between two more impervious rocks such as masses of clay or limestone, and that this porous stratum sloping down from higher ground comes out to the surface near the base of a line of abrupt cliff. The water which finds its way down into this layer will use it as its channel of escape, and travelling along its course will issue in springs or in a more general oozing forth along its outcrop at the foot of the declivity. Under these circumstances the support of the overlying mass of rock is apt to be loosened. The water not only removes piecemeal the sandy layer on which that overlying mass rests, but as it were lubricates the rock underneath. Consequently at intervals portions of the upper rock may break off and slide down into the valley or plain below. Such dislocations are known as *landslips*. Many illustrative examples might be cited. Thus in the year 1839 a mass of chalk on the Dorsetshire coast slipped over a bed of clay into the sea, leaving a rent three-quarters of a mile long, 150 feet deep, and 240 feet wide. The shifted mass, bearing with it houses, roads, and fields, was cracked, broken, and tilted in various directions, and was thus prepared for further attack and removal by the waves. On many parts of the coasts of Britain there are landslips on a large scale which doubtless took place many centuries ago, or even in some cases beyond the times of human history. The undercliff of the Isle of Wight, the cliffs west of Brandon Head, county Kerry, the basalt escarpments of Antrim, and the edges of the great volcanic plateaus of Mull, Skye, and Raasay furnish illustrations of such prehistoric landslips. Of Continental examples, the well-known fall of the Rossberg, behind the Righi in Switzerland, is one of the most memorable. After a rainy summer in 1806 a large part of one side of the mountain, consisting of sloping beds of hard red sandstone and conglomerate, resting upon soft sandy layers, gave way. Thousands of tons of solid rock suddenly swept across the valley of Goldau, burying four villages, with about 500 of their inhabitants. In 1855 a mass of debris, 3500 feet long, 1000 feet wide, and 600 feet high, slid into the valley of the Tiber, which, dammed back by the obstruction, overflowed the village of San Stefano to a depth of 50 feet, until drained off by a tunnel.

§ 3. *Brooks and Rivers.*

These will be considered under four aspects:—(1) their sources of supply, (2) their discharge, (3) their flow, and (4) their geological action.

I. Sources of Supply.—Rivers are the natural drains of a land surface. They carry out to sea the surplus water after evaporation, and not water only, but a vast and almost incredible amount of material annually worn off the land. Their contents are derived partly from rain (including mist and dew) and melted snow, partly from springs. In a vast river system like that of the Mississippi, the area of drainage is so extensive as to embrace many different climates and varieties of rainfall, so that on the whole the amount of discharge, being in a great measure independent of local variations in the weather, remains tolerably uniform. But in smaller rivers, such as those of Britain, whose basins lie in a region having the same general features of climate, the quantity of water is regulated by the local rainfall. A wet season swells the streams, a dry one diminishes them. Were rivers entirely dependent, however, upon direct supplies of rain, they would only flow in rainy seasons, and disappear in dry weather. This does not happen, because they derive a great deal of their water not directly from rain, but indirectly through the intermediate agency of springs. Hence they continue to flow even in very dry weather, because, though the superficial supplies have failed, the underground sources still continue available. In a long drought, however, the latter begin to fail, the surface springs ceasing first, and gradually drying up in their order of depth, until at last only deep-seated springs furnish a perhaps daily diminishing quantity of water. It is a matter of great economic as well as scientific interest to know how long any river would continue to yield a certain amount of water during a prolonged drought. So far as we can tell, no rule could possibly be laid down for a generally applicable calculation, every area having its own peculiarities of underground drainage. Mr. Joseph Lucas gives some particulars which show what may happen in a chalk district. The river Wandle drains an area of 51 square miles of the chalk downs in the south-east of England. For eighteen months, from May, 1858, to October, 1859, as tested by gauging, there was very little absorption of rainfall over the drainage basin, and yet the minimum recorded flow of the Wandle was 10,000,000 gallons a day, which, Mr. Lucas says, represents not more than ·4090 inch of rain absorbed on the 51 square miles of chalk. The rock is so saturated that it can continue to supply a large yield of water for eighteen months after it has ceased to receive supplies from the surface, or at least has received only very much diminished supplies.[1]

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[1] Lucas, *Horizontal Wells*, London, 1874, pp. 40, 41. See also Braithwaite, "On the Rise and Fall of the Wandle," *Minutes Proc. Inst. C. E.*, xx.

II. Discharge.—As the natural drains of the land, rivers carry the surplus moisture out to sea. What proportion of the total rainfall is thus discharged by them is a question of great geological and industrial interest. From the very moment that water takes visible form as mist, cloud, dew, rain, snow, or hail, it is subject to evaporation. When it reaches the ground, or flows off into brooks, rivers, lakes, or the sea, it undergoes continual diminution from this cause. Hence in regions where rivers receive no tributaries, they grow smaller in volume as they move onward, till they sometimes even disappear. Apart from temperature, the amount of evaporation is very largely regulated by the nature of the surface from which it takes place, one soil or rock differing from another, and all of them probably from a surface of water. There is no question in meteorology where full and detailed observations are more wanting than in the determination of the relation of evaporation to rainfall and river discharge.[1] During severe storms of rain, the water discharged over the land of course to a very large extent finds its way at once into brooks and rivers, where it causes floods, and whence it reaches the sea. Mr. David Stevenson remarks that, according to different observations, the amount carried off in floods varies from 1 to 100 cubic feet per minute per acre.[2] But though floods cannot be deemed exceptional phenomena, forming as they do a part of the regular system of water circulation over the land, they do not represent the ordinary proportions between rainfall and river discharge in such a climate as that of Britain, where the rainfall is not crowded into one season, but is spread more or less equally throughout the year. According to Beardmore's table,[3] the Thames at Staines has a mean annual discharge of 32·40 cubic inches per minute per square mile, equal to a depth of 7·31 inches of rainfall run off, or less than a third of the total rainfall. The most carefully collected data at present available are probably those given by Humphreys and Abbot for the basin of the Mississippi and its tributaries as shown in the subjoined table:—

	Ratio of Drainage to Rainfall.
Ohio River	0·21
Missouri River	0·15
Upper Mississippi River	0·24
Small tributaries	0·90
Arkansas and White River	0·15
Red River	0·20
Yazoo River	0·90
St. Francis River	0·90
Entire Mississippi, exclusive of Red River	0·25

Perhaps in Great Britain not more than a fourth part of the total moisture deposited on the land from the atmosphere is carried out to sea by streams.[4] But this is a point on which, until far more facts have been gathered, no definite statement can be accepted as at all trustworthy.

III. Flow.—Rivers, in obedience to the law of gravitation, always move from a higher to a lower level. Where the channel of a river becomes vertical, or nearly so, a waterfall is formed; a steep rocky declivity in the channel gives rise to rapids; a flat plain allows the stream to linger with a scarcely perceptible current; while a lake renders the flow nearly or altogether imperceptible. Thus the rate of flow is regulated in the main by the angle of inclination and form of the channel, but partly also by the volume of water, an increase of volume in a narrow channel increasing the rate of motion even without an increase of slope.

The course of a great river may be divided into three parts:—1. *The Mountain Track*,—where, amidst the clouds and snows it takes its rise as a mere brook, and, fed by innumerable similar torrents, dashes rapidly down the steep sides of the mountains, leaping from crag to crag in endless cascades, growing every moment in volume, until it enters lower ground. 2. *The Valley Track*.—It now flows through the lower hills or undulations which traverse or flank a great mountain chain, and is found at one time in a wide fertile valley, then in a dark gorge, now falling headlong in a cataract, now expanding into a broad lake. This is the part of its career where it assumes the most varied aspects, receives the largest tributaries, and fulfils most characteristically the various conditions which are present to our minds in the idea of a river. 3. *The Plain Track*.—Having quitted the undulating region, it finally emerges upon broad plains, probably wholly, or in great part, made by itself. Here it winds sluggishly in wide curves, perhaps divides so as to enclose tracts of flat meadow or marsh, and finally, amid banks of mud and sand, passes out into the great ocean. In Europe the Rhine, Rhone, and Danube, in Asia the Ganges and Indus, in America the Mississippi and Amazon, in Africa the Nile, more or less fully illustrate this typical course of a great river.

If we draw a longitudinal section of the course of any such river from its source, or from the highest peaks around that source to its mouth at the sea, we find that the line forms a concave curve. Steep at first, where it slopes from the mountain crests down into the valleys, the curve grows less and less through the middle portion, until it finally can hardly be distinguished from a horizontal line. Though characteristic of great rivers, this feature is not confined to their courses, but belongs to the architecture of the continents.

It is evident that a river must flow, on the whole, fastest in the first portion of its course, and slowest in the last. The common method of comparing the fall or slope of rivers is to divide the difference of height between their source and the sea-level by their length, so as to give the declivity per mile. This mode, however, often fails to bring out the real resemblances and differences of rivers, even in regard to their angle of slope. For example, two streams rising at a height of 1000 feet, and flowing 100 miles, would each have an average slope of 10 feet per mile; yet they might be wholly unlike each other, one making its descent almost entirely in the first or mountain part of its course, and lazily winding for most of its way through a vast low plain, the other toiling through the mountains, then keeping among hills and table-lands, so as to form on the whole a tolerably equable and rapid flow. The great rivers of the globe have probably a less average slope than 2 feet per mile. The Missouri has a descent of 28 inches per mile. The average slope of the channel of the Thames is 21 inches per mile; of the Shannon about 11 inches per mile, but between Killaloe and Limerick about 6½ feet per mile; of the Nile, below Cairo, 3·25 to 5·5 inches per mile; of the Doubs and Rhone, from Besançon to the Mediterranean, 24·18 inches per mile; of the Volga from its source to the sea, a little more than three inches per mile. Higher angles of descent are those of torrents, as the Arve, with a slope of 1 in 616 at Chamounix, and the Durance, whose angle varies from 1 in 467 to 1 in 208. The slope of a navigable river ought not, if possible, to exceed 10 inches per mile, or 1 in 6336.[5]

But not only does the rate of flow of a river vary at different parts of its course, it is not the same in every part of the cross section of the river taken at any given point. The sides and bottom being retarded by friction against the channel, move less rapidly than the centre. The central piers of a bridge have thus a greater velocity of river current to bear than those at the banks. It follows that whatever tends to diminish the friction of the moving current will increase its rate of flow. The same body of water, other conditions being equal, will move faster through a narrow gorge with steep smooth walls than over a broad rough rocky bed. For the same reason, when two streams join, their united current, having in many cases a channel not much larger than that of one of the single streams, flows faster, because the water encounters now the friction of only one channel. The average rate of flow of rivers is much less than might be supposed, even in what are termed swift rivers. A moderate rate is about 1½ miles in the hour; even that of a torrent does not exceed 18 or 20 miles in the hour.[1] Mr. D. Stevenson states that the velocity of such rivers as the Thames, the Tay, or the Clyde may be found to vary from about one mile per hour as a minimum to about three miles per hour as a maximum velocity.[2]

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[1] In the present state of our information it seems almost useless to state any of the results already obtained, so widely discrepant and irreconcilable are they. In some cases the evaporation is given as usually three times the rainfall! and that the evaporation always exceeded the rainfall was for many years the belief among the French hydraulic engineers. (See *Annales des Ponts et Chaussées*, 1850, p. 383.) Observations on a larger scale, and with greater precautions against the undue heating of the evaporator, have since shown, as might have been anticipated, that as a rule, save in exceptionally dry years, the evaporation is lower than the rainfall. As the average of ten years from 1860 to 1869 Mr. Greaves found that at Lea Bridge the evaporation from a surface of water was 20·946, while the rainfall was 25·534 (Symon's *British Rainfall* for 1869, p. 162). But we need a vast accumulation of observations, taken in many different situations and exposures, in different rocks and soils, and at various heights above the sea. (For a notice of a method of trying the evaporation from soil, see *British Rainfall*, 1872, p. 206.)

[2] *Reclamation and Protection of Agricultural Land*, Edin. 1874, p. 15.

[3] *Hydrology*, p. 201.

[4] In mountainous tracts having a large rainfall and a short descent to the sea, the proportion of water returned to the sea must be very much greater than this. Mr. Bateman's observations for seven years in the Loch Katrine district gave a mean annual rainfall of 87½ inches at the head of the lake, with an outflow equivalent to a depth of 81·70 inches of rain removed from the drainage basin of 71½ square miles

[5] D. Stevenson, *Canal and River Engineering*, p. 224.

It may be remarked, in concluding this part of the subject, that elevations and depressions of the land must have a powerful influence upon the slope of rivers. The upraising of the axis of a country must increase the slope, and consequently the rate of flow, which, on the contrary, will be diminished by a depression of the axis or by an elevation of the maritime regions.

IV. GEOLOGICAL ACTION.—Like all the other forms of moving water, the streams which traverse a country have both a *chemical* and *mechanical* action. The latter receives most attention, as it undoubtedly is the more important; but the former ought not to be omitted in any survey of the general waste of the earth's surface.

i. *Chemical.*—The water of rivers must possess the powers of a chemical solvent like rain and springs, though its actual work in this respect can be less easily measured, seeing that river water is directly derived from rain and springs, and necessarily contains in solution mineral substances supplied to it by them and not by its own operation. Nevertheless, it is sometimes easy to prove that streams dissolve chemically the rocks of their channels. Thus in limestone districts the base of the cliffs of river ravines may be found eaten away into tunnels, arches and overhanging projections presenting in their smooth surfaces a great contrast to the angular jointed faces of the same rock where exposed to the influence only of the weather on the higher parts of the cliff.

The composition of the river waters of western Europe is well shown by numerous analyses. The substances held in solution include variable proportions of the carbonates of lime, magnesia, and soda; silica; peroxides of iron and manganese; alumina; sulphates of lime, magnesia, potash, and soda; chlorides of sodium, potassium, calcium, and magnesium; silicate of potash; nitrates; and organic matter. The minimum proportion of mineral matter among the analyses collected by Bischof was 2·61 in 100,000 parts of water in a mountain stream 3800 feet above the sea. On the other hand as much as 54·5 parts in the 100,000 were obtained in the waters of the Beuvronne, a tributary of the Loire above Tours. The average of the whole of these analyses is about 21 parts of mineral matter in 100,000 of water, whereof carbonate of lime usually forms the half, its mean quantity being 11·34. Bischof calculated that, assuming the mean quantity of carbonate of lime in the Rhine to be 9·46 in 100,000 of water, which is the proportion ascertained at Bonn, enough carbonate of lime is carried into the sea by this river for the annual formation of three hundred and thirty-two thousand millions of oyster shells of the usual size. The mineral next in abundance is sulphate of lime, which in some rivers constitutes nearly half of the dissolved mineral matter. Silica amounting to 4·88 parts in 100,000 of water has been found in the Rhine, near Strasburg. The largest amount of alumina was 0·71 in the Loire, near Orleans. The proportion of mineral matter in the Thames, near London, amounts to about 33 in 100,000 parts of water, 15 of which (nearly half of the whole) consist of carbonate of lime.

It requires some reflection properly to appreciate the amount of solid mineral matter which is every year carried in solution from the rocks of the land and diffused by rivers into the sea. According to recent calculations by Mr. T. Mellard Reade, C.E., a total of 8,370,630 tons of solids in solution is every year removed by running water from the rocks of England and Wales, which is equivalent to a general lowering of the surface of the country from that cause alone at the rate of ·0077 of a foot in a century or one foot in 12,978 years. The same writer computes the annual discharge of solids in solution by the Rhine to be equal to 92·3 tons per square mile, that of the Rhone at Avignon 232 tons per square mile, and that of the Danube at 72·7 tons per square mile; and he supposes that on an average over the whole world there may be every year dissolved by rain about 100 tons rocky matter per English square mile of surface.[3]

ii. *Mechanical.*—The mechanical work of rivers is threefold:—(1) to transport mud, sand, gravel, or blocks of stone from higher to lower levels; (2) to use these loose materials in eroding their channels; and (3) to deposit these materials where possible, and thus to make new geological formations.

1. Transporting Power.—It is one of the distinctions of river water, as compared with that of springs, that, as a rule, it is less transparent, that is, it contains more or less mineral matter in suspension. The same stream differs much at successive intervals in the amount of material thus transported. In dry weather when the water is low it may be tolerably clear; but a sudden heavy shower or a season of wet weather will render it turbid. The mud thus so frequently noticeable in rivers is partly derived from the surface of the ground on either side, whence it is washed into the main streams by rain and brooks, but partly also by the abrasion of the water-channels through the operations of the streams themselves. In the mountain tributaries of a river we find the channels choked with large fragments of rock disengaged from the cliffs and crags on either side. Traced downwards the blocks are seen to become gradually smaller and more rounded. They are ground against each other and upon the rocky sides and bottom of the channel, getting more and more reduced as they descend, and at the same time abrading the rocks over or against which they are driven. Hence a great deal of debris is produced, and is swept along by the onward and downward movement of the brooks and rivers. The finer portions, such as mud and fine sand, are carried in suspension, and impart the characteristic turbidity to rivers; the coarser sand and gravel are driven along the river bottom.

The transporting capacity of a stream depends (*a*) on the volume and velocity of the current, and (*b*) on the size, shape, and specific gravity of the sediment. (*a*) According to the calculations of Hopkins, the capacity of transport increases as the sixth power of the velocity of the current; thus the motive power of the current is increased 64 times by the doubling of the velocity, 729 times by trebling, and 4096 times by quadrupling it. It has been found by experiment that "ordinary sandy soil is moved by a current having a velocity of about half a mile an hour, and that a current of about one mile per hour will move fine gravel, while heavy gravel resists a current of upwards of two miles per hour." Mr. David Stevenson[4] gives the subjoined table of the power of transport of different velocities of river currents.

In. per Second.		Miles per Hour.	
3	=	0·170	will just begin to work on fine clay.
6	=	0·340	will lift fine sand.
8	=	0·4545	will lift sand as coarse as linseed.
12	=	0·6819	will sweep along fine gravel.
24	=	1·3638	will roll along rounded pebbles 1 inch in diameter.
36	=	2·045	will sweep along slippery angular stones of the size of an egg.

We must never lose sight, however, of the fact that it is not the surface velocity, nor even the mean velocity, of a river which can be taken as the measure of its power of transport, but the bottom velocity—that is, the rate at which the stream overcomes the friction of its channel. (*b*) The average specific gravity of the stones in a river ranges between two and three times that of pure fresh water; hence these stones lose from a half to a third of their weight in air when borne along by the river. Huge blocks which could not be moved by the same amount of energy applied to them on dry ground are swept along with ease when they have found their way into a strong river current. The shape of the fragments greatly affects their portability, when they are too large and heavy to be carried in mechanical suspension. Rounded stones are of course most easily moved; flat and angular ones are moved with comparative difficulty.

Besides their ordinary powers of transport, rivers gain at times considerable additional force from several causes. Those liable to sudden and heavy falls of rain acquire by flooding an enormous increase of transporting and excavating power. More work may thus be done by a stream in a day than could be accomplished by it during years of its ordinary condition.[5] Another source of increase to the action of rivers is provided when, from landslips, formed by earthquakes, by the undermining influence of springs, or otherwise, a stream is temporarily dammed back, and the barrier subsequently gives way. The bursting out of the arrested waters produces great destruction in the valley. Blocks as big as houses may be set in motion, and carried down for considerable distances. Again, the transporting power of rivers is greatly augmented in countries where they freeze in winter. As the ice gathers along the banks it encloses gravel, sand, and even large blocks of rock, which, when thaw comes, are lifted up by the ice and carried down the stream. Ground-ice likewise appears in cold latitudes on the bottoms of the rivers, whence, rising in cakes to the surface, it carries with it sand, mud, or stones lying on the bottom, which are then swept seaward. When rivers such as those of northern Russia and Siberia, flowing from south to north, have the ice thawed in their higher courses before it breaks up farther down, much disaster is sometimes caused by the piling up of the ice, and then by the bursting of the impeded river through the temporary ice-barrier. In another way ice sometimes vastly increases the destructive powers of small streams where avalanches or an advancing glacier cross a valley and pond back its drainage. The valley of the Dranse, in Switzerland, has several times suffered from this cause. In 1818 the glacier barrier extended across the valley for more than half a mile, with a breadth of 600 and a height of 400 feet. The waters above the ice-dam accumulated into a lake containing 800,000,000 cubic feet. By a tunnel driven through the ice, the water was drawn off without desolating the plains below.

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[1] Contjean, *Géologie*, p. 225.

[2] *Reclamation of Land*, p. 18.

[3] *Address to Liverpool Geological Society*, 1877.

[4] *Canal and River Engineering*, p. 315.

[5] The extent to which heavy rains can alter the usual characters of rivers is forcibly exemplified in the graphic account of *The Moray-*

That rivers differ vastly from each other in the amount of material they transport is made evident by the great diversities in their relative muddiness. It should be borne in mind that the actual amount of sediment borne downwards by a river is not necessarily determined by the carrying power of the current. The swiftest streams are not always the muddiest. The proportion of sediment is partly dependent upon the hardness or softness of the rocks of the channel, the number of tributaries, the nature and slope of the ground forming the drainage basin, the amount and distribution of the rainfall, the size of the glaciers (where such exist) at the sources of the river, etc. A rainfall spread with some uniformity throughout the year may not sensibly darken the rivers with mud, but the same amount of fall crowded into a few weeks or months may be the means of sweeping a vast amount of earth into the rivers, and sending them down in a greatly discolored state to the sea. Thus the rivers of India during the rainy season become rolling currents of mud.

In his journeys through equatorial Africa Livingstone came upon rivers which appear usually to consist more of sand than of water. He describes the Zingesi as "a sand rivulet in flood, 60 or 70 yards wide, and waist-deep. Like all these sand-rivers it is for the most part dry; but, by digging down a few feet, water is to be found, which is percolating along the bed on a stratum of clay. In trying to ford it," he remarks, "I felt thousands of particles of coarse sand striking my legs, which gave me the idea that the amount of matter removed by every freshet must be very great. . . . These sand rivers remove vast masses of disintegrated rock before it is fine enough to form soil. In most rivers where much wearing is going on, a person diving to the bottom may hear literally thousands of stones knocking against each other. This attrition being carried on for hundreds of miles in different rivers, must have an effect greater than if all the pestles and mortars and mills of the world were grinding and wearing away the rocks."

The amount of mineral matter transported by rivers can be estimated by examining their waters at different periods and places, and determining their solid contents. A complete analysis should take into account what is chemically dissolved, what is mechanically suspended, and what is driven or pushed along the bottom. We have already dealt with the chemically dissolved ingredients. In determinations of the mechanically mixed constituents of river water, it is most advantageous to obtain the proportion first by weight, and then from its average specific gravity to estimate its bulk as an ingredient in the water. The Ganges, according to Everest, contains during the four months of flood earthy matter in the proportion of $\frac{1}{428}$ by weight or $\frac{1}{856}$ by volume,—the mean average for the year being $\frac{1}{510}$ by weight or $\frac{1}{1020}$ by volume. According to Mr. Login, the waters of the Irrawaddy contain $\frac{1}{1700}$ by weight of sediment during floods, and $\frac{1}{5725}$ during a low state of the river. The most elaborate measurements and calculations yet made regarding this aspect of the operations of a river are those by Messrs. Humphreys and Abbot on the Mississippi, who found, as the mean of many observations carried on continuously at different parts of the river for months together, that the average proportion of sediment contained in the water of the Mississippi is $\frac{1}{1500}$ by weight, or $\frac{1}{2900}$ by volume. But besides the matter held in suspension, they observed that a large amount of coarse detritus is constantly being pushed along the bottom of the river. They estimated that this moving stratum carries every year into the Gulf of Mexico about 750 million cubic feet of sand, earth, and gravel. Their observations led them to conclude that the annual discharge of water by the Mississippi is 19,500,000 millions cubic feet, and consequently that the weight of mud annually carried into the sea by this river must reach the sum of 813,500 million ℔. Taking the total annual contributions of earthy matter, whether in suspension or moving along the bottom, they found them to equal a prism 268 feet in height, with a base of one square mile.

2. Excavating Power.—In transporting its freight of sediment a river performs a vast amount of abrasion. In the first place it rubs the loose stones against each other, breaks them into smaller pieces, rounds off their edges, reduces them to rounded pebbles, and finally to sand or mud. In the next place by driving these loose materials over the rocks it wears down the sides and bottom of its channel which is thereby widened and deepened.

The familiar effect of running water upon fragments of rock, in reducing them to smoothed, rounded pebbles, is expressed by the common phrase "water-worn." Every stream which descends from high rocky ground may be compared to a grinding mill; large boulders and angular blocks of rocks, disengaged by frosts, springs, and general atmospheric waste, fall into the upper end, and only fine sand and silt are discharged into the sea. M. Daubrée has instituted some ingenious experiments for ascertaining the circumstances under which angular fragments are converted into rounded pebbles with the production of sand and mud. Using fragments of granite and quartz, he caused them to slide over each other in a hollow cylinder partially filled with water, and rotating on its axis with a mean velocity of 0·80 to 1 metre in a second. He found that after the first 25 kilometres (about 15½ English miles) the angular fragments of granite had lost $\frac{4}{10}$ of their weight, while in the same distance fragments already well-rounded had not lost more than $\frac{1}{100}$ to $\frac{1}{400}$. The fragments rounded by this journey of 25 kilometres in a cylinder could not be distinguished either in form or in general aspect from the natural detritus of a river bed. A second product of these experiments was an extremely fine impalpable mud, which remained suspended in the water several days after the cessation of the movement. During the production of this fine sediment the water acted chemically upon the granite fragments, for after a day or two it was found, even though cold, to have dissolved a very sensible proportion of silicate of potash. After a journey of 160 kilometres, 3 kilogrammes (about 6½ ℔ avoirdupois) had yielded 3·3 grammes (about 50 grains) of soluble salts consisting chiefly of silicate of potash. A third product was an extremely fine angular sand consisting almost wholly of quartz, with scarcely any felspar, almost the whole of the latter mineral having passed into the state of clay. The sand grains, as they are continually pushed onward over each other upon the bottom of a river, become rounded as the larger pebbles do. But, as M. Daubrée points out, a limit is placed to this attrition by the size and specific gravity of the grains. So long as they are carried in suspension they will not abrade each other, but remain angular; for he found that the milky tint of the Rhine at Strasburg in the months of July and August was due not to mud but to a fine angular sand (with grains about $\frac{1}{20}$ millimetre in diameter) which constitutes $\frac{2}{100000}$ of the total weight of water. Yet this sand had travelled in a rapidly flowing tumultuous river from the Swiss mountains, and had been tossed over waterfalls and rapids in its journey. He ascertained also that sand with a mean diameter of grain of $\frac{1}{10}$ mm will float in feebly agitated water; so that all sand

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shire Floods, by the late Sir T. Dick Lauder. In the year 1829 the rivers of that region rose 10, 18, and in one case even 50 feet above their common summer level, producing almost incredible havoc.

of finer grain must remain angular. The same observer has noticed that sand composed of grains with a mean diameter of $\frac{1}{2}$ mm., and carried along by water moving at a rate of 1 metre per second, gets rounded, and loses about $\frac{1}{10000}$ of its weight in every kilometre travelled.

The effects of abrasion upon the loose materials on a river bed are only a portion of the erosive work performed by the stream. Where the bottom is covered with a layer of debris only the upper portion of which is pushed onward by the current, the solid rock of the river channel is there protected from waste. But this protection is only local, and is apt to be swept away from time to time by violent floods. In those parts of a river channel where the current is strong enough to keep gravel and boulders moving along, these loose materials rub down the rocky bottom over which they are driven. As the shape and declivity of the channel vary constantly from point to point, with at the same time frequent changes in the nature of its rocks, this erosive action is liable to continual modifications. While there is a general abrasion of the whole bottom over which loose detritus is rolled, the erosion goes on most briskly in the numerous hollows and grooves along which chiefly these loose materials travel. Wherever an eddy occurs in which gravel is kept in gyration, erosion is much increased. The stones in their movement excavate a hole in the channel, while as they themselves are reduced to sand and mud, or are swept out by the force of the current, their places are taken by fresh stones brought down by the stream. Such *pot-holes*, as they are termed, vary in size from mere cup-like depressions to huge cauldrons or pools. As they often coalesce by the giving way of the intervening walls between two or more of them, they materially increase the deepening of the river bed.

The shape of a river channel at any given point in its course depends mainly upon the nature and structure of the material out of which it has been eroded. One of the most characteristic features of streams, whether large or small, is the tendency to wind in serpentine curves when the angle of declivity is low and the general surface of the country tolerably level. This peculiarity may be observed in every stream which traverses a flat alluvial plain. Some slight weakness in one of its banks enables the current to cut away a portion of the bank at that point. By degrees a concavity is formed, whence the water is deflected to the opposite side, there to break with increased force against the bank. Gradually a similar concavity is cut out on that side, and so, bending alternately from one side to the other, the stream is led to describe a most sinuous course across the plain. By this process, however, while the course is greatly lengthened, the velocity of the current proportionately diminishes, until it may, before quitting the plain, become a lazy, creeping stream, which in England is bordered perhaps with sedges and willows. Such meandering courses are most frequent in soft alluvial plains, but they may also be found in solid rock if the original form of the surface was tolerably flat. The windings of the gorges of the Moselle and Rhine through the table-land between Treves, Mainz, and the Siebengebirge form a notable illustration.

Abrupt changes in the geological structure or lithological character of the rocks of a river-channel may give rise to waterfalls. In many cases waterfalls have originated in lines of escarpment over which the water at first found its way, or in the same geological arrangement of hard and soft rocks by which the escarpments themselves have been produced. In the case of the falls of Niagara, for example, the stream may have fallen over the Queenstown cliff when the river first sought its way to the sea. But much more probably the escarpment and waterfall began to arise simultaneously and from the same geological structure. As the escarpment grew in height, it receded from its starting point. The river-ravine likewise crept backward, but at a more rapid rate, and the result has been that at present the cliff worn down by atmospheric causes stands at Queenstown, while the ravine extends 7 miles further inland, with a width of from 200 to 400 yards, and a depth of from 200 to 300 feet. In this as in other cases the waterfall has cut its way backward up the course of its stream, and will continue to do so as long as the structure of the gorge continues as it is now—a thick bed or beds of limestone resting horizontally upon soft shales. The softer strata at the base are undermined, and slice after slice is cut off from the cliff over which the cataract pours. It has been estimated that at their present rate of recession the Niagara Falls must have taken about 35,000 years to cut their way backward and excavate the gorge between their present position and Queenstown. In other cases waterfalls have been produced by the existence of a harder and more resisting band or barrier of rock crossing the course of the stream, as, for instance, where the rocks have been cut by an intrusive dyke or mass of basalt. In these and all other cases the removal of the harder mass destroys the waterfall, which, after passing into a series of rapids, is finally lost in the general abrasion of the river-channel. The most marvellous river gorges in the world are those of the Colorado region in North America. The rivers there flow in ravines thousands of feet deep and hundreds of miles long, through vast table-lands of nearly horizontal strata. The Grand Cañon (ravine) of the Colorado river is 300 miles long, and in some places more than 6000 feet in perpendicular depth. The country is hardly to be crossed except by birds, so profoundly has it been trenched by these numerous gorges. Yet the whole of this excavation has been effected by the erosive action of the streams themselves.

In the excavation of a ravine, whether by the recession of a waterfall or of a series of rapids, the action of the river is more rapid than that of the atmospheric agents. The sides of the ravine consequently retain their vertical character. But where, from the nature of the ground, the denuding action of rain, frost, and general weathering is more rapid than that of the river, a wider and opener valley is hollowed out, through which the river flows, and from which it carries away the materials discharged into it from the surrounding slopes by the rain and brooks.

3. Reproductive Power.—Every body of water which when in motion carries along sediment drops it when at rest. The moment a current has its rapidity checked it is deprived of some of its carrying power, and begins to lose hold upon its sediment, which tends more and more to sink and halt on the bottom the slower the motion of the water. In the course of every brook and river there are frequent checks to the current. If these are examined, they will usually be found to be each marked by a more or less conspicuous deposit of sediment. We may notice seven different situations in which stream deposits or *alluvium* may be accumulated.

(*a*.) *At the foot of Mountain Slopes*—When a runnel or torrent descends a steep declivity it tears down the soil and rocks, cutting a deep gash out of the side of the mountain. On reaching the level ground at the base of the slope the water, abruptly checked in its velocity, at once drops its coarser sediment, which gathers in a fan-shaped pile or cone, with the apex pointing up the water course. Huge accumulations of boulders and shingle may thus be seen at the foot of such torrents,—the water flowing through them often in several channels which re-unite in the plain beyond.

(*b*.) *In River-beds.*—This is characteristically shown in many of the rivers of Britain, by the accumulation of a bed of sand or shingle at the concave side of each sharp bend of the river course. While the main current is making a great sweep round the opposite bank, the water lingers along the inner side of the curve and drops there its freight of loose detritus, which, when laid bare in dry weather, forms the familiar sand-bank or shingle beach. Again, when a river, well supplied with sediment, leaves rough ground where its course has been rapid, and enters a region of level plain, it begins to drop its burden on its bed, which is thereby heightened, till sometimes, as in parts of the courses of the Po, Adige, and Brenta across the plains of Lombardy, it is higher than the surrounding level region. This could not happen were it not that in floods a river deposits sediment along its banks, which are thus also heightened so as to retain the river in its ordinary state. But in such cases, if man lives along the margin of the river, he needs all his skill and labor to keep the banks secure. And even with his utmost efforts the river will now and then break through, sweeping down the barrier which it has itself made, as well as any additional embankments constructed by him, and carrying its flood far and wide over the plain. Left to itself, the river would incessantly shift its course, until in turn every part of the plain had been again and again traversed. It is indeed in this way that a great alluvial plain is gradually levelled and heightened.[1]

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[1] It is in the north of Italy that the struggle between man and nature in this department has been most persistently waged. See on this subject Lombardini in *Ann. des Ponts et Chaussées*, 1847.

(*c.*) *On River-banks and Flood-plains.*—This deposit is partly implied in the action described in the foregoing paragraph. It is laid down on the level tracts or flood-plain over which a river spreads in flood, and consists usually of fine silt, mud, earth, or sand, though close to the river it may be partly made up of much coarser materials. When a flooded river overflows, the portions of water which spread out on the plains, by losing velocity and consequently power of transport, are compelled to let fall some or all of their mud and sand. If the plains happen to be covered with woods, bushes, scrub, or even tall grass, the vegetation acts the part of a sieve, and filters the muddy water, which may rejoin the main stream comparatively clear. Every flood increases the height of the plain, until, partly from this cause and partly, in the case of a rapid stream, from the erosion of its bed, the river can no longer overspread it. As the channel is more and more deepened, the river continues, as before, to be liable from inequalities in the material of its banks, sometimes of the most trifling kind, to be turned from side to side in wide curves and loops, and cuts into its old alluvium, making eventually a newer plain at a lower level. Continued erosion carries the channel to a still lower level, where the stream can attack the later alluvial deposit, and form a still lower and newer one. The river comes by this means to be fringed with a series of terraces, each of which represents a former flood-level of the stream. In Britain it is common to find three such terraces, but sometimes as many as six or seven or even more may occur. In North America the river terraces exist on so grand a scale that the geologists of that country have named one of the later periods of geological history, during which those deposits were formed, the Terrace Epoch. In the attempt to reconstruct the history of the old river-terraces of a country, we have to consider whether they have been entirely cut out of older alluvium (in which case, of course, the valleys must have been as deep as now before the formation of the terraces); whether they afford any indications of having been formed during a period of greater rain-fall, when the rivers were larger than at present; whether they point to any upheaval of the interior of the country which would accelerate the erosive action of the streams, or to any depression of the interior or rise of the seaward tracts, which would diminish that action and increase the deposition of alluvium. Professor Dana has connected those of America with the elevation of the axis of that continent.

(*d.*) *In Lakes.*—When a river enters a lake its current is at once checked, and its sediment begins to gather over the lake bottom. If the lake be long enough in proportion to the volume of the river, the whole of the detritus may be deposited, so that, at its outflow, the river becomes as clear as when its infant waters began their course from the springs, snows, and mists of the far mountains. Thus the Rhone enters the Lake of Geneva turbid and impetuous, but it escapes at Geneva as blue translucent water. Its sediment is laid down on the floor of the lake, and chiefly at the upper end. Hence, lakes act as filters or sieves to intercept the sediment which is travelling in the rivers from the high grounds to the sea. If we look down from a height even upon a small lake among mountains, we observe that at the mouth of each torrent or brook which enters it there lies a little tongue of flat land (a true *delta*), through which the streamlet winds in one or more branches before mingling its waters with those of the lake. Each of these tongues consists of alluvium, laid down in obedience to the same law which governs the formation of river alluvium elsewhere, and continually creeping further out from the land as the deposit of sediment advances. Two streams entering a lake from opposite sides may join their alluvia so as to divide the lake into two, like the once united lakes of Thun and Brienz at Interlaken. Or the lake may be finally filled up altogether, as has happened in innumerable cases in all mountainous countries; the hilly tracts of Britain, for example, furnish abundant illustrations of every stage in this process. Where a large river with abundant sediment enters an important lake (as the Rhone at the head of the Lake of Geneva), the accumulation of its alluvium or delta may quite rival that of a great river in the sea, as described in paragraph (*f.*) below.

(*e.*) *Bars and Lagoon-Barriers.*—If we take a broad view of the degradation of the land, we must admit that the deposit of any sediment on the land is only temporary; the inevitable destination of all this material is the ocean. Most rivers which enter the sea have their mouths crossed by a bar of gravel, sand, or mud. The formation of this barrier results from the conflict between the river and the ocean. Although the muddy fresh water floats on the heavier salt water, its current is lessened, and it can no longer push along the mass of detritus on its bed. It has been ascertained, moreover, that, though fresh water can retain for a long while fine mud in suspension, this sediment is rapidly thrown down when the fresh is mixed with saline water. Hence, apart from the necessary loss of transporting power by the checking of the river current at the mouth, the mere mingling of a river with the sea must of itself be a cause of the deposit of sediment. But a large body of fresh water may float for a long distance before it is thoroughly mingled with the heavier water of the ocean. Ultimately, however, the fine detritus dropped by a river, together with the coarser materials on the bottom, are arrested by the sea. Moreover, in many cases the sea itself piles up great part of the sand and gravel of the bar. Heavy river-floods push the bar farther to sea, or even temporarily destroy it; storms from the sea, on the other hand, drive the bar farther up the stream. Another remarkable illustration of the contest between the alluvium-carrying streams and the land-eroding ocean is shown by the vast lines of bar or bank which, both in the Old World and the New, stretch along the coast. The streams do not flow straight into the sea, but run sometimes for many miles parallel to the coast, accumulating behind the barriers into broad and long lagoons, but eventually breaking through the barriers of alluvium and entering the sea. The lagoons of the Italian coast and of the Baltic near Dantzic are familiar examples. A conspicuous series of these alluvial bars fronts the American mainland for many hundred miles round the Gulf of Mexico and the shores of Florida, Georgia, and North Carolina. A space of several hundred miles on the east coast of India is similarly bordered. M. E. de Beaumont, indeed, has estimated that about a third of the whole of the coast-lines of the continents is fringed with such alluvial bars.

(*f.*) *Deltas in the Sea.*—The tendency of sediment to accumulate in a tongue of flat land when a river loses itself in a lake is exhibited on a far vaster scale where the great rivers of the continents enter the sea. It was to one of these maritime accumulations, that of the Nile, that the Greeks gave the name Delta, from its resemblance to their letter Δ, with the apex pointing up the river, and the base fronting the sea. This shape being the common one in all such alluvial deposits at river mouths, the term delta has come to be always applied to them. A delta therefore consists of successive layers of detritus, brought down from the land and spread out in the sea at the mouth of a river until they reach the surface, and then, partly by growth of vegetation and partly by flooding of the river, form a plain, of which the inner and higher portion comes eventually to be above the reach of the floods. Large quantities of drift-wood are often carried down, and bodies of animals are swept off to be buried in the delta, or even to be floated out to sea. Hence, in deposits formed at the mouths of rivers, we may always expect to find terrestrial organic remains.

When a river enters upon the delta-portion of its course it assumes a new character. In the previous parts of its journey it is always being augmented by tributaries; but now it begins to split up into branches, which wind to and fro through the flat alluvial land, often coalescing and thus enclosing insular spaces of all dimensions. The feeble current, no longer able to bear along all its weight of sediment, allows much of it to sink to the bottom and to gather over the tracts which are from time to time submerged. Hence many of the channels get choked up, while others are opened out in the plain, to be in turn abandoned, and thus the river restlessly shifts its channels. The seaward ends of at least the main channels grow outwards by the constant accumulation of detritus pushed into the sea, unless this growth chances to be checked by any marine current sweeping past the delta.

The European rivers furnish many excellent illustrations of delta-growth. Thus the Rhine, Meuse, Sambre, Scheldt, and other rivers have formed the wide maritime plain of Holland and the Netherlands. The Rhone has deposited an important delta in the Mediterranean Sea. The upper reaches of the Adriatic Sea are being rapidly shallowed and filled up by the Po, Adige, and other streams. Thus Ravenna, originally built in a lagoon like Venice, is now 4 miles from the sea. The port of Adria, so well known in ancient times as to have given its name to the Adriatic, is now 14 miles inland, while in other parts of that coast-line the breadth of land gained within the last 1800 years has been as much as 20 miles. On the opposite side, also, of the Italian peninsula, great additions have been made to the coast-line within the historical period. It is computed that the Tuscan rivers lay down as much as 12 million cubic yards of sediment every year within the marshes of the Maremma. The "yellow" Tiber, as it was aptly termed by the Romans, owes its color to the abundance of the sediment which it carries to sea. It has long been adding to the coast-line at its mouth at the rate of from 12 to 13 feet per annum. Hence the ancient harbor of Ostia is now more than 3 miles inland. Its ruins are at present (1879) being excavated, but every flood of the river leaves a thick deposit of mud on the streets and on the floors of the uncovered houses. Whence it would seem that the Tiber has not only advanced its coast-line, but has raised its bed on the plains by the deposit of alluvium, so that it now overflows places which, 2000 years ago, could not have been so frequently under water.[1] In the Black Sea a great delta is rapidly growing at the mouths of the Danube. At the Kilia outlets the water is shallowing so fast that the lines of soundings of 6 feet and 30 feet are advancing into the sea at the rate of between 300 and 400 feet per annum.[2]

The typical delta of the Nile has a seaward border 180 miles in length, the distance from which to the apex of the plain where the river bifurcates is 90 miles. That of the Mississippi contains an area of 40,000 square miles. The united delta of the Ganges and Brahmaputra covers a space of between 50,000 and 60,000 square miles, and has been bored through to a depth of 481 feet.

(*g.*) *Sea-borne Sediment.*—Although more properly to be noticed under the section on the sea, the final course of the materials worn by rains and rivers from the surface of the land may be referred to here. By far the larger part of these materials sinks to the bottom close to the land. It is only the fine mud carried in suspension in the water which is carried out to sea, the distance depending on the velocity of the stream, the specific gravity and shape of the particles of the mud, and the help or hinderance given by marine currents. The sea fronting the Amazon is discolored for 300 miles by the mud of that river. The soundings taken by the "Challenger" brought up land-derived detritus from depths of 1500 fathoms—several hundreds of miles distant from the nearest shores.

The amount of material carried by a river into the sea may be taken as the measure or gauge of the general lowering of the surface of the basin drained by the river. If we ascertain the annual quantity of mineral matter thus delivered into the sea, and know the superficial extent of ground from which it has been derived, the one sum divided by the other gives the extent by which the mean level of the country is reduced in one year. Both the fine mud mechanically suspended in the water and the salts dissolved in it should be taken into account, as well as the coarser detritus pushed along the bottom. It is the mechanically suspended mud which has generally been measured. According to the data of Messrs. Humphreys and Abbot, already cited, the proportion of sediment in the Mississippi is $\frac{1}{1500}$ by weight, or $\frac{1}{2900}$ by volume. The annual discharge of sediment is 7,459,267,200 cubic feet, and the drainage basin 1,147,000 square miles. This is equal to a loss of $\frac{1}{6000}$ of a foot of rock from the general surface of the drainage basin in 1 year, or 1 foot in 6000 years. Other rivers work faster than this rate. The Ganges has been estimated to remove 1 foot of rock from its drainage area in 2358 years, and the Po 1 foot in 729 years. Such computations are at the best only approximations to the truth, but they are useful in showing how great an amount of change must be effected even within comparatively short geological periods by the various agents which are disintegrating the surface of the land.

§ 4. *Lakes*

Depressions filled with water on the surface of the land, and known as lakes, occur abundantly in the northern parts of both hemispheres, and more sparingly, but often of large size, in warmer latitudes. They do not belong to the normal system of erosion in which running water is the prime agent, and to which the excavation of valleys and ravines must be attributed. On the contrary, they are exceptional to that system, and the constant tendency of running water is to fill them up. Their origin, therefore, must be sought among some of the other geological processes. See part vii.

Lakes are conveniently classed as fresh or salt. Those which possess an outlet contain in almost all cases fresh water; those which have none are usually salt.

1. *Fresh-water Lakes.*—These, in a vast number of cases, are simply depressions or expansions of the valleys in which they lie. They receive a river at the upper end, together probably with many minor tributaries from the sides, and let the accumulated waters overflow at the lower end. In all these cases they act as filters for the river water, allowing its sediment to settle, and discharging it purified at the outflow, to continue its course of erosion and mud-making down the valley. A river which flows through a succession of lakes cannot carry much sediment to the sea, unless it has a long course to run after it has passed the lowest lake, and receives one or more muddy tributaries. But the sediment which would have reached the sea and gone to form a delta or deposit on the sea-bed serves its purpose in contributing to fill up the lakes. Hence it is rare to find any lake with an inflowing and outflowing river, where proofs of the gradual encroachment of the land upon the water may not be gathered.

In other cases lakes do not lie in the natural drainage lines of a country, but are scattered apparently at random over the surface, fed by springs, rains, and streamlets from the slopes, or, if of large size, lying as great basins, receiving the collected waters of a wide region, and forming in this way the source out of which full-formed rivers emerge. From the little tarns of Wales and the lochans of Scotland a series may be traced, through innumerable grades of size and form, in Scandinavia, Finland, and Canada, till we reach such vast sheets of inland water as Lakes Huron, Erie, and Superior, and the great equatorial lakes of Africa. In lakes of this kind also the process of filling up may often be traced. Each tributary stream pushes its delta into the water. Where the lakes are shallow, and lie in temperate countries, vegetation comes in to aid in the conversion of the water, first into marsh, then into peat-bog, and finally into dry ground. In Scotland during the last few centuries great changes of this kind have been going on.

On large lakes the wind throws the water into waves which almost rival those of the ocean in size and destructive power. Beaches, sand-dunes, shore-cliffs, and the other familiar features of the meeting line between land and sea reappear along the margins of such great fresh-water seas as Lake Superior.

Three geological functions of lakes are (1) to arrest and equalize the drainage by regulating the outflow and preventing or lessening the destructive effects of floods;[3] (2) to filter river water and permit of the undisturbed accumulation of new deposits, which in some modern cases may cover thousands of square miles of surface, and might attain a thickness of nearly 3000 feet (Lake Superior has an area of 32,000 square miles; Lago Maggiore is 2800 feet deep); (3) to furnish an abode for a lacustrine fauna and flora, to receive the remains of the plants and animals washed down from the surrounding country, and to entomb all these organisms in the growing deposits, so as to preserve a record of the terrestrial life of the period. The deposits in lakes consist of alternations of sand, silt, mud, and gravel, with occasional irregular seams of vegetable matter, and layers of calcareous marl formed from the accumulation of lacustrine shells, *Entomostraca*, etc. In a lake receiving much sediment there will be little or no marl formed, at least not during the time when the sediment is being deposited. In clear lakes, on the other hand, where there is very little sediment or where it only comes occasionally at wide intervals of flood, beds of white marl, formed entirely of organic remains, may gather on the bottom to a depth of many yards.

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[1] See an interesting article by Prof. Charles Martins on the Aigues-Mortes, in *Revue des Deux Mondes*, 1874, p. 780. The present writer accompanied the distinguished French geologist on the occasion of his visit to Ostia in the spring of 1873, and was much struck with the proofs of the rapidity of deposit in favorable situations. In the article just cited some valuable information is given regarding the progress of the delta of the Rhone in the Mediterranean.

[2] Hartley, *Min. of Proc. Inst. Civ. Engin.*, xxxvi. 216.

[3] Winds, by blowing strongly down the length of a lake, sometimes considerably increase for the time being the volume of the outflow. If this takes place coincidently with a heavy rainfall, the flood of the river is greatly augmented. These features are noticed in Loch Tay (D. Stevenson, *Reclamation of Land*, p. 14). Hence, though on the whole lakes tend to moderate floods in the outflowing rivers, they may by a combination of circumstances sometimes increase them.

2. *Salt Lakes* may be divided into two classes—(*a*) those which owe their saltness to the evaporation and concentration of the fresh water poured into them by their feeders; and (*b*) those which were originally parts of the ocean. Salt lakes of the first kind are abundantly scattered over the inland areas of drainage in the heart of continents, as in the great Lake of Utah, and numerous other minor lakes in North America, and the abundant salt lakes of the great plateau of Central Asia. These sheets of water were doubtless fresh at first, but they have progressively increased in salinity, because though the water is evaporated as fast as it is received, there is no escape for the dissolved salts, which consequently remain in the increasingly concentrated liquid. Salt lakes of the second class are comparatively few in number. In their case portions of the sea have been isolated by movements of the earth's crust, and these detached areas, exposed to evaporation, which is only partially compensated by inflowing rivers, have shrunk in level, and at the same time have sometimes grown much salter than the parent ocean. The Caspian Sea, 180,000 square miles in extent, and with a maximum depth of from 2000 to 3000 feet, is a magnificent example. The shells are chiefly the same as those still living in the Black Sea. Banks of them may be traced between the two seas, with salt lakes and marshes and other evidence to prove, not only that the Caspian was once joined to the main ocean, but that a great firth ran up between Europe and Asia, and possibly stretched completely across what are now the steppes and plains of the Tundras till it merged into the Arctic Sea. Even at present, by means of canals connecting the rivers Volga and Dwina, vessels can pass from the Caspian into the White Sea. But the surface of the Caspian is now more than 80 feet below that of the Black Sea. At present the amount of water supplied by rivers to the Caspian just balances that removed by evaporation, so that the level appears to be no longer sinking. But though, owing to the enormous volume of fresh water poured into it by these rivers, the Caspian is not as a whole so salt as the main ocean, and still less so than the Mediterranean, nevertheless the inevitable result of evaporation is there manifested. Along the shallow pools which border this sea a constant deposition of salt is taking place, forming sometimes a pan or layer of rose-colored crystals on the bottom, or gradually getting dry, and covered with drift sand. This concentration of the water is still more marked in the great offshoot called the Karaboghaz, which is connected with the middle basin of the Caspian by a channel 150 yards wide and 5 feet deep. Through this narrow mouth there flows from the main sea a constant current, which Von Baer estimated to carry daily into the Karaboghaz 350,000 tons of salt. An appreciable increase of the saltness of that gulf has been noticed: seals, which once frequented it, have forsaken its barren shores. Layers of salt are gathering on the mud at the bottom, and the sounding-line, when scarcely out of the water, is covered with saline crystals.[1] These facts furnish an illustration of the circumstances under which the rock-salt deposits in the New Red Sandstone and other geological formations were probably accumulated.

Proportion of Saline Materials in Waters of some Salt Lakes.

		Elton Lake, Kirghis Steppe, in Summer. (Erdmann.)	Indertsch Lake. (Göbel.)	Dead Sea. (C. G. Gmelin.)	Caspian Sea. (Göbel.)
Chloride of	Sodium........	7·4	23·9	7·1	0·3673
"	Magnesium .	16·3	1·7	11·8	0·0632
"	Calcium	.....	...	3·2	0·0013 Bicarb.mag.
"	Potassium....	.....	0·1	1·7	0·0076
"	Manganese ..	.....	...	0·2	...
"	Aluminium..	.....	...	0·1	...
Bromide of	Magnesium..	.....	...	0·4	... trace.
"	Potassium....	.....	...	...	...
Sulphate of	Calcium.......	.....	...	0·05	0·0490
"	Potassium ...	0·04	0·04	...	0·0171 Bicarb.lime.
"	Magnesium..	2·2	0·3	...	0·1239
Water..........................		73·5	73·8	74·5	99·3806
		99·44	99·84	99·05	100·0000

II. FRESH WATER IN THE SOLID STATE—ICE.

Fresh water under ordinary circumstances, when it reaches a temperature of 32° Fahr., passes into the solid state by crystallizing into ice. In this condition it performs a series of important geological operations before being again melted and relegated to the general mass of liquid terrestrial waters. Five conditions under which ice occurs on the land deserve notice, viz., frost, frozen rivers and lakes, hail, snow, and glaciers.

1. *Frost.*—Water in freezing expands. If it be confined in such a way that expansion is impossible, it remains liquid even at temperatures far below the freezing point; but the instant that the pressure is removed this chilled water becomes solid ice. There is a constant effort on the part of the water to become solid, and very considerable pressure is needed to counterbalance its expansive power. The lower the temperature the greater this exerted pressure becomes. At a temperature of 30° Fahr. the pressure must amount to 146 atmospheres, or the weight of a column of ice a mile high, or 138 tons on the square foot. Consequently when the water freezes at a lower temperature its pressure on the walls of its enclosing cavity must exceed 138 tons on the square foot. Bomb-shells and cannon filled with water and hermetically sealed have been burst in strong frosts by the expansion of the freezing water within them. It is easy to see, therefore, that we have here a geological agent of great potency. It is true that in nature the enormous pressures which can be obtained artificially occur rarely or not at all, because the spaces into which water penetrates can hardly ever be so securely closed as to permit the water to be cooled down very considerably below 32° Fahr. before freezing. Still ice forming at even two or three degrees below the freezing point exerts an enormous disruptive force.

Soils and rocks are all porous, and usually contain a good deal of moisture. When frost congeals this interstitial water, the particles of the soil or rock are pushed asunder by the expanding ice; their cohesion is loosened or destroyed, so that when a thaw comes, they seem as if they have been ground down in a mortar. Water lodges also in the numerous joints and crevices of rocks. Freezing there, it exerts great pressure upon the walls between which it lies, pushing them asunder as if a wedge were driven between them. When this ice melts, the separated masses do not return to their original position. Their centre of gravity in successive winters becomes more and more displaced, until the sundered masses fall apart. In mountainous districts, where the winters are severe, and in high latitudes, a great deal of waste is thus produced on exposed cliffs and loose blocks of rock. Some measure of its magnitude may be seen in the heaps of angular rubbish which in these regions are so frequently to be met with at the foot of crags and steep slopes. At Spitzbergen and on the coast of Greenland the amount of destruction caused by frost is enormous. The short and warm summer, melting the snow, fills the pores and joints of the rocks with water, which when it freezes splits off large blocks of rock from the hills, and sends them to the base of the declivities, where they are further broken up by the same cause.

2. *Frozen Rivers and Lakes.*—In countries where the winter temperature falls considerably below 32° Fahr., the lakes and rivers become solidly frozen over. The amount of geological change effected during the process is probably hardly appreciable. But when the ice breaks up in spring its power as a geological agent becomes apparent. In lakes, such as Lake Superior, the ice in forming encloses beach-pebbles and boulders, and when thaw sets in, floats these off, so as either to drop them in deeper water or to strand them on some other part of the coast. Should a gale arise during the breaking up of the ice, vast piles of the latter, with mingled gravel and boulders, may be driven ashore and pushed up the beach. By this means blocks of stone, even of considerable size, are sometimes forced to a great height inland on some of the Canadian lakes, tearing up the soil on their way, and helping to form a bank above the water level. It has been observed that during a severe frost ice occasionally forms on the bottoms of rivers where it encloses

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[1] Carpenter, *Journ Geog. Soc.*, vol. xviii., No. 4, quoting from Von Baer's "Kaspische Studien, "in *Bull. Acad. Sci. St. Petersburg*, 1855–6.

stones and large boulders. These are borne up to the surface in cakes of ground-ice to join the rest of the superficial ice-borne detritus. Great damage is frequently done to quays and bridges in Canada by masses of river-ice driven against them on the arrival of spring. Reference has already been made to the increased power of transport and erosion acquired by rivers liable to be frozen over, and especially when their ice is broken up in the higher parts of their courses, before it gives way in the lower.

3. *Hail.*—When rain or aqueous vapor is cooled down in the atmosphere to the freezing point of water, it is frozen, and falls to the earth as hail or snow. The formation of hail is not yet well understood. It is chiefly in summer and during thunderstorms that hail falls. When the pellets of ice are frozen together so as to reach the ground in lumps as large as a pigeon's egg, or larger, great damage is often done to cattle, flying birds, and vegetation. Trees have their leaves and fruit torn off, and farm crops are beaten down.

4. *Snow.*—In those parts of the earth's surface where, either from geographical position or from elevation into the upper cold regions of the atmosphere, the mean annual temperature is below the freezing point, the condensed moisture falls chiefly as snow, and remains in great measure unmelted throughout the year. A line can be traced below which the summer heat suffices to cause the disappearance of the snow, but above which the snow continues to cover the whole or great part of the surface. This line has received the name of the snow-line, or line of perpetual snow. It comes down to the sea within the polar circles. Between these limits it rises gradually in level till it reaches its highest elevation in tropical latitudes. In northern Scandinavia it is less than 3000 feet above the sea. None of the British mountains quite reach it. In the Alps it stands at 8500 feet, on the Andes at 18,000 feet, and on the northern slopes of the Himalayas at 19,000 feet.

Snow exhibits two different kinds of geological behavior, one conservative, the other destructive. Lying stationary and unmelted it exercises a protective influence on the face of the land, shielding rocks, soils, and vegetation from the effects of frost. On low grounds this is doubtless its chief function. When snow falls in a partially melted state it is apt to accumulate on branches and leaves, until by its weight it breaks them off, or even bears down entire trees. Snow which falls thickly on steep mountain slopes is frequently during spring and summer detached in large sheets. These rush down the declivities as *avalanches*, and often create much destruction of trees, soil, crops, and houses in their course. Another indirect effect of snow is seen in the sudden rise of the rivers when warm weather rapidly melts the mountain snows. Many summer floods are caused in this way in Switzerland.

5. *Glaciers.*—(1.) Nature and Origin.—A glacier is a river of ice formed by the slow movement and compression of the snow which by gravitation creeps downward into a valley descending from a snow-field. The structure and physics of glaciers are described elsewhere (see GLACIERS). From a geological point of view these ice-rivers may be regarded as the drainage of the snow-fall above the snow-line, as rivers are the drainage of the rainfall. In a mountainous region, such as the Alps, or a table-land like Scandinavia, where a considerable mass of ground lies above the snow-line, three varieties of glaciers have been observed. (*a.*) Glaciers of the first order, where the ice-river comes down well below the snow and extends into the valley, even it may be far below the upper limits of cultivation, or in northern region approaches or even reaches the sea. In the Alps such glaciers may be 20 or 30 miles long, by a mile or more wide, and 600 feet or more deep. (*b.*) Glaciers of the second order, which hardly creep beyond the high recesses wherein they are formed, and do not therefore reach as far as the nearest valley. Many beautiful examples of this type may be seen along the steep declivities which intervene between the snow-covered plateau of Arctic Norway and the sea. (*c.*) Re-cemented glaciers, consisting of fragments which fall from an ice-cliff crowning precipices of rock, and are re-frozen at the bottom into a solid mass, creeping downward as a glacier usually of the second order. Probably the best illustrations in Europe are furnished by the Nus Fjord, and other parts of the north of Norway. In some cases a cliff of blue ice appears at the top of the precipice,—the edge of the great "snee-fond," or snow-field, —while several hundred feet below, in the corrie or cwm at the bottom, lies the re-cemented glacier (*glacier remanié* of the Swiss), white at its upper edge, but acquiring somewhat of the characteristic blue gleam of compact ice as it moves towards its lower margin.

But it is in high Arctic, and still more in Antarctic, latitudes that land-ice, formed from the drainage of a great snow-field, attains its greatest dimensions. The land in these regions is completely buried under an ice-cap, which ranges in thickness up to a depth (in the South Polar circle) of 10,000 feet (2 miles) or even more. Greenland lies under such a pall of snow that all its inequalities, save the mere steep mountain peaks, are concealed. The snow creeping down the slopes, and mounting over the minor hills, passes beneath by pressure into compact ice. From the main valleys great glaciers like vast tongues of ice, 2000 or 3000 feet thick, and sometimes 50 miles or more in breadth, push out to sea, where they break off in huge fragments, which float away as icebergs.

A glacier, like a river, is always in motion, though so slowly that it seems to be solid and stationary. The motion also, like that of a river, and for the same reason, is unequal in the different parts, the centre moving faster than the sides and bottom. This important fact was first ascertained through accurate measurement by J. D. Forbes, who found that in the Mer de Glace of Chamouni, the mean daily rate of motion in the summer and autumn was from 20 to 27 inches in the centre, and from 13 to 19½ near the side. The consequence of this differential motion is seen in the arrangement of the lines of rubbish thrown down at the end of a glacier, which often present a horse-shoe shape, corresponding to that of the end of the ice by which they were discharged.

There are some features of geological importance also in the behavior of the ice as it descends its valley. When it has to travel over a very uneven floor, some portions may get embayed, while overlying parts slide over them. A massive ice-sheet may thus have many local eddies in its lower portions, the ice there even travelling for various distances, according to the nature of the ground, obliquely to the general flow of the main mass. In descending by a steep slope from an upper to a lower and more level part of its course, a glacier becomes a mass of fissured ice in great confusion. It descends by a slowly creeping ice-fall, where a river would shoot over in a rushing waterfall. A little below the fall the fractured ice is pressed together again into a solid mass as before. The body of the glacier throughout its length is traversed by a set of fissures called *crevasses*, which, though at first as close-fitting as cracks in a sheet of glass, widen by degrees as the glacier moves on, till they form wide yawning chasms, reaching, it may be, to the bottom of the ice, and travelling down with the glacier, but apt to be effaced by the pressing of their walls together again as the glacier winds down its valley. The glacier continues to descend until it reaches that point where the supply of ice is just equalled by the liquefaction. There it ends, and its place down the rest of the valley is taken by the tumultuous river of muddy water which escapes from under the melting extremity of the ice. A prolonged augmentation of the snow-fall will send the foot of the glacier further down the valley; a diminution of the snow-fall with a general rise of temperature will cause it to retreat farther up.

(2.) Work done by Glaciers.—Glaciers have two important geological tasks to perform,—(1) to carry the debris of the mountains down to lower levels; and (2) to erode their beds.

a. Transport.—This takes place chiefly on the surface of the glacier. Descending its valley, the glacier receives and bears along on its margin the earth, stones, and rubbish which, loosened by frost, or washed down by rain and rills, slip from the cliffs and slopes to the level of the ice. In this part of its work the glacier resembles a river which carries down branches and leaves from the woods on its banks. Most of the detritus rests on the surface of the ice. It includes huge masses of rock, sometimes as big as a large cottage, all which, though seemingly at rest, are slowly travelling down the valley with the ice, and liable at any moment to slip into the crevasses which may open below them. When they thus disappear they may descend to the bottom of the ice, and move with it along the rocky floor, which is no doubt the fate of the smaller stones and sand. But the large stones seem sometimes at least to be cast up again by the ice to the surface of the glacier at a lower part of its course. Whether, therefore, on the ice, in the ice, or under the ice, a vast quantity of detritus is continually travelling with the glacier down towards the plains. The rubbish lying on the surface is called *moraine* stuff. Naturally it accumulates on either side of the glacier, where it forms the so-called *lateral moraines.* When two glaciers unite, their two adjacent lateral moraines are brought together, and travel thereafter down the centre of the glacier as a *medial moraine.* A glacier, formed by the union of many tributaries in its upper parts, may have many medial lines of moraine, so many indeed as sometimes to be entirely covered with debris to the complete concealment of the ice. At such parts the glacier resembles a bare field or earthy plain rather than a solid mass of clear ice of which only the surface is dirty with rubbish. At the point where the glacier ends, the pile of loose materials is tumbled upon the valley in what is called the *terminal moraine.*

In such comparatively small and narrow ice-sheets as the present glaciers of Switzerland, the rock-bottom on which the ice moves is usually, as far as it can be examined, swept clean by the trickle or rush of water over it from the melting ice. But when the ice does not flow in a mere big drain (which, after all, the largest Alpine valley really is), but overspreads a wide area of uneven ground, there cannot fail to be a great accumulation of rubbish here and there underneath it. When the broad central plain of Switzerland between the Alps and the Jura was filled with ice, the latter certainly pushed a vast deal of mud, sand, and stones over the floor of the valley. This material is known to Swiss geologists as the *moraine profonde* or *Grundmoräne.*[1]

When from any cause a glacier diminishes in size, it may drop its blocks upon the sides of its valley, and leave them there sometimes in the most threatening positions. Such stranded stones are known as *perched blocks.* They abound in the Swiss valleys, extending even across the great plain of Switzerland, and appearing in numbers high upon the flanks of the Jura. Since the latter mountains consist chiefly of limestone, and the blocks are of various crystalline rocks belonging to the higher parts of the Alps, the proof of transport is irrefragable. The agent of removal is now recognized to have been an enormous extension of the glacier system of the Alps, whereby the whole country was buried under snow and ice. Similar evidence abounds in the valleys among the mountainous parts of Britain, as well as in other parts of Europe and America, no longer the abode of glaciers.

b. Erosion.—The manner in which glacier ice erodes its channel differs in many respects from that in use by any other geological agent, and forms therefore one of the distinguishing features of ice-action. This erosion is effected not by the mere contact and pressure of the ice upon the rocks, though undoubtedly fragments of rock must now and then be detached from this cause. It is by means of the fine sand, stones, and blocks of rock, which fall between the ice and the rocks on which it moves, that the grinding work of the glacier is done. These materials, held by the ice as it creeps along, are pressed against the rocky sides and bottom of the valley so firmly and persistently as to descend into each little hollow and mount over each ridge, yet all the while moving along steadily in one dominant direction with the general movement of the glaciers. As a result, the most compact resisting rocks are ground down, smoothed, polished, and striated. The striæ vary from such fine lines as may be made by the smallest grains of quartz up to deep ruts and grooves. They sometimes cross each other, one set partially effacing an older one, and thus pointing to shiftings in the movement of the ice. On the retirement of the glacier, hummocky bosses of rock having smooth undulating forms like dolphins' backs are conspicuous. These have received the name of *roches moutonnées.* The stones by which this scratching and polishing are effected suffer in exactly the same way. They are ground down and striated, and since they must move in the line of least resistance, or "end on," their striæ run in a general sense lengthwise. It will be seen, when we come to notice the traces of former glaciers, how important is the evidence given by these striated stones.

As rocks present great diversities of structure and hardness, and consequently vary much in the resistance they offer to denudation, they are necessarily worn down unequally. The softer, more easily eroded portions are scooped out by the grinding action of the ice, and basin-shaped or various irregular cavities are dug out below the level of the general surface. Similar effects may be produced by an augmented excavating power of a glacier, as where the ice is strangled in some narrow part of a valley, or where, from change in declivity, it is allowed to accumulate in greater mass as it moves more slowly onward. Such hollows, on the retirement of the ice, become receptacles for water, and form pools, tarns, or lakes, unless indeed they chance to have been already filled up with glacial rubbish. It is now some years since Professor A. C. Ramsay drew attention to this peculiar power of land-ice, and affirmed that the abundance of excavated rock-basins in northern Europe and America was due to the fact that these regions had been extensively eroded by sheets of land-ice. This glaciation was due not to independent glaciers but to the pressure and grinding power of vast masses of continental ice. In short the more northern parts of Europe and North America must have been in a condition like that of North Greenland at the present day. It is therefore among the ice-fields of Greenland rather than among the valley glaciers of isolated mountain-groups that we ought to look for analogies to the operations which produced the widespread general glaciation of the period of the rock-basins. A single valley-glacier retires towards its parent snow-field as the climate ameliorates, leaving its *roches moutonnées,* moraine-mounds, and rock-basins, yet at times discharging its water-drainage in such a way perhaps as to sweep down the moraine-mounds, fill up the basins, bury the ice-worn hummocks of rock, and strew the valley with gravel, earth, sand, and big blocks of rock. Hence the actual floor of the glacier is apt to be very much obscured. But in the case of a vast sheet of land-ice covering continuously a wide region, there can be but little superficial debris. When such a mass of ice retires it must leave behind it an ice-worn surface of country more or less strewn with the subsoil which accumulated under the ice and was pushed along by it. This infra-glacial detritus forms the *Grundmoräne* (*moraine profonde*) or bottom moraine. We know as yet very little regarding its formation in Greenland. Most of our knowledge regarding it is derived from a study of the till or boulder-clay of Britain, which is believed to represent the bottom moraine of an ancient ice-sheet. In countries where true boulder-clay occurs, numerous rock-basins are commonly to be met with among the uncovered portions of the rocks.

The abundant fine sediment which gives the characteristic milky turbidity to all streams that escape from the melting ends of glaciers is an index of the amount of erosion unceasingly effected by the ice. From the end of the Aar glacier, for example, though by no means one of the largest in Switzerland, it has been estimated that there escape every day in the month of August 2 million cubic metres (440 million gallons) of water, containing 284,374 kilogrammes (280 tons) of sand.

B. OCEANIC WATERS.

The area, depth, temperature, density, and composition of the sea have been already treated of in part ii. Viewed as a dynamical agent in geology, the ocean may be studied under two aspects—(1) its movements, and (2) its geological work.

I. MOVEMENTS OF THE OCEAN.

These may be grouped as—(1) tides, (2) currents, and (3) waves.

1. *Tides.*—These are oscillations of the mass of the oceanic waters caused by the attraction of the sun and moon. We have at present to deal with them merely in so far as their geological bearings are concerned. In a wide deep ocean the tidal elevation probably produces no perceptible geological change. It passes at a great speed; in the Atlantic its rate is 500 geographical miles an hour. But as this is merely the passing of an oscillation whereby the particles of water are gently raised up and let down again, there can hardly be any appreciable effect upon the deep ocean bottom. When, however, the tidal wave enters a narrow and shallow sea, it has to accommodate itself to a smaller channel, and encounters more and more the friction

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[1] The present writer examined in 1869 a characteristic section of it near Solothurn, full of scratched stones, and lying on the striated pavement of rock to be immediately described as further characteristic of ice-action.

of the bottom. Hence, while its rate of motion is diminished, its height and force are increased. It is in shallow water and along the shores of the land that the tides acquire their main geological importance. They there show themselves in an alternate advance upon and retreat from the coast. Their upper limit has received the name of *high-water mark*, their lower that of *low-water mark*, the space between being termed the *beach*. If the coast is precipitous, a beach can only occur in the shelving bays and creeks, since elsewhere the tides will rise and fall against a face of rock, as they do on the piers and bulwarks of a port. On such rocky coasts the line of high water is sometimes admirably defined by the grey crust of barnacles adhering to the rocks. Where the beach is flat, and the rise and fall of the tide great, an area of several hundred square miles of sand or mud may be laid bare in one bay at low-water.

The height of the tide varies from zero up to 60 or 70 feet. It is greatest where, from the form of the land, the tidal wave is cooped up within a narrow inlet or estuary. Under such circumstances the advancing tide sometimes gathers itself into one or more large waves, and rushes furiously up between the converging shores. This is the origin of the "bore" of the Severn, which rises to a height of 9 feet, while the rise and fall of the tide there amounts to 40 feet. In like manner the tides which enter the Bay of Fundy, between Nova Scotia and New Brunswick, get more and more cooped up as they ascend that strait, till they reach a height of 70 feet.

While the tidal swelling is increased in height by the shallowness and convergence of the shores, it gains at the same time force and rapidity. No longer a mere oscillation or pulsation of the great ocean, the tide acquires a true movement of translation, and gives rise to currents which rush past headlands and through narrows in powerful currents and eddies. The rocky and intricate navigation of the west of Scotland and Scandinavia furnishes many admirable illustrations of the rapidity of these tidal currents. The famous whirpool of Corryvreckan, the lurking eddies in the Kyles of Skye, the breakers at the Bore of Duncansbay, and the tumultuous tideway, grimly named by the northern fishermen the Merry Men of Mey, in the Pentland Firth, bear witness to the strength of these sea rivers. At the last-mentioned strait the current at its strongest runs at the rate of 10 miles an hour, which is fully three times the speed of most of our larger rivers.

2. *Currents.*—Recent researches in ocean temperature have disclosed the remarkable fact that beneath the surface layer of water affected by the temperature of the latitude there lies a vast mass of cold water, the bottom temperature of every ocean in free communication with the poles being little above and sometimes actually below the freezing point of fresh water. In the North Atlantic a temperature of 40° Fahr. is reached at an average depth of about 800 fathoms, all beneath that depth being progressively colder. In the equatorial parts of the same ocean the same temperature comes to within 300 fathoms of the surface. In the South Atlantic, off Cape of Good Hope, the mass of cold water (below 40°) comes likewise to about 300 fathoms from the surface. This distribution of temperature proves that there must be a transference of cold polar water towards the equator, for in the first place the temperature of the great mass of the ocean is much lower than that which is normal to each latitude, and in the second place it is lower than that of the superficial parts of the earth's crust underneath. On the other hand, the movement of water from the poles to the equator requires a return movement of compensation from the equator to the poles, and this must take place in the superficial strata of the ocean. Apart therefore from those rapid river-like streams which traverse the ocean, and to which the name of currents is given, there must be a general drift of warm surface water towards the poles. This is doubtless most markedly the case in the North Atlantic, where besides the current of the Gulf-stream there is a prevalent set of the surface waters towards the north-east. As the distribution of life over the globe is everywhere so dependent upon temperature, it becomes of the highest interest to know that a truly arctic submarine climate exists everywhere in the deeper parts of the sea. With such uniformity of temperature we may anticipate that the abyssal fauna will be found to possess a corresponding sameness of character, and that arctic types may be met with even on the ocean-bed at the equator.

But besides this general drift or set, a leading part in oceanic circulation is taken by the more defined streams termed currents. The tidal wave only becomes one of translation as it passes into shallow water, and is thus of but local consequence. But a vast body of water, known as the Equatorial Current, moves in a general westerly direction round the globe. Owing to the way in which the continents cross its path, this current is subject to considerable deflexions. Thus that portion which crosses the Atlantic from the African side strikes against the mass of South America and divides, one portion turning towards the south and skirting the shores of Brazil, the other bending north-westward into the Gulf of Mexico, and issuing thence as the well-known Gulf-stream. This equatorial water is comparatively warm and light. At the same time the heavier and colder polar water moves towards the equator, sometimes in surface currents like those which skirt the eastern and western shores of Greenland, but more generally as a cold under-current which creeps over the floor of the ocean even as far as the equator.

Much discussion has arisen in recent years as to the cause of oceanic circulation. Two rival theories have been given. According to one of these the circulation entirely arises from that of the air. The trade-winds blowing from either side of the equator drive the water before them until the north-east and south-east currents unite in equatorial latitudes into one broad westerly-flowing current. Owing to the form of the land portions of this main current are deflected into temperate latitudes, and, as a consequence, portions of the polar water require to move towards the equator to restore the equilibrium. According to the other view the currents arise from differences of temperature (and according to some, of salinity also); the warm and light equatorial water is believed to stand at a higher level than the colder and heavier polar water; the former, therefore, flows down as it were polewards, while the latter moves as a bottom inflow towards the equator; the cold bottom water under the tropics is constantly ascending to the surface, whence, after being heated, it drifts away towards the pole, and on being cooled down there, descends and begins another journey to the equator. There can be no doubt that the winds are directly the cause of such currents as the Gulf-stream, and therefore, indirectly, of return cold currents from the polar regions. It seems hardly less certain that, to some extent at least, differences of temperature, and therefore of density, must occasion movements in the mass of the oceanic waters. The discussion of this subject, however, belongs to another part of this work.[1] The main facts for the geological reader to grasp are—that a system of circulation exists in the ocean; that warm currents move round the equatorial regions, and are turned now to the one side now to the other by the form of the continents along and round which they sweep; that cold currents set in from poles to equator; and that apart from actual currents, there appears to be an extremely slow "creep" of the polar water under the warmer upper layers towards the equator.

3. *Waves and Ground-Swell.*—A gentle breeze curls into ripples the surface of water over which it blows. A strong gale or furious storm raises the surface into waves. The agitation of the water in a storm is prolonged to a great distance beyond the area of the original disturbance, and then takes the form of the long heaving undulations termed ground-swell. Waves which break upon the land are called breakers, and the same name is applied to the ground-swell as it bursts into foam and spray upon the rocks. The concussion of earthquakes sometimes gives rise to very disastrous earthquake-waves, as already explained.

The height and force of waves depend upon the breadth and depth of sea over which the wind has driven them, and the form and direction of the coast-line. The longer the "fetch," and the deeper the water, the higher the waves. A coast directly facing the prevalent wind will have larger waves than a neighboring shore which presents itself at an angle to this wind or bends round so as to form a lee-shore. The highest waves in the narrow British seas probably never exceed 15 or 20 feet, and usually fall short of that amount. The greatest height observed by Dr. Scoresby among the Atlantic waves was 43 feet.[1]

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[1] The reader may consult Maury's *Physical Geography of the Sea*, but more particularly Dr. Carpenter's papers in the *Proceedings of the Royal Society* for 1869–73, and *Journal of R. Geographical Society* for 1871–77, on the side of temperature; and Herschel's *Physical Geography*, and Dr. Croll's *Climate and Time*, on the side of the winds.

Ground-swell propagated across a broad and deep ocean produces by far the most imposing breakers. So long as the water remains deep and no wind blows, the only trace of the passing ground-swell on the open sea is the huge broad heaving of the surface. But when the water shallows, the superficial part of the swell travelling faster than the bottom begins to curl and crest as a huge billow or wall of water, which finally bursts with enormous force against the shore. Such billows, even when no wind is blowing, often cover the cliffs of the north of Scotland with sheets of water and foam up to heights of 100 or even nearly 200 feet. At Dunnet Head during north-westerly gales the windows of the lighthouse, at a height of upwards of 300 feet above high-water mark, are said to be sometimes broken by stones swept up the cliffs by the sheets of sea water which then deluge the building.

A single roller of the ground-swell 20 feet high falls, according to Mr. Scott Russell, with a pressure of about a ton on every square foot. Mr. Thomas Stevenson conducted some years ago a series of experiments on the force of the breakers on the Atlantic and North Sea coasts of Britain. The average force in summer was found in the Atlantic to be 611 ℔ per square foot, while in winter it was 2086 ℔, or more than three times as great. But on several occasions, both in the Atlantic and North Sea, the winter breakers were found to exert a pressure of three tons per square foot, and at Dunbar as much as three tons and a half.[2] Besides the waves produced by ordinary wind action, others of an extraordinary size and destructive power are occasionally caused by a violent cyclone storm. The mere diminution of atmospheric pressure in a cyclone must tend to raise the level of the ocean within the cyclone limits. But the further furious spiral in-rushing of the air towards the centre of the low pressure area drives the sea onward, and gives rise to a wave or succession of waves having great destructive power. Thus, on 5th October, 1864, during a great cyclone which passed over Calcutta, the sea rose in some places 24 feet, and swept everything before it with irresistible force, drowning upwards of 48,000 people.

4. *Ice on the Sea.*—In this place may be most conveniently noticed the origin and movements of the ice which in circumpolar latitudes covers the sea. This ice is derived from two sources—(1) the freezing of the sea itself, and (2) the seaward prolongation of land-ice.

1. Three chief types of sea-ice have been observed. (*a.*) In the Arctic sounds and bays the littoral waters freeze along the shores and form a cake of ice which, upborne by the tide and adhering to the land, is thickened by successive additions below, as well as by snow above, until it forms a shelf of ice 120 to 130 feet broad and 20 or 30 feet high. This shelf, known as the ice-foot, serves as a platform on which the abundant debris loosened by the severe frosts of an arctic winter gathers at the foot of the cliffs. It is more or less completely broken up in summer, but forms again with the early frosts of the ensuing autumn. (*b.*) The surface of the open sea likewise freezes over into a continuous solid sheet which in summer breaks up into separate masses sometimes of large extent. This is what navigators term *floe-ice*, and the separate floating cakes are known as *floes.* Ships fixed among these floes have been drifted with the ice for hundreds of miles until at last liberated by its disruption. (*c.*) In the Baltic Sea, off the coast of Labrador and elsewhere, ice has been observed to form on the sea-bottom. It is known as ground-ice or anchor ice. In the Labrador fishing-grounds it forms even at considerable depths. Seals caught in the lines at those depths are brought up sometimes solidly frozen.

2. In the Arctic regions the vast glaciers which drain the snow-fields and descend to the sea extend for some distance from the land until large fragments break off and float away seawards. These detached masses are icebergs. Their shape and size greatly vary, but lofty peaked forms are common, and they sometimes rise from 200 to 300 feet above the level of the sea. As only about a ninth part of the ice appears above water, these larger bergs must sometimes be from 2000 to 3000 feet thick from base to top. They consequently require water of some depth to float them, but they are often seen aground. In the Antarctic regions, where one vast sheet of ice envelopes the land and extends into the sea as a high rampart of ice, the detached icebergs often reach a great size, and are characterized by the frequency of a flat tabular form.

II. GEOLOGICAL WORK OF THE SEA.

I. INFLUENCE ON CLIMATE.—Were there no agencies in nature for distributing temperature, there would be a regular and uniform diminution in the mean annual temperature from equator to poles, and the *isothermal* lines, or lines of equal heat, would coincide with lines of latitude. But no such general correspondence actually exists. If we look at a chart of the globe with the isothermal lines drawn across it, we shall find that their divergences from the parallels are striking, and most so where they approach and cross the ocean. Currents from warm regions raise the temperature of the tracts into which they flow; those from cold regions lower it. The ocean, in short, is the great distributor of temperature over the globe. As an illustration the two opposite sides of the Atlantic may be taken. The cold arctic current flowing southward along the north-east coast of America reduces the mean annual temperature of that region. On the other hand, the Gulf-stream brings to the shores of the north-west of Europe a temperature much above what they would otherwise enjoy. Dublin and the south-eastern headlands of Labrador, lie in the same parallel of latitude, yet differ as much as 18° in their mean annual temperature, that of Dublin being 50°, and that of Labrador 32° Fahr. Dr. Croll has calculated that the Gulf-stream conveys nearly half as much heat from the tropics as is received from the sun by the entire Arctic regions.[3]

II. EROSION.—The chemical action of the sea upon the rocks of its bed and shores has not yet been properly studied.[4] It is evident, however, that changes analogous to those effected by fresh water on the land must be in progress. Oxidation, and the formation of carbonates, no doubt continually take place. We may judge indeed of the nature and rapidity of some of these changes by watching the decay of stones and material employed in the construction of piers. At the Bell Rock light-house, twenty-five different kinds and combinations of iron were exposed to the action of the sea, and all yielded to corrosion. Mr. Mallet—as the result of experiments with specimens sunk in the sea—concluded that from $\frac{2}{10}$ths to $\frac{4}{10}$ths of an inch in depth in iron castings 1 inch thick, and about $\frac{6}{10}$ths of an inch of wrought iron, will be destroyed in a century in clear salt water. Mr. Stevenson, in referring to these experiments, remarks that he has in his possession specimens of iron which show even a more rapid rate of decay. In castings used at the Bell Rock the loss has been at the rate of an inch in a century. "One of the bars which was free from air holes had its specific gravity reduced to 5·63, and its transverse strength from 7409 to 4797 ℔, and yet presented no external appearance of decay. Another apparently sound specimen was reduced in strength from 4068 ℔ to 2352 ℔, having lost nearly half its strength in fifty years."[5] Similar results were recently observed by Mr. Grothe, resident engineer at the railway bridge across the Firth of Tay. A cast-iron cylinder which had been below water for only sixteen months was found to be so corroded that a penknife could be stuck through it in many places.

An examination of the shore will sometimes reveal a good deal of quiet chemical change on the outer crust of rocks exposed to the waves. Such rocks as basalt have their felspar decomposed, and show the presence of carbonates by effervescing briskly with acid. One of their minerals, augite, is occasionally replaced by *pseudomorphs* of carbonate of iron.

It is mainly by its mechanical action that the sea accomplishes its erosive work. This can only take place where the water is in motion, and, other things being equal, is greatest where the motion is strongest. Hence we cannot suppose that erosion to any appreciable extent can be effected in the abysses of the sea, where the only motion possible is that slow creeping of the polar water along the bottom already referred to. But where the currents are powerful enough to move grains of sand and gravel, very slow erosion may take place even at considerable depths. It is in the upper portions of the sea, however, where, owing to currents, tides, and waves, the water suffers most disturbance, that the main mechanical erosion goes on. The depth to which the influence of waves and ground-swell may extend seems to vary greatly according to the situation. The astronomer-royal states that ground-swell may break in 100 fathoms water.[1] It is common to find boulders and shingle disturbed at a depth of 10 fathoms, and even driven from that depth to the shore, and waves may be noticed to become muddy from the working up of the silt at the bottom when they have reached water of 7 or 8 fathoms in depth.[2] Gentle movement of the bottom water is said to be sometimes indicated by ripple-marks on the fine sand of the sea-floor at a depth of 600 feet. A good test for the absence of serious abrasion is furnished by the presence of fine mud on the bottom. Wherever that is found, we may be tolerably sure that the bottom at that place lies beyond the reach of ordinary breaker action.[3] From the upper limit at which the accumulation of mud is possible to high-water mark, and in exposed places up to 100 feet or more above high-water mark, lies the zone within which the sea does its work of abrasion. To this zone, even where the breakers are heaviest, a greater extreme vertical range can hardly be assigned than 300 feet, and in most cases it probably falls far short of that extent.

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[1] *Brit. Assoc. Rep.*, 1850, p. 26. The reader will find a table of the observed heights of waves round Great Britain in Mr. T. Stevenson's treatise on *Harbors*, p. 20.

[2] *Trans. Roy. Soc. Edin.*, xvi. 25; treatise on *Harbors*, p. 42.

[3] See papers by Dr. Croll on "Gulf-stream and Ocean-currents," in *Geol. Mag.* and *Phil. Mag.* for 1869, 1870–74, and *Climate and Time.*

[4] See Bischof's *Chemical Geology*, vol. i. chap. vii.

[5] T. Stevenson on *Harbors*, p. 47.

The mechanical work of erosion by the sea is done in four ways:—(1) the enormous force of the breakers suffices to tear off fragments of the solid rocks; (2) the alternate compression and expansion of the air in the crevices of rocks exposed to heavy breakers dislocates rocks even above the limits of wave-action; (3) the hydraulic pressure of those portions of large waves which enter fissures and cavities forces asunder masses of rock; (4) the waves make use of the loose fragments within their reach in battering down the cliffs exposed to their fury.

(1.) Abundant examples of the dislodgment of huge blocks of rock from their parent masses are furnished by the precipitous shores of Caithness, and of the Orkney and Shetland Islands. It sometimes happens that demonstration of the height to which the effective force of breakers may reach is furnished at lighthouses built on exposed parts of the coast. Thus, at Unst, a door was broken open at a height of 195 feet above the sea, and at the Bishop Rock lighthouse a bell was wrenched off at a level of 100 feet above high-water mark.[4] Some of the most remarkable instances of the power of breakers have been observed by Mr. Thomas Stevenson among the islands of the Shetland group. On the Bound Skerry he found that blocks of rock up to 9½ tons in weight had been washed together at a height of nearly 60 feet above the sea, that blocks weighing from 6 to 13½ tons had been actually quarried out of their original bed, at a height of from 70 to 75 feet, and that a block of nearly 8 tons had been driven before the waves at the level of 20 feet above the sea, over very rough ground, to a distance of 73 feet (figs. 7 and 8). He likewise records the moving of a 50-ton block by the waves at Barrahead, in the Hebrides.[5] At Plymouth also, blocks of several tons in weight have been known to be washed about the breakwater like pebbles.[6]

Fig. 7.

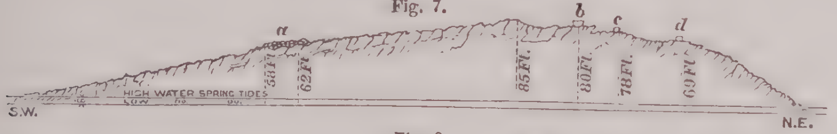
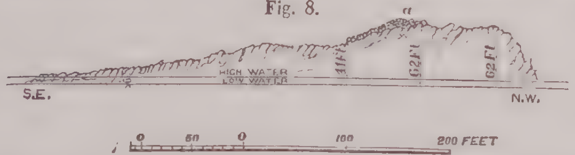


Fig. 8.



Figs. 7 and 8.—Sections of the Bound Skerry of Whalsey, Shetland (from Stevenson's *Harbors*, p. 32); *a*, *b*, *c*, and *d*, positions of blocks moved by the sea.

(2.) But, besides their mechanical force, waves acquire a singular and most effective aid from the air. It is a fact familiar to engineers that, even from a vertical and apparently perfectly solid wall of well-built masonry exposed to heavy seas, stones will sometimes be started out of their places, and that when this happens a rapid enlargement of the cavity may be effected, as if the walls were breached by a severe bombardment. At the Eddystone lighthouse, during a storm in 1840, a door which had been securely fastened against the force of the surf from without, was actually driven outward by a pressure acting from within the tower, in spite of the strong bolts and hinges, which were broken. We may infer that, by the sudden sinking of a mass of water hurled against the building, a partial vacuum was formed, and that the air inside forced out the door in its efforts to restore the equilibrium.[7] This explanation may partly account for the way in which the stones are started from their places in a solidly built sea-wall. But besides this cause we must also consider a perhaps still more effective one in the condensation of the air driven before the wave between the joints and crevices of the stones, and its subsequent instantaneous expansion when the wave drops. During gales when large waves are driven to shore, many tons of water are poured suddenly into each cleft and cavern within reach. These volumes of water, as they rush in, compress the air into every joint and pore of the rock at the further end, and then quickly retiring, exert such a suction as from time to time to bring down part of the walls or roof. The sea may thus gradually form an inland passage for itself to the surface above, in a "blow-hole" or "puffing-hole," through which spouts of foam and spray are in storms shot high into the air. On the more exposed portions of the west coast of Ireland numerous examples of such blow-holes occur. In Scotland, likewise, they may often be observed, as in the Bullers (boilers) of Buchan on the coast of Aberdeenshire, and the Geary Pot near Arbroath. Magnificent instances occur among the Orkney and Shetland Islands, some of the more shattered rocks of these northern coasts being, as it were, honeycombed by sea-tunnels, many of which open up into the middle of fields or moors.

(3.) The sea-water which, as part of an inrushing wave, fills the gullies and chinks of the shore-rocks exerts the same pressure upon the walls between which it is confined as the rest of the wave is doing upon the face of the cliff. Each cleft so circumstanced becomes a kind of hydraulic press, the potency of which is to be measured by the force with which the waves fall upon the rocks outside—a force which often amounts to three tons on the square foot. There can be little doubt that by this means considerable pieces of a cliff are from time to time dislodged.

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[1] *Encyclopædia Metropolitana*, art. "Waves."

[2] T. Stevenson on *Harbors*, p. 15.

[3] *Ibid.*

[4] *Ibid.*, p. 31.

[5] *Ibid.*, pp. 21–37.

[6] The reader will bear in mind that the specific gravity of bodies is greatly reduced when in water, and still more in sea-water. The following examples will illustrate this fact (Stevenson on *Harbors*, p. 107):—

	Spec. Grav.	No. of cub. feet to a ton in air.	No. of feet to a ton in sea-water of sp. grav. 1·028.
Basalt...........	2·99	11·9	18·26
Red granite..............	2·71	13·2	21·30
Sand Stone..............	2·41	14·8	26·00
Cannel coal..............	1·54	23·3	70·00

[7] Walker, *Proc. Inst. Civ. Engin.*, i. 15; Stevenson's *Harbors*, p. 10.

(4.) But probably by far the largest amount of erosion accomplished by the sea is due not to its own direct mechanical impetus, but to the blows dealt by the boulders, gravel, or sand which it hurls against the shores. This action was aptly compared by Playfair to a kind of artillery.[1] During a storm upon a shingly coast we may hear, at a distance of several miles, the grind of the stones against each other, as they are dragged back by the recoil of the waves which had launched them forward. In this tear and wear the loose stones are ground smaller, and acquire the smooth round form so characteristic of a surf-beaten beach. At the same time they bruise and wear down the solid cliffs against which they may be driven. Wherever the rock is much jointed, or from any cause presents less resistance to attack, it is excavated into gullies, creeks, and caves; its harder parts standing out as promontories are pierced; gradually a series of detached buttresses and sea-stacks appears as the cliff recedes, and these in turn are wasted until they become mere skerries and sunken surf-beaten reefs. Of this progress of destruction the more exposed parts of the British coast-line furnish many admirable examples. The west coast of Ireland, exposed to the full swell of the Atlantic, is in innumerable localities completely undermined by caverns, into which the sea enters from both sides. In many places the cliffs are as vertical as walls, this feature depending upon their joints, which enable slice after slice to be undermined and removed. The precipitous coasts of Skye, Sutherland, Caithness, Forfar, Kincardine, and Aberdeenshire abound in the most impressive lessons of the waste of a rocky sea-margin; while the same picturesque features are prolonged into the Orkney and Shetland Islands, the magnificent cliffs of Hoy towering as a vast wall some 1200 feet above the Atlantic breakers, which are tunnelling and fretting their base.

If such is the progress of waste where the materials consist of the most solid rocks, we may expect to meet with at least equally impressive proofs of decay where the coast-line can oppose only soft sand or clay to the march of the breakers. Again, the geological student in Britain can examine for himself many illustrations of this kind of destruction around the shores of these islands. Within the last few hundred years entire parishes with their towns and villages have been washed away, and the tide now ebbs and flows over districts which in old times were cultivated fields and cheerful hamlets. The coast of Yorkshire between Flamborough Head and the mouth of the Humber, and also that between the Wash and the mouth of the Thames, suffer at a specially rapid rate, for the cliffs in these parts consist in great measure of soft clay. In some places this loss is said to amount to 3 feet per annum.

While investigating the proofs of decay along the shore, the geologist endeavors to ascertain to what extent the action of the waves is assisted by that of rain, springs, frosts, and general atmospheric disintegration. He often finds that the progress of the waves depends not so much upon their own labors as upon those of the terrestrial agencies already described. A crumbling cliff, battered and wasted by the breakers, will yield to him abundant evidence of the manner in which the other agents of destruction prepare the way for its final demolition and removal by the sea; and he will learn that the very blocks of stone which give the waves so much of their efficacy are in great measure furnished to them by these co-operating agents. If the cutting back of a cliff were mainly the work of the sea, we ought to find the cliff overhanging, because the sea acts only at its base. But the fact that in the vast majority of cases sea-cliffs, instead of overhanging, slope backward, at a greater or less angle, from the sea, shows that the waste from subaerial action is really greater than that from the action of the breakers. What the sea chiefly does is to break down and wash away the rubbish that falls from the cliffs, and thus to leave an ever fresh surface for renewed denudation.

(5.) Among the erosive operations of the sea must be included what is performed by floating ice. Along the margin of arctic lands a good deal of work is done by the broken up floe-ice and ice-foot. These cakes of ice, driven ashore by storms, tear up the soft shallow-water or littoral deposits, rub and scratch the rocks, and push gravel and blocks of rock before them as they strand on the beach. Icebergs also, when they get aground in deep water, must greatly disturb the sediment accumulating there, and must grind down any submarine rock on which they grate as they are driven along.

The general result of the erosive action of the sea on the land is the production of a submarine plain. As the sea advances by cutting slice after slice away from the coast, successive lines of beach pass under low-water mark. The whole of the littoral belt, as far down as wave action has influence, is continually being ground down by the moving detritus. If no change of level between sea and land should take place, the sea might conceivably eat its way slowly far into the land, and produce a gently sloping yet almost horizontal selvage of plain covered permanently by the waves. In such a submarine plain the influence of geological structure, and notably of the relative powers of resistance of different rocks, would make itself conspicuous. The present promontories caused by the superior hardness of their component rocks would no doubt be represented by ridges on the subaqueous plateau, while the existing bays and creeks worn out of softer rocks would be marked by lines of valleys or hollows.

III. Transport.—The sea by means of its surface-drifts and currents carries sedimentary material to great distances and strews them over its floor. Near land, where the movements of the water are active, much coarse detritus is transported along shore or swept farther out to sea. A prevalent wind, by creating a current in a given direction along a coast-line, will cause the shingle to travel coastwise, the stones getting more and more rounded and reduced in size as they recede from their sources. The Chesil Bank, which runs as a natural breakwater 16 miles long connecting the Isle of Portland with the mainland of Dorsetshire, consists of rounded shingle which is constantly being driven westwards. On the Moray Firth the reefs of quartz-rock about Cullen furnish abundance of shingle, which moves westwards along the coast for more than 15 miles. The coarser sediment probably seldom goes much beyond the littoral zone. Fine gravel, however, is pushed along the bottom by currents even at 600 fathoms; for at that depth in the North Atlantic between the Faroe Islands and Scotland small pebbles of volcanic and other rocks are dredged up which have probably been carried by an arctic under-current from the north. At greater depths the force of currents at the bottom must be too feeble to push along any detritus. But much fine sediment is carried in suspension by the sea for long distances from land. Some rivers, as the Amazon, pour so much silt into the sea as to discolor its water for several hundred miles away from land. After wet weather the coast-waters round the shores of the British Islands are sometimes made turbid from the quantity of mud brought down from the land. Dr. Carpenter found the bottom waters of the Mediterranean to be everywhere permeated by an extremely fine mud, derived no doubt from the rivers and shores of that sea, borne away out far from land, and settling slowly down upon the bottom. He remarks that the characteristic blueness of the Mediterranean may be explained, like that of the Lake of Geneva (as shown by Dr. Tyndall), by the diffusion of those exceedingly minute sedimentary particles through the water.

But the most startling evidence of the wide extent to which transport takes place in the ocean is that supplied by the observations made during the voyage of the "Challenger." From the abysses of the Pacific Ocean, at the furthest distances from land, the dredge brought up bushels of rounded pieces of pumice of all sizes up to blocks a foot in diameter. These fragments were all evidently water-worn, and almost certainly were derived from the land. Some small pieces indeed were taken on the surface in the townet. Round volcanic islands, and off the coasts of volcanic tracts of the mainland, the sea is sometimes covered with floating pieces of water-worn pumice swept out by flooded rivers. These fragments drift away for hundreds or even thousands of miles until, becoming water-logged, they sink to the bottom. Their universal distribution was one of the most noticeable features in the dredgings of the "Challenger." The clay which is found on the bottom of the ocean at the greatest distances from any shore may be partly due to its transport in that condition from land, but more probably to the decomposition of the drifted pumice.[2]

Another not unimportant process of marine transport is that performed by floating ice. Among the arctic glaciers moraine stuff is of rare occurrence; but occasional blocks of rock and heaps of earth and stones fall from the cliffs which rise above the general waste of snow. Hence on the icebergs that float off from these glaciers, rock debris sometimes may be observed. It is transported southward for hundreds of miles until, by the shifting or melting of the bergs, it is dropped into deep water. The floor of certain portions of the North Atlantic in the pathway of the bergs must be plentifully strewn with this kind of detritus. By means of the ice-foot also, an enormous quantity of earth and stones is every year borne away from the shore as the ice breaks up, and strewn over the floor of the sounds, bays, and channels.

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[1] *Illustrations of the Huttonian Theory*, sec. 97.

[2] Murray, *Proc. Roy. Soc. Edin.*, 1876–7, p. 247.

IV. Reproduction.—The sea being the receptacle for the material worn away from the land must receive and store up in its depths all that vast amount of detritus by the removal of which the level and contours of the land are in the course of time so greatly changed. The deposits which take place within the area covered by the sea may be divided into two groups—the inorganic and organic. It is the former with which we have at present to deal; the latter will be discussed with the other geological functions of plants and animals. The inorganic deposits of the sea-floor are partly (*a*) land-derived or terrigenous, partly (*b*) abyssal.

(*a.*) *Land-derived or Terrigenous.*—These may be conveniently grouped according to their relative places on the sea-bed.

(1.) Shore Deposits.—The most conspicuous and familiar are the layers of gravel and sand which accumulate between tide-marks. As a rule, the coarse materials are thrown up about the upper limit of the beach. They seem to remain stationary there; but if watched and examined from time to time they will be found to be continually shifted by high tides and storms, so that the bank or bar of shingle retains its place though its component pebbles are being constantly moved. Below the limit of coarse shingle upon the beach lies the zone of fine gravel, and then that of sand. These zones are far from being constant; yet when they all occur on the same beach, they tend to range themselves according to their relative coarseness, the rougher detritus lying at the upper, and the finer towards the lower edge of the shore. The nature of the littoral accumulations on any given part of a coast-line must depend either upon the character of the shore-rocks which at that locality are broken up by the waves, or upon the set of the shore-currents and the kind of detritus they bear with them. Coasts exposed to heavy surf, especially where of a rocky character, are apt to present beaches of coarse shingle between their projecting promontories. Sheltered bays, on the other hand, where wave action is comparatively feeble, afford a gathering ground for fine sediment such as sand and mud. Estuaries and inlets into which rivers enter frequently show wide muddy flats at low water. The mud brought down by the fresh water is allowed to sink to the bottom when the motion of the current is checked as it enters the sea.

(2.) Infra-Littoral and Deeper-Water Deposits.—These extend from below low-water mark to a depth of sometimes as much as 2000 fathoms, and reach a distance from land varying up to 200 miles or even more. Near land, and in comparatively shallow water, they consist of banks or sheets of sand more rarely mixed with gravel. The bottom of the North Sea, for example, which between Britain and the continent of Europe lies at a depth never reaching 100 fathoms, is irregularly marked by long ridges of sand enclosing here and there hollows where mud has been deposited. In the English Channel large banks of gravel extend through the Straits of Dover as far as the entrance to the North Sea. These features seem to indicate the line of the chief mud-bearing streams from the land, and the general disposition of currents and eddies in the sea which covers that region, the gravel ridges marking the tracks of the more rapidly moving currents, while the muddy hollows point to the eddies where the fine sediment is permitted to settle on the bottom. It is possible, however, that the inequalities on the floor of the North Sea, and their peculiarities of sediment, may not be due wholly to modern accumulations, but partly to the contour of the ground before it was submerged and the land connection between Britain and Europe was destroyed.

During the course of the voyage of the "Challenger," the approach to land could always be foretold from the character of the bottom, even at distances of 150 and 200 miles from land. The deposits were found to consist of blue and green muds derived from the degradation of older crystalline rocks. At depths of 100 to 700 fathoms they are often colored green by glauconite. At greater depths they consist of blue or dark slate-colored mud with a thin upper layer of red or brown. Throughout these land-derived sediments particles of mica, quartz, and other minerals are distributed, the materials becoming coarser towards land. Pieces of wood, portions of fruits, and leaves of trees occur in them, and further indicate the reality of the transport of material from the land. Shells of pteropods, larval gasteropods, and lamellibranchs are tolerably abundant in these muds, with many infra-littoral species of *Foraminifera*, and diatoms. Below 1500 or 1700 fathoms pteropod shells seldom appear, while at 3000 fathoms hardly a foraminifer or any calcareous organism remains (Murray, *Proc. Roy. Soc. Edin.*, 1876, p. 519). Round volcanic islands the bottom is found to be covered with grey mud and sand derived from the degradation of volcanic rocks. These deposits can be traced to great distances, as at Hawaii for 200 miles or more. Pieces of pumice, scoriæ, etc., occur in them, mingled with marine organisms, and more particularly with abundant grains, incrustations, and nodules of an earthy peroxide of manganese. Near coral-reefs the sea-floor is coated with a white calcareous mud derived from the abrasion of the coral. The east coast of South America supplies a peculiar red mud which is spread over the Atlantic slope down to depths of more than 2000 fathoms.

(*b.*) *Abyssal.*—Passing over at present the organic deposits which form so characteristic a feature on the floor of the deeper and more open parts of the ocean, we come to certain red and grey clays found at depths of more than 2000 fathoms down to the bottoms of the deepest abysses. These consist of exceedingly fine clay, colored sometimes red by iron-oxide, sometimes of a chocolate tint from manganese oxide, with grains of quartz, mica, pumice, scoriæ, peroxide of manganese, and other mineral substances, together with *Foraminifera*, and in some regions a large proportion of siliceous *Radiolaria*. Mr. Murray has shown the high probability that these clays result from the decomposition of pumice and fine volcanic dust transported from volcanic islands into mid-ocean. The extreme slowness of their deposit is strikingly brought out in the tracts farthest removed from land. From these localities great numbers of sharks' teeth, with ear-bones and other bones of whales, were dredged up in the "Challenger" expedition,—some of them quite fresh, others partially crusted with peroxide of manganese, and some completely and thickly surrounded by that substance. We cannot suppose that sharks and whales so abound in the sea as to cover the floor of the ocean with a continuous stratum of their remains. No doubt each haul of the dredge which brought up so many bones represented the droppings of many generations. The successive stages of manganese incrustation point to a long, slow, undisturbed period, when so little sediment accumulated that the bones dropped at the beginning remained at the end still uncovered, or only so slightly covered as to be easily scraped up by the dredge. In these deposits, moreover, Mr. Murray has found numerous minute spherular particles of metallic iron which there is every reason to believe are of cosmic origin—portions of the dust of meteorites which in the course of ages have fallen upon the sea-bottom. Such particles no doubt fall all over the ocean; but it is only on those parts of the bottom which, by their distance from any land, receive accessions of deposit with extreme slowness, and where therefore the present surface may contain the dust of a long succession of years, that it has been possible to detect them.

The abundant deposit of peroxide of manganese over the floor of the deep sea is one of the most singular features of recent discovery. It occurs as an earthy incrustation round bits of pumice, bones, and other objects. The nodules possess a concentric arrangement of lines not unlike those of urinary calculi. That they are formed on the spot, and not drifted from a distance, was made abundantly clear from their containing abyssal organisms, and enclosing more or less of the surrounding bottom, whatever its nature might happen to be. Mr. Murray refers their origin to the decomposition of the manganese-bearing minerals in the universally diffused volcanic detritus. Quite recently Mr. J. Y. Buchanan has dredged similar manganese concretions from some of the deeper parts of Loch Fyne. In connection with the chemical reactions indicated by these nodules as taking place on the sea-bottom, reference may be made to a still more remarkable but yet unpublished discovery made by Mr. Murray in the course of his examinations of the materials brought up from the same abyssal deposits. He has detected abundant minute concretions or bundles of crystals which on analysis are found to resemble olivine in composition. These silicates (there may be several of them) have certainly been formed directly on the sea-bottom, for they are found gathered round abyssal organisms. It is difficult to overestimate the importance of this fact in reference to the chemistry of marine deposits.

From a comparison of the results of the dredgings made in recent years in all parts of the oceans, it is impossible to resist the conclusion that there is nothing in the character of the deep-sea deposits which finds a parallel among the marine geological formations visible to us on the land. It is only among the comparatively shallow water accumulations of the existing sea that we encounter analogies to the older formations. And thus we reach by another and a new approach the conclusion which on very different grounds has been arrived at, viz., that the present continental ridges have existed from the remotest times, and that the marine strata which constitute so large a portion of their mass have been accumulated not as deep water formations, but in comparatively shallow water along their flanks.

Section III.—Life.

Among the agents by which geological changes are carried on upon the surface of the globe living organisms must be enumerated. Both plants and animals co-operate with the inorganic agents in promoting the degradation of the land; and in some cases, on the other hand, they protect rocks from decay. Again by the accumulation of their remains they form extensive formations both upon the land and in the sea. Their operations may hence be described as alike destructive, conservative, and reproductive. Under this heading also we may notice the influence of man as a geological agent.

I. Destructive Action.—Plants aid in the general progress of disintegration in various ways. 1. By keeping the surfaces of rocks moist, and thus promoting both the mechanical and chemical dissolution of the rocks. This action is especially shown by liverworts, mosses, and other plants which only thrive in copious moisture. 2. By producing through their decay carbonic and other acids, which, with decaying organic matter taken up by passing moisture, become potent in effecting the chemical decomposition of rocks, and in promoting the disintegration of soils. 3. By inserting their roots or branches between joints of rock, which are thereby loosened, so that large slices may be eventually wedged off. On the sides of wooded hills and cliffs this process may often be seen; even among old ruins an occasional sapling ash or elm may be found to have cast its roots round a portion of the masonry and to be slowly detaching it from the rest of the wall. 4. By attracting rain, as thick woods, forests, and mosses do, and thus accelerating the general scouring of a country by running water. The indiscriminate destruction of the woods in the Levant has been assigned with much plausibility as the main cause of the present desiccation of that region. 5. By promoting the decay of diseased and dead plants and animals, as when fungi overspread a damp rotting tree or the carcase of a dead animal.

Of the destructive influences of animal life numerous illustrations might be given. 1. The composition and arrangement of soil are affected. Worms are continually engaged in bringing up the lower portions of the soil to the surface, and thus increase its fertility and its capability of being washed away by rain. Burrowing animals, by throwing up the soil and subsoil, expose these to be dried and blown away by the wind. At the same time their subterranean passages serve to drain off the superficial water and to injure the stability of the surface of the ground above them. In Britain the mole and rabbit are familiar examples. In North America the prairie dog has undermined extensive tracts of pasture land in the west. In Cape Colony wide areas of open country seem to be in a constant state of eruption from the burrowing operations of multitudes of *Bathyergi* and *Chrysochloris*—small mole-like animals which bring up the soil and bury the grassy vegetation under it. 2. The flow of streams is sometimes interfered with, or even diverted, by the operations of animals. Thus the beaver, by constructing dams, checks the current of water-courses, intercepts floating materials, and sometimes even diverts the water into new channels. This action is typically displayed in Canada and other parts of North America. The embankments of the Mississippi are sometimes weakened to such an extent by the burrowings of the cray-fish as to give way and allow the river to inundate the surrounding country. Similar results have happened in Europe from the subterranean operations of rats. 3. Some Mollusca (*Pholas, Saxicava, Teredo*, etc.) bore into stone or wood, and by the number of contiguous perforations greatly weaken the material. Pieces of drift-wood are soon riddled with long holes by the teredo; while wooden piers, and the bottom of wooden ships, are often rapidly perforated. The saxicavous shells, by piercing rocks and leaving open cavities for rain and sea water to fill, promote the decay of the stone. 4. Many animals exercise a ruinously destructive influence upon vegetation. Of the many insect plagues of that kind it will be enough to enumerate the locust, phylloxera, and Colorado beetle. The pasture in some parts of the south of Scotland has in recent years been much damaged by mice, which have increased in numbers owing to the indiscriminate shooting and trapping of owls, hawks, and other predaceous creatures. Grasshoppers cause the destruction of vegetation in some parts of Wyoming and other western territories of the United States. The way in which animals destroy each other, often on a great scale, may likewise be included among the geological operations now under description.

II. Conservative Action.—This is admirably shown by many kinds of vegetation. 1. The formation of a stratum of turf protects the soil and rocks from being rapidly disintegrated and washed away by atmospheric action. Hence the surface of a district so protected is denuded with extreme slowness except along the lines of its water-courses. 2. Many plants, even without forming a layer of turf, serve by their roots or branches to protect the loose sand or soil on which they grow from being removed by wind. The common sand-carex and other arenaceous plants bind the loose sand-dunes of our coasts, and give them a permanence which would at once be destroyed were the sand laid bare again to storms. In North America the sandy tracts of the western territories are in many places protected by plants known as sage-brush and grease-wood. The growth of shrubs and brushwood along the course of a stream not only keeps the alluvial banks from being so easily undermined and removed as would otherwise be the case, but serves to arrest the sediment in floods, filtering the water, and thereby adding to the height of the flood plain. On some parts of the west coast of France extensive ranges of sand-hills have been gradually planted with pine woods which, while preventing the destructive inland march of the sand, also yield a large revenue in timber, and have so improved the climate as to make these districts a resort for pulmonary invalids. In tropical countries the mangrove grows along the margin of the sea, and not only protects the land, but adds to its breadth, by forming and increasing an alluvial belt along the coast. 3. Some marine plants likewise afford protection to shore rocks. This is done by the calcareous nullipores, which form upon them a hard incrustation; likewise by the tangles and smaller fuci which grow abundantly on the littoral zone and break the force of the waves, or diminish the effects of ground swell. 4. Forests and brushwood protect the soil, especially on slopes, from being washed away by rain. This is shown by the disastrous results of the thoughtless destruction of such woods. According to Reclus (*La Terre*, p. 410), in the three centuries from 1471 to 1776, the "vigueries," or provostry-districts of the French Alps, lost a third, a half, and even three-fourths of their cultivated ground, and the population has diminished in somewhat similar proportions. From 1836 to 1866 the departments of Hautes and Basses Alpes lost 25,000 inhabitants, or nearly one-tenth of their population—a diminution which has with plausibility been assigned to the reckless removal of the pine forests, whereby the steep mountain sides have been washed bare of their soil. The desiccation of the countries bordering the eastern Mediterranean has been ascribed to a similar cause. 5. In mountain districts pine forests exercise also an important conservative function in preventing the formation or arresting the progress of avalanches. In Switzerland some of the forests which cross the lines of frequent snow-falls are carefully preserved.

Animals do not exert any important conservative action upon the earth's surface, save in so far as they form new deposits, as will be immediately referred to. In the prairie regions of Wyoming and other tracts of North America, some interesting minor effects are referable to the herds of roving animals which migrate over these territories. Professor Comstock describes the trails made by the bison, the elk, and the big-horn or mountain sheep as firmly-trodden tracks on which vegetation will not grow for many years. All over the region traversed by the bison numerous circular patches of grass are to be seen which have been formed on the hollows where this animal has wallowed. Originally they are shallow depressions formed in great numbers where a herd of bisons has rested for a time. On the advent of the rains they become pools of water; thereafter grasses spring up luxuriantly, and so bind the soil together that these grassy patches, or "bison-wallows," may actually become slightly raised above the general level if the surrounding ground becomes parched and degraded by the winds (*Reconnaissance of N. W. Wyoming*, 1875, p. 175).

III. Reproductive Action.—Both plants and animals contribute materials towards new geological formations. Their remains are enclosed in deposits of sand and mud and there preserved. But they form of themselves not unimportant accumulations. Of plant formations the following illustrative examples may be given. (1.) *Peat-Mosses.*—These are accumulations of marshy vegetation which occur in temperate and arctic latitudes, sometimes to a depth of 40 feet or more. In Europe they have been largely formed by plants of the genus *Sphagnum*, which, growing as a spongy fibrous mass over wet ground, die in their lower parts and send out new fibres above. It is this lower decaying stratum which forms the peat. Every stage of the process may be seen in a large moss, from the green living plants at the top, through fibrous brown turf full of the scarcely decayed rootlets of the *Sphagnum*, down to the compact brown or almost black peat at the bottom. Many peat-mosses were at one time lakes which have been gradually filled up by the accumulation of marsh-plants. Peat possesses a great antiseptic power; the bodies of animals which have been entombed in it are sometimes preserved for many centuries. (2.) *Mangrove Swamps.*—On the low moist shores and river mouths of tropical countries, the mangrove tree plays an important geological part. It grows in such situations in a dense jungle, sometimes 20 miles broad, which fringes the coast as a green selvage, and runs up if it does not quite occupy creeks and inlets. The mangrove flourishes in sea-water even down to low-water mark, forming there a dense thicket which, as the trees drop their radicles and take root, grows outward into the sea. It is singular to find terrestrial birds nestling in the branches above and crabs and barnacles living among the roots below. By this network of subaqueous radicles and roots the water is filtered of its sediment, which, retained among the vegetation, helps to turn the spongy jungle into a firm soil. On the coast of Florida the mangrove swamps stretch for long distances as a belt from 5 to 20 miles broad, which winds round the creeks and inlets. At Bermuda the mangroves co-operate with grasses and other plants to choke up the creeks and brackish lakes. In these waters calcareous algæ abound, and as their remains are thrown up amidst the sand and vegetation they form a remarkably calcareous soil. (3.) *Diatom Mud or Earth.*—As the minute siliceous plants called diatoms occur both in fresh and salt water, the deposit formed from their congregated remains is found both on the sites of lakes and on the sea-floor. "Infusorial" earth and "tripoli powder" consist mainly of the frustules and fragmentary debris of diatoms which have accumulated on the bottoms of lacustrine areas. Towards the Antarctic circle the "Challenger" met with *Diatomaceæ* in abundance, both in the surface waters of the ocean and on the bottom. They form at depths of from 1260 to 1975 fathoms a pale straw-colored deposit, which when dried is white and very light.

Animal formations are chiefly composed of the remains of the lower grades of the animal kingdom, especially of *Mollusca, Actinozoa,* and *Foraminifera.* (1.) In some cases they are *calcareous.* Lime, chiefly in the form of carbonate, is the mineral substance of which the solid parts of animals are mainly built up. Hence the great majority of the accumulations formed of animal remains are calcareous. In fresh water they are represented by the *marl* of lakes—a white, chalky deposit consisting of the mouldering remains of *Mollusca, Entomostraca,* and partly of fresh-water algæ. On the sea-bottom in shallow water they consist of beds of shells, such as the oyster-banks of English seas. The fringing, barrier, and atoll coral-reefs of warm seas are conspicuous examples of wide and thick masses of rock formed from the accumulated growth of animal organisms. The great reef of Australia, for example, is 1250 miles long, from 10 to 90 miles broad, and more than 1800 feet thick. The coral rock, though formed by the continuous growth of the polyps, gradually loses any distinct organic structure, and acquires an internal crystalline character owing to the infiltration of water through its mass, whereby carbonate of lime is carried down and deposited in the pores and crevices as in a growing stalactite. Great quantities of calcareous mud are produced by the breakers which beat upon the outer edge of the reefs. This mud is partly washed up upon the reefs and aids in their consolidation, but in great measure it is swept away by the ocean currents and distributed over many thousands of square miles of the sea-floor. In deep water over the bed of the Atlantic and other oceans a remarkable calcareous ooze occurs which is formed of the remains of *Foraminifera,* and chiefly of species of the genus *Globigerina.* It is next in abundance to the red and grey clays of the deep sea. It is a pale-grey marl, sometimes red from peroxide of iron, or brown from peroxide of manganese; and it usually contains more or less clay, even with occasional fragments of pumice. (2.) *Siliceous* deposits formed from animal exuviæ are illustrated by another of the deep-sea formations brought to light by the "Challenger" researches. In certain regions of the western and middle Pacific Ocean, the bottom was found to be covered with an ooze consisting almost entire of *Radiolaria.* These minute organisms occur, indeed, more or less abundantly in almost all deep oceanic deposits. From the deepest sounding yet taken (4575 fathoms, or more than 5 miles) a radiolarian ooze was obtained. The spicules of sponges likewise furnish materials towards these siliceous accumulations. (3.) *Phosphatic* deposits, in the great majority of cases, betoken some of the vertebrate animals, seeing that phosphate of lime enters largely into the composition of their bones and occurs in their excrement. The most typical modern accumulations of this nature are the guano beds of rainless islands off the western coast of South America and Southern Africa. In these regions immense flocks of sea-fowl have in the course of centuries covered the ground with an accumulation of their droppings to a depth of sometimes 30 to 80 feet, or even more. This deposit, consisting chiefly of organic matter and ammoniacal salts, with about 20 per cent. of phosphate of lime, has acquired a high value as a manure, and is being rapidly cleared off. It could only have been preserved in a rainless or almost rainless climate. On the west of Europe isolated stacks and rocky islands in the sea are often seen to be white from the droppings of clouds of sea birds; but it is merely a thin crust, which is not allowed to grow thicker in a climate where rains are frequent and heavy.

IV. Man as a Geological Agent.—No survey of the geological workings of plant and animal life upon the surface of the globe can be complete which does not take account of the influence of man—an influence of enormous and increasing consequence in physical geography, for man has introduced, as it were, an element of antagonism to nature. Not content with gathering the fruits and capturing the animals which she has offered for his sustenance, he has, with advancing civilization, engaged in a contest to subdue the earth and possess it. His warfare indeed has often been a blind one, successful for the moment, but leading to sure and sad disaster. He has, for instance, stripped off the woodland from many a region of hill and mountain, gaining his immediate object in the possession of their stores of timber, but thereby laying bare the slopes to parching droughts or fierce rains. Countries once rich in beauty, and plenteous in all that was needful for his support, are now burnt and barren, or washed bare of their soil. It is only in comparatively recent years that he has learnt the truth of the aphorism—"*Homo Naturæ minister et interpres.*"

But now, when that truth is coming more and more to be recognized and acted on, man's influence is none the less marked. His object still is to subdue the earth, and he attains it, not by setting nature and her laws at defiance, but by enlisting her in his service. Within the compass of this article it is impossible to give more than merely a reference to this vast subject. The action of man may be witnessed on climate, on the flow of water, on the character of the terrestrial surface, and on the distribution of life.[1]

1. *On Climate.*—Human interference affects meteorological conditions—(1) by removing forests and laying bare to the sun and winds areas which were previously kept cool and damp under trees, or which, lying on the lee side, were protected from tempests; as already stated, it is supposed that the wholesale destruction of the woodlands formerly existing in countries bordering the Mediterranean has been in part the cause of the present desiccation of these districts; (2) by drainage, the effect of this operation being to remove rapidly the discharged rainfall, to lessen the evaporation, and thereby to diminish the rainfall and somewhat increase the general temperature of a country; (3) by the other processes of agriculture, such as the transformation of moor and bog into cultivated land, and the clothing of bare hillsides with green crops or plantations of coniferous and hardwood trees.

2. *On the Flow of Water.*—1. By increasing or diminishing the rainfall man directly affects the course of the waters over the land. 2. By his drainage operations he makes the rain to run off more rapidly than before, and thereby increases the floods in the rivers. 3. By wells, bores, mines, or other subterranean works he interferes with the underground waters and consequently with the discharge of springs. 4. By embanking rivers he confines them to narrow channels, sometimes increasing their scour, and enabling them to carry their sediment further seaward, sometimes causing them to deposit it over the plains and raise their level.

3. *On the Surface of the Land.*—Man's operations alter the aspect of a country in many ways:—(1) by changing forest into bare mountain, or clothing bare mountains with forest; (2) by promoting the growth or causing the removal of peat-mosses; (3) by heedlessly uncovering sand-dunes, and thereby setting in motion a process of destruction which may convert hundreds of acres of fertile land into waste sand, or by prudently planting the dunes with sand-loving vegetation or pines, and thus arresting their landward progress; (4) by so guiding the course of rivers as to make them aid him in reclaiming waste land, and bringing it under cultivation; (5) by piers and bulwarks, whereby the ravages of the sea are stayed, or by the thoughtless removal from the beach of stones which the waves had themselves thrown up, and which would have served for a time to protect the land; (6) by forming new deposits either designedly or incidentally. The roads, bridges, canals, railways, tunnels, villages, and towns with which man has covered the surface of the land will in many cases form a permanent record of his presence. Under his hand the whole surface of civilized countries is very slowly covered by a stratum, either formed wholly by him, or due in great measure to his operations, and containing many relics of his presence. The soil of old cities has been increased to a depth of many feet by the rubbish of his buildings; the level of the streets of modern Rome stands high above that of the pavements of the Cæsars, and that again above the roadways of the early republic. Over cultivated fields his potsherds are turned up in abundance by the plough. The loam has risen within the walls of his graveyards, as generation after generation has mouldered there into dust.

4. *On the Distribution of Life.*—It is under this head, perhaps, that the most subtle of human influences come. Some of man's doings in this domain are indeed plain enough, such as the extirpation of wild animals, the diminution or destruction of some forms of vegetation, the introduction of plants and animals useful to himself, and especially the enormous predominance given by him to the cereals and to the spread of sheep and cattle. But no such extensive disturbance of the normal conditions of the distribution of life can take place without carrying with it many secondary effects, and setting in motion a wide cycle of change and of reaction in the animal and vegetable kingdoms. For example, the incessant warfare waged by man against birds and beasts of prey in districts given up to the chase leads sometimes to unforeseen results. The weak game is allowed to live, which would otherwise be killed off and give more room for the healthy remainder. Other animals which feed perhaps on the same materials as the game are by the same cause permitted to live unchecked, and thereby to act as a further hindrance to the spread of the protected species. But the indirect results of man's interference with the *régime* of plants and animals still require much prolonged observation.

From this brief and imperfect outline the reader may perceive that man takes an important place as a geological agent, and that in future ages the traces of his interference will introduce a new element of difficulty into the study of geological phenomena.

PART IV.—STRUCTURAL GEOLOGY,

OR THE ARCHITECTURE OF THE EARTH'S CRUST.

Having considered the nature of the materials constituting the crust of the earth, and the operation of the different agencies by which these materials are produced, arranged, and modified, we may now proceed to examine the structure of the crust itself with the view of marking how its component parts have been put together. Since by far the largest portion of the crust consists of sedimentary or aqueous rocks, it will be of advantage to treat of them first, noting, in the first place, their original characters as resulting from the circumstances under which they were formed, and afterwards the modifications subsequently effected upon them. Many of these superinduced structures, which are not peculiar to sedimentary, but occur more or less markedly in all rocks, may be conveniently described together. The distinctive characters of the igneous or eruptive rocks, as portions of the architecture of the crust will then be described; and lastly, those of the crystalline schists and other associated rocks to which the name of metamorphic is usually applied.

I. Stratification and its Accompaniments.

The term "stratified," so often applied as a general designation to the aqueous or sedimentary rocks, expresses their leading structural feature. They are arranged in layers or strata, an arrangement characteristic of them alike in hand-specimens and in the cliffs of mountains. Not that every morsel of aqueous rock exhibits evidence of stratification. But it is this characteristic which is least frequently absent. The general aspects of stratification will be best followed in an explanation of the terms by which they are expressed.

Laminæ are the thinnest paper-like layers of deposit in a stratified rock. Such fine layers only occur where the material is fine-grained, as in mud or shale, or where fine scales of some mineral have been plentifully deposited, as in micaceous sandstone. In some laminated rocks the laminæ cohere so firmly that they can hardly be split open, and the rock will break more readily across them than in their direction. More usually, however, the planes of lamination serve as convenient divisional planes by means of which the rock can be split open. The frequency with which laminæ can be separated from each other, indicating, as it does, a failure of coherence between the layers of deposit, may probably be taken as a proof that these layers were originally laid down at intervals of sufficient duration to admit of a considerable amount of consolidation of one layer before the deposition of the next. It is quite possible that in many, if not in most cases, these intervals were of longer duration than those required for the successive deposit of the laminæ. In estimating therefore the length of time represented by say one foot of such finely laminated rock, we might reasonably regard the actual time occupied in deposition as only a small fraction of the whole interval.

The existence of laminæ points to tranquil conditions of slow intermittent deposit. The sediment has been borne at intervals and fallen over the same area of undisturbed water. Regularity of thickness and persistence of lithological character among the laminæ may be taken to indicate periodic currents, of approximately equal force, from the same quarter. In some cases successive tides in a sheltered estuary may have been the agent of deposition. In others the sediment was doubtless brought by recurring river-floods. A great thickness of laminated rock, like the massive shales of Palæozoic formations, points to a prolonged period of quiescence, and probably, in most cases, to slow, tranquil subsidence of the sea-floor. On the other hand, the alternation of thin bands of laminated rock with others coarser in texture and non-laminated suggests considerable oscillation of currents from different quarters bearing different qualities and amounts of sediment.

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[1] The reader will find much suggestive matter in Marsh's *Man and Nature*, a work which, as its title denotes, specially treats of this subject. A new and enlarged edition of this volume was published in 1874 under the title of *The Earth as Modified by Human Action.*

Strata or *Beds* are layers of rock varying from an inch or less up to many feet in thickness. A stratum may be made up of many laminæ, if the nature of the sediment and mode of deposit have favored the production of this structure. This has very commonly been the case where the sediment has been exceedingly fine-grained. Where the materials are of coarser grain, the strata, as a rule, are not laminated, but form the thinnest parallel divisions of the mass of rock. Strata, like laminæ, may either cohere firmly, or, as more usually happens, be separable with more or less ease from each other. In the former case we may suppose the upper to have followed the lower bed without the lapse of an interval long enough to allow of the consolidation of the latter. The common merging of a stratum into that which overlies it must no doubt be regarded as evidence of more or less gradual change in the conditions of deposit. Where the overlying bed shows no cohesion with that below it, the interval was probably of some duration. A stratum may be one of a series of similar beds in the same mass of rock. Thus a thick sandstone consists of many individual strata, varying it may be very considerably in their respective thicknesses. Or a stratum may be complete and distinct in itself, as where one of limestone or ironstone runs through the heart of a series of shales. As a general rule we may conclude that wherever among sedimentary accumulations stratification is exceedingly well-marked the rocks were formed rather slowly, and that where it is weak or absent the conditions of deposit were more rapid, without the intervals and changes necessary for the production of the distinctly stratified structure.

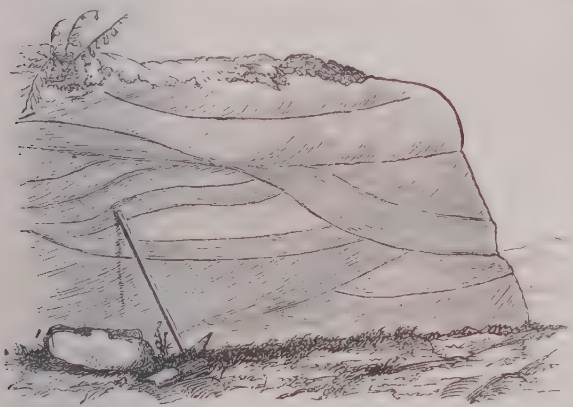

FIG. 9.—Section of false-bedded strata on the coast of Waterford.[1]

False-bedding, Current-bedding.—Some strata, particularly sandstones, are marked by an irregular lamination, wherein the laminæ, though for short distances parallel to each other, are oblique to the general stratification of the mass, at constantly varying angles and in different directions. The accompanying section (fig. 9) illustrates this structure, which is known by the name of false-bedding or current-bedding. The finer lines in this drawing represent the laminæ of deposit, the stronger lines mark successive surfaces on which these laminæ were laid down. Such a structure points to frequent changes in the direction of the currents by which the sediment was carried along and deposited. Sand pushed over the bottom of a sheet of water by varying currents tends to accumulate irregularly in bands and ridges, which often advance with a steep slope in front. The upper and lower surfaces of the bank or bed of sand may remain parallel with each other as well as with the underlying bottom, yet the successive laminæ composing it may lie at an angle of 30° or even more. We may illustrate this structure by the familiar formation of a railway embankment. The top of the embankment on which the permanent way is to be laid is kept level, but the advancing end of the earth-work shows a steep slope over which the workmen are constantly discharging wagon-loads of rubbish. Hence the embankment, if cut open longitudinally would present a "false-bedded" structure, for it would be found to consist of many irregular layers inclined at a high angle in the direction in which the formation of the mound had advanced. In the accompanying figure (fig. 10) the water moving in the direction of the arrow may drop sand at *b*, which will correspond in lamination with the general stratification of the locality; but when the current reaches the steep front of one of the advancing sand sheets it will allow the sand to roll down the slope, and may continue to bring fresh supplies of sediment until the slope is gradually effaced. Now and then, however, instead of laying down sediment, a current of greater strength than usual may appear and sweep away portions of the sediment already deposited.

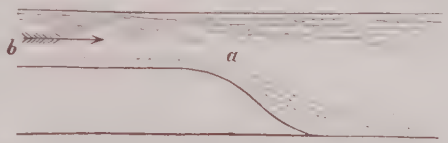

FIG. 10.—Section illustrating the production of false-bedding.

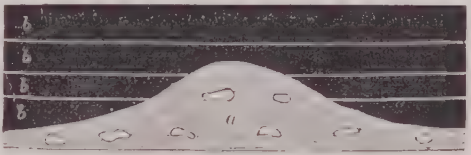

FIG. 11.—Mound of clay with ironstone balls (*a*), covered by beds of coal (*bb*).

Irregularities of Bedding due to Inequalities of Deposition or of Erosion.—A sharp ridge of sand or gravel may be laid down under water by current-action of some strength. Should the motion of the water diminish, finer sediment may be brought to the place and be deposited around and above the ridge. In such a case the stratification of the later accumulation will end off abruptly against the flanks of the older ridge, which will appear to rise up through the overlying bed. In fig. 11, for example, the lower bed seems to have been locally heaped up into the shape of a mound or ridge before the coal was accumulated over it. Appearances of this kind are not uncommon in some coal-fields, where they are known to the miners as "rolls," "swells," or "horses' backs." A structure exactly the reverse of the preceding occurs where a stratum has been scooped out before the deposition of the layers which cover it. This has often been observed in mining for coal. Channels have been cut out of a coal-seam, or rather out of the bed of vegetation which ultimately became coal, and these channels, ramifying and winding sometimes like those of streamlets on flat ground, have been filled up with sandy or muddy sediment. In fig. 12 a section is given of a remarkable series of such erosions, where beds of clay and sandstone have been extensively denuded in the intervals between the deposit of the successive beds. In these and similar cases it is evident that the erosion took place contemporaneously with the accumulation of the deposits as a

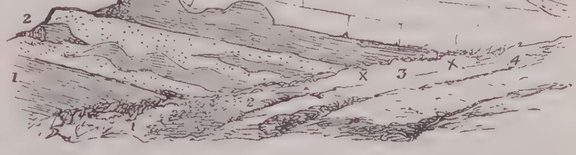

FIG. 12.—Section of New Red Sandstone, road-cutting near Wolverhampton. 1 Red and white clay or marl; 2, Brown sandstone with irregular patches of marl; 3, Red marl, partially eroded before the deposition of 4, Brown sandstone eroded before the formation of 5, Calcareous sandstone or cornstone.

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[1] The woodcuts in this Part are (with the exception of Nos. 20 and 31) from the article GEOLOGY in the last edition of the *Ency. Brit.*, written by the late J. B. Jukes, F. R. S.

whole. We cannot tell, of course, how long an interval elapsed between the formation of a given stratum and that of the next stratum which lies upon its eroded surface, nor how much depth of rock may have been removed in the erosion. When, however, as in the instances with which we are dealing, the structure occurs among conformable strata, evidently united as one lithologically continuous series of deposits, we may reasonably infer that the missing portions are of small moment, and that the erosion was merely due to the irregular and more violent action of the very currents by which the sediment of the successive strata was supplied.

The case is very different when the eroded strata are inclined at a different angle to those above them, and are strongly marked off by lithological distinctions. In some of the coal-mines in central Scotland, for instance, deep channels have been met with entirely filled with sand, gravel, or clay belonging to the general superficial drift of the country. These channels have evidently been water-courses worn out of the coal-measure strata at a comparatively recent geological period, and subsequently buried under the glacial accumulations. There is a complete discordance between them and the Palæozoic strata below, pointing to the existence of a vast interval of time.

Ripple-mark.—The surface of many beds of sandstone is marked with lines of wavy ridge and hollow, such as may be seen on any shore from which the tide has retired. This kind of surface is known as "ripple-mark." It may be formed on dry blown sand by the action merely of the wind, and it is of everyday occurrence under shallow water, not merely on sea-shores, but on the floors of lakes and of river-pools. The water, gently agitated by the wind in a given direction, throws a surface of the underlying sediment into ripples which tend to run at right angles to the course of movement. But as the wind veers from point to point, producing corresponding changes in the direction of the water-currents, the ripples on the bottom are not strictly parallel, but often coalesce, intersect, and undulate in their course. Their general direction, however, suffices to indicate the quarter whence the chief movement of the water has come. No satisfactory inference can be drawn from the existence of a rippled surface as to the depth of water in which the sediment was accumulated. As a rule it is in water of only a few feet or yards in depth that ripple-mark is formed. But it may be produced at any depth to which the agitation caused by wind on the upper waters may extend.

On an ordinary beach each tide usually effaces the ripple-marks made by its predecessor, and leaves a new series to be obliterated by the next tide. But where the markings are formed in water which is always receiving fresh accumulations of sediment, a rippled surface may be gently overspread by the descent of a layer of sediment upon it and may thus be preserved. Another series of ripples may then be made in the overlying layers, which in turn may be buried and preserved under a renewed deposit of sand. In this way a considerable thickness of such rippled-marked strata may be accumulated, as has frequently taken place among geological formations of all ages.

An examination of any sandy beach from which the sea has recently retired brings before us many modifications of the perfect ripple-mark. The ridges may be seen to grow more and more notched and irregular, until at last the beach seems to be dotted over with little, flat, dome-shaped mounds, or as if the ridges of the ripple-mark had been furrowed across. These modifications are doubtless due to the partial effacement of the ridges by subsequent action of the water agitated by wind from a different quarter. Such indications of shallow-water conditions may often be observed among old arenaceous deposits, as in the Cambrian and Silurian rocks. In like manner we may frequently detect, among these ancient formations, small isolated or connected linear ridges directed from some common quarter, like the current-marks frequently to be found behind projecting fragments of shell, stones, or bits of seaweed on a beach from which the tide has just retired.

Sun-cracks, Rain-pittings, etc.—Proofs may not infrequently be found that during deposition aqueous strata have been laid bare to air and sun. The nature and validity of this evidence will be best ascertained by observations made at the margin of the sea, or of any inland sheet of water, which from time to time leaves tracts of mud or fine sand exposed to sun and rain. The way in which the muddy bottom of a dried-up pool cracks into polygonal cakes when exposed to the sun may be illustrated abundantly among geological formations of all ages. These desiccation-cracks, or sun-cracks, could not have been produced so long as the sediment lay under water. Their existence therefore among any strata proves that the surface of rock on which they lie was exposed to the air and dried before the next layer of water-borne sediment was deposited upon it.

With these markings are not infrequently associated prints of rain-drops. The familiar effects of a heavy shower upon a surface of moist sand or mud may be witnessed among rocks even as old as parts of the Cambrian system. In some cases the rain-prints are found to be ridged up on one and the same side in such a manner as to indicate that the rain-drops as they fell were driven along in a slanting direction. The prominent side of the markings therefore indicates the side towards which the wind blew.

Numerous proofs of shallow shore-water, and likewise of exposure to the air, are supplied by markings left by animals. Castings and trails of worms, tracks of mollusks and crustaceans, fin-marks of fishes, footprints of birds, reptiles, and mammals, may all be preserved and give their evidence regarding the physical conditions under which sedimentary formations were accumulated. It may frequently be noticed that such impressions are associated with ripple-marks, rain-prints, or sun-cracks; so that more than one kind of evidence may be gleaned from a locality to show that it was sometimes laid bare of water.

Gas-spurts.—The surfaces of some strata, usually of a dark color and containing much organic matter, may be observed to be raised into little heaps of various indefinite shapes, not, like the heaps associated with worm burrows, connected with pipes descending into the rock, nor composed of different material from the surrounding sandstone or shale. These may be conjectured to be due to the intermittent escape of gas from the decomposing organic matter in the original sand or mud, as we may sometimes witness in operation among the mud flats of rivers and estuaries. On a small scale these protrusions of the upper surface of a deposit may be compared with the well-known mud-lumps at the mouths of the Mississippi, where the muddy bottom rises into mounds sometimes to a height of several yards above the water, from the top of which great quantities of carburetted hydrogen gas make their escape, together with water and mud.

Concretions.—Many sedimentary rocks are marked by the occurrence of concretions in them, either distinct in aspect and composition from the general mass of the rock, or forming really part of that mass, though separated from the rest by their being agglutinated into concretionary forms. Such concretions, where they differ in petrographical characters from the surrounding matter, are almost invariably of original or contemporaneous formation, that is, were formed at the same time as the strata among which they lie. Where, however, they appear to be merely compacted portions of the stratum, they may be regarded as generally due to some subsequent change effected upon the rock.

Contemporaneous concretions most commonly consist of carbonate of iron, carbonate of lime, or silica. Many clay-ironstone beds assume a nodular form, and this mineral occurs abundantly in the shape of separate nodules in shales and clay-rocks. The nodules have frequently formed round some organic body such as a fragment of plant, a shell,

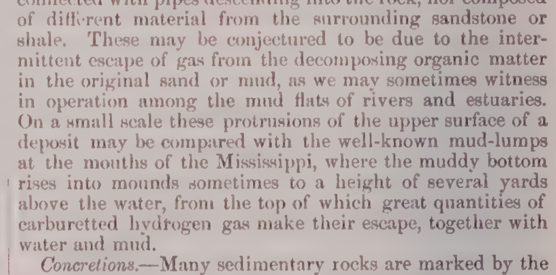

FIG. 13.—Sketch of limestone-beds, with concretions of white chert, Middleton Moor, Derbyshire.

bone, or coprolite. That the carbonate of iron was slowly precipitated during the formation of the bed of shale in which its nodules lie may often be satisfactorily proved by the lines of deposit passing continuously through the nodules. In many cases the internal first-formed parts of a nodule have contracted more than the outer and more compact crust; and have cracked into open polygonal spaces which are commonly filled with calcite. Similar concretions of carbonate of lime occur in some clays and in connection with limestones. Concretions of silica occur in limestone of many geological ages (see *ante*, p. 213). The flints of the English chalk are a familiar example, but similar siliceous concretions occur even in Lower Silurian limestones. The silica in these cases has not infrequently been deposited round organic bodies such as sponges, sea-urchins, and mollusca, which are completely enveloped in it and have even themselves been silicified. Iron-bisulphide (pyrite or marcasite) often assumes the form of concretions, more particularly among clay-rocks, and these, though presenting many eccentricities of shape, round like pistol-shot or cannon-balls, kidney-shaped, botryoidal, etc., agree in usually possessing an internal fibrous radiated structure. Phosphate of lime is found as concretions in formations where the coprolites and bones of reptiles and other animals have been collected together.

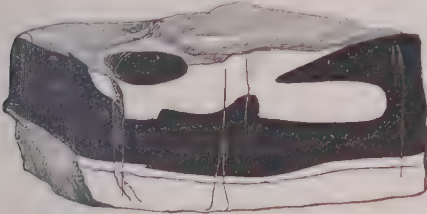

FIG. 14.—Sketch of part of a block of black chert in the limestone near Dublin.

Concretions produced subsequently to the formation of the rock may be observed in some sandstones, which, when exposed to the weather, decompose into large round balls. Some shales exhibit this structure in a still more striking manner, inasmuch as the concretions consist of the general mass of the laminated shale, and the lines of stratification pass through them and mark them out distinctly as superinduced upon the rock. Some magnesian limestones are so concretionary as to resemble masses of conglomerate; yet the concretions, among all their fantastic shapes and with their acquired crystalline texture, may often be found to retain traces of the original stratification of the rock. Beds of rock-salt may likewise be observed to be marked with traces of a concretionary arrangement.

Order of Superposition—the Foundation of Geological Chronology.—As sedimentary strata are laid down upon one another in a more or less nearly horizontal position, the underlying beds must be older than those which cover them. This simple and obvious truth is termed the law of superposition. It furnishes the means of determining the chronology of rocks, and though other methods of ascertaining this point are employed, they must all be based originally upon the observed order of superposition. The only case where the apparent superposition may be deceptive is where the strata have been inverted. In the Alps, for example, the rocks composing huge mountain masses have been so completely overturned that the highest beds appear as if regularly covered by others which ought properly to underlie them. But these are exceptional occurrences, where the true order can usually be made out from other sources of evidence.

Alternations of Strata.—Though great variations occur in the nature of the strata composing a mass of sedimentary rocks, it may often be observed that certain repetitions occur. Sandstones, for example, are found to be interleaved with shale above, and then to pass into shale; the latter may in turn become sandy at the top and be finally covered by sandstone, or may assume a calcareous character and pass up into limestone. Such alternations bring before us the conditions under which the sedimentation took place. A sandstone group indicates water of comparatively little depth, moved by changing currents, bringing the sand now from one side now from another. The passage of such a group into one of shale points to a diminution in the motion and transporting power of the water, perhaps to a sinking of the tract, whereby only fine mud was then intermittently brought into it. The advent of a limestone above the shale serves to show that the water cleared, owing to a deflexion of the sediment-carrying currents, or to continued and perhaps more rapid subsidence, and that *Foraminifera*, corals, crinoids, *Mollusca*, or other lime-secreting organisms, established themselves upon the spot. Shale overlying the limestone would tell of fresh inroads of mud, which destroyed the animal life that had been flourishing on the bottom; while a return of sandstone beds would mark how, in the course of time, the original conditions of troubled currents and shifting sandbanks returned. Such alternating groups of sandy, calcareous, and argillaceous strata are well illustrated among the Jurassic formations of England.

Associations of Strata.—Certain kinds of strata very commonly occur together, because the conditions under which they were formed were apt to arise in succession. One of the most familiar examples is the association of coal and fire-clay. A seam of coal is almost invariably found to lie on a bed of fire-clay, or on some argillaceous stratum. The reason of this union becomes at once apparent when we learn that the fire-clay formed the soil on which the plants grew that went to form the coal. Where the clay was laid down under suitable circumstances vegetation sprang up upon it. Again conglomerate and sandstone occur together rather than conglomerate and shale, because the agitation of the water which could form and deposit coarse detritus, like that composing conglomerate, was too great to admit of the accumulation of fine silt. For a similar reason we may look for shale or clay rather than sandstone as an accompaniment of limestone.

Relative Persistence of Strata.—Observation of what takes place on any lake bottom, estuary, or sea-margin teaches that some kinds of sediment are much more widely spread than others, and prepares us to find that the same has been the case in past time, and therefore that some kinds of sedimentary rocks possess far greater persistence than others. As a general rule it may be said that the coarser the grain the more local the extent of a rock. Conglomerates are thus by much the most variable and inconstant of all sedimentary formations. They suddenly sink down from a thickness of several hundred feet to a few yards, or die out altogether, to reappear perhaps further on, in the same wedge-like or lenticular fashion. Sandstones are less liable to such extremes of inconstancy, but they too are apt to thin away and to swell out again. Shales are much more persistent, the same zone being often traceable for many miles. Limestones sometimes occur in thick local masses, as among the Silurian formations of Wales and Scotland, but they often also display remarkable continuity. Three thin limestone bands, each of them only 2 or 3 feet in thickness, and separated by a considerable thickness of intervening sandstones and shales, can be traced through the coal-fields of central Scotland over an area of at least 1000 square miles. Coal-seams also possess great persistence. The same seams, varying slightly in thickness and quality, may often be traced throughout the whole of an extensive coal-field.

What is thus true of individual strata may be affirmed also of groups of such strata. A thick mass of sandstone will be found as a rule to be more continuous than one of conglomerate, but less so than one of shale. A series of limestone-beds will usually be found to stretch further than either of them. But even to the most extensive stratum or group of strata there must be a limit. It must end off and give place to others, either suddenly, as a bank of shingle is succeeded by the sheet of sand heaped against its base, or very gradually, by insensibly passing into other strata on all sides.

Great variations in the character of stratified rocks may frequently be observed in passing from one part of a country to another along the outcrop of the same rocks. Thus at one end we may meet with a thick series of sand-stones and shales which, traced in a certain direction, may be found passing into limestones. A group of strata may consist of massive conglomerates at one locality, and may graduate into fine fissile flagstones in another. A thick mass of clay may be found to alternate more and more with shelly sands as it is traced outward, until it loses its argillaceous nature altogether. No difficulty need be felt in admitting the strict contemporaneity of these diverse layers of sediment. At the present time we see how coarse shingle may be formed along the beach at the same time that the finest mud is being laid down on the same sea-bottom further from land. Could we raise up that bottom, we should doubtless find as gradual a passage from the littoral to the deeper water deposits as we do among the geological formations of the earth's crust. The existing differences of character between the deposits of the shore and of the opener sea would no doubt continue to be maintained, with slight geographical displacements, even if the whole area were undergoing subsidence, giving rise to a thick group of littoral beds in one tract and of deeper-water accumulations at another. In like manner among the formations of former geological periods the same conditions of deposit appear sometimes to have continued for a considerable period. Hence the thick Mountain or Carboniferous Limestone of Derbyshire is gradually replaced northwards by the thick sandstone shales, ironstones, and coal-seams of Scotland.

Overlap.—When strata have been laid down in a subsiding region wherein the area of deposit gradually increased, the sediment must have spread over a progressively augmenting surface. By this means the later portions of a sedimentary series will extend beyond the limits of the older parts, and will repose directly upon the shelving bottom, with none of those older strata underneath them. This relation is called Overlap (see fig. 59). The higher or newer members are said to overlap the older. This structure may often be detected among formations of all geological ages. It brings before us the shore line of ancient land-surfaces, and shows how, as these sank under water, the gravels, sands, and silts gradually advanced and covered them.

Relative Lapse of Time represented by Strata and by the Intervals between them.—Of the absolute length of time represented by any strata or groups of strata we can form no satisfactory estimates. Certain general conclusions may indeed be drawn, and comparisons may be made between different series of rocks. Sandstones full of false-bedding were probably accumulated more rapidly than finely-laminated shales or clays. It is not uncommon in certain Carboniferous formations to find huge coniferous trunks imbedded in an inclined position in sandstone. These trees seem to have been carried along and to have sunk, their heavier or root-end touching the bottom, and their upper end pointing upward in the direction of the current, exactly as in the case of the snags of the Mississippi. The continuous deposit of sand at last rose above the level of the trunks and buried them. It is clear then that the rate of deposit must have been sufficiently rapid to have allowed a mass of 20 or 30 feet of sand to accumulate before the decay of the wood; though modern instances are known where, under certain circumstances, submerged trees may last for some centuries. Continuous layers of the same kind of deposit suggest a persistence of geological conditions; numerous alternations of different kinds of sedimentary matter point to vicissitudes or alternations of conditions. As a rule, we should infer that the time represented by a given thickness of similar strata was less than that shown by the same thickness of dissimilar strata, because the changes needed to bring new varieties of sediment into the area of deposit would usually require the lapse of some time for their completion. But this conclusion might often be erroneous. It would be best supported when, from the very nature of the rocks, wide variations in the character of the water-bottom could be established. Thus a group of shales followed by a fossiliferous limestone would almost always mark the lapse of a much longer period than an equal depth of sandy strata. Limestones made up of organic remains which lived and died upon the spot, and whose remains are crowded together generation above generation, must have demanded many years for their formation.

But in all speculations of this kind we must bear in mind that the length of time represented by a given depth of strata is not to be estimated merely from their thickness or lithological characters. It has already been pointed out that the interval between the deposit of two successive laminæ of shale may have been as long as, or even longer than, that required for the formation of one of the laminæ. In like manner, the interval needed for the transition from one stratum or kind of strata to another may often have been more than equal to the time required for the formation of the strata on either side. But the relative chronological importance of the bars or lines in the geological record can seldom be satisfactorily discussed merely on lithological grounds. This must mainly be decided on the evidence of organic remains, as will be shown in part v. By this kind of evidence it can be made nearly certain that the intervals represented by strata were in many cases much shorter than those not so represented,—in other words, that the time during which no deposit of sediment went on was longer than that wherein deposit did take place.

Groups of Strata.—Passing from individual strata to large masses of stratified rock, the geologist finds it needful for convenience of reference to subdivide these into groups. He avails himself of two bases of classification—(1) lithological characters, and (2) organic remains.

1. The subdivision of stratified rocks into groups according to their mineral aspect is an obvious and easily applied classification. Moreover, it often serves to connect together rocks formed continuously in certain circumstances which differed from those under which the strata above and below were laid down,—so that it expresses natural and original subdivisions of strata. In the middle of the English Carboniferous system of rocks, for example, a zone of sandy and pebbly beds occurs, known as the Millstone Grit. No abrupt and sharp line can be drawn between these strata and those above and below them. They shade upward and downward into the beds between which they lie. Yet they form a conspicuous belt, traceable for many miles by the scenery to which it gives rise. The red rocks of central England, with their red sandstones, marls, rock-salt, and gypsum, form likewise a well-marked group or rather series of groups. It is obvious, however, that characters of this kind, though sometimes wonderfully persistent over wide tracts of country, must be at best but local. The physical conditions of deposit must always have been limited in extent. A group of strata showing great thickness in one region will be found to die away as it is traced into another. Or its place is gradually taken by another group which, even if geologically contemporaneous, possesses totally different lithological characters. Just as at the present time a group of sandy deposits gradually gives place along the sea-floor to others of mud, and these to others of shells or of gravel, so in former geological periods contemporaneous deposits were not always lithologically similar. Hence mere resemblance in mineral aspect usually cannot be regarded as satisfactory evidence of contemporaneity except within comparatively contracted areas. The Carboniferous Limestone of Ireland is a thick calcareous group of rocks, full of corals, crinoids, and other organisms, which bear witness to the formation of these rocks in the open sea. But if these limestones, with their characteristic marine fossils, are traced into the north of England and Scotland they are found to pass into sandstones and shales, with numerous coal-seams, and only a few thin beds of limestone. The soft clay beneath the city of London is represented in the Alps by hard schists and contorted limestones. We conclude therefore that lithological agreement when pushed too far is apt to mislead us, partly because contemporaneous strata often vary greatly in their lithological character, and partly because the same lithological characters may appear again and again in different ages. By trusting too implicitly to this kind of evidence, we may be led to class together rocks belonging to very different geological periods, and on the other hand to separate groups which really, in spite of their seeming distinction, were formed contemporaneously.

2. It is by the remains of plants and animals imbedded among the stratified rocks that the most satisfactory subdivisions of the geological record can be made, as will be more fully stated in parts v. and vi. A chronological succession of organic forms can be made out among the rocks of the earth's crust. A certain common facies or type of fossils is found to characterize particular groups of rock, and to hold true even though the lithological constitution of the strata should greatly vary. Moreover, though comparatively few species are universally diffused, they possess remarkable persistence over wide areas, and even when they are replaced by others, the same general facies of fossils remains. Hence the stratified formations of two countries geographically distant, and having little or no lithological resemblance to each other, may be compared and paralleled zone by zone, simply by means of their enclosed organic remains.

II. JOINTS.

All rocks are traversed more or less distinctly by vertical or highly inclined divisional planes termed *Joints.* Soft rocks indeed, such as loose sand and uncompacted clay, do not show these lines; but wherever a mass of clay has been subjected to some pressure and consolidation, it will usually be found to have acquired them. It is by means of the intersection of joints that rocks can be removed in blocks; the art of quarrying consists in taking advantage of these natural planes of division. Joints differ in character according to the nature of the material which they traverse; those in sedimentary rocks are usually distinct from those in crystalline masses.

1. *In Sedimentary Rocks.*—Joints vary in sharpness of definition, in the regularity of their perpendicular and horizontal course, in their lateral persistence, in number, and in the directions of intersection. As a rule, they are most sharply defined in proportion to the fineness of grain of the rock. In limestones and close-grained shales, for example, they often occur so clean-cut as to be invisible until revealed by fracture or by the slow disintegrating effects of the weather. The rock splits up along these concealed lines of division, whether the agent of demolition be the hammer or frost. In coarse-textured rocks, on the other hand, joints are apt to show themselves as irregular rents along which the rock has been shattered, so that they present an uneven sinuous course, branching off in different directions. In many rocks they descend vertically in straight lines at not very unequal distances, so that the spaces between them are thus marked off into so many wall-like masses. But this symmetry often gives place to a more or less tortuous course with lateral joints in various random directions, more especially where the different strata vary considerably in lithological characters. A single joint may be traced sometimes for many yards, or even for several miles, more particularly when the rock is fine-grained, as in limestone. But where the texture is coarse and unequal, the joints, though abundant, run into each other in such a way that no one in particular can be identified for so great a distance. The number of joints in a mass of stratified rock varies within wide limits. Among strata which have undergone little disturbance the joints may be separated from each other by intervals of several yards. But in other cases where the terrestrial movement appears to have been considerable, the rocks are so jointed as to have acquired therefrom a fissile character that has nearly or wholly obliterated their tendency to split along the lines of bedding.

An important feature in the joints of stratified rocks is the direction in which they intersect each other. As the result of observation we learn that they possess two dominant trends, one coincident in a general way with the direction in which the strata are inclined to the horizon, and the other running transversely at a right angle or nearly so. The former set is known as *dip-joints*, because they run with the *dip* or inclination of the rocks, the latter is termed *strike-joints*, inasmuch as they conform to the general *strike* or mean outcrop. It is owing to the existence of this double series of joints that ordinary quarrying operations can be carried on. Large quadrangular blocks can be wedged off, which would be shattered if exposed to the risk of blasting. A quarry is usually worked to the dip of a rock, hence the strike-joints form clean-cut faces in front of the workmen as they advance. These are known as "backs," and the dip-joints which traverse them as "cutters." The way in which this double set of joints occurs in a quarry may be seen in fig. 15, where the parallel lines which traverse the shaded and unshaded faces mark the successive strata. The broad white spaces running along the length of the quarry behind the seated figure are strike-joints or "backs," traversed by some highly inclined lines which mark the position of dip-joints or "cutters." The shaded ends looking towards the spectator are "cutters" from which the rock has been quarried away on one side.

In some conglomerates the joints may be seen traversing the enclosed pebbles as well as the surrounding matrix. Large blocks of hard quartz are cut through by them as sharply as if they had been sliced in a lapidary's machine, and the same joints can be traced continuously through many yards of the rock. Such facts show that the agency to which the jointing of rocks was due must have operated with considerable force.[1] Further indication of movement is often supplied by the rubbed and striated surfaces of joints. These surfaces, termed *slickensides*, have evidently been ground against each other. They are often coated with hæmatite, calcite, chlorite, or other mineral, which has taken a cast of the striæ and then seems itself to be striated.

Joints form natural lines for the passage downward and upward of subterranean water. They likewise furnish an effective lodgment for surface water which, frozen by a lowering of temperature, expands into ice, and wedges off blocks of rock in the manner already described. As they serve, in conjunction with bedding, to divide stratified rocks into large quadrangular blocks, their effect on cliffs and other exposed masses of rock is seen in the apparently splintered, dislocated aspect so familiar in mountain scenery.

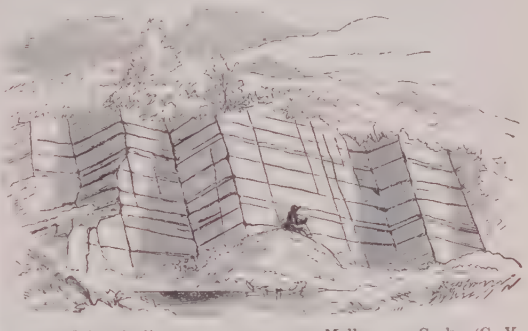

FIG. 15.—Joints in limestone quarry near Mallow, co. Cork. (G. V. Du Noyer.)

Occasionally a prismatic or columnar form of joints may be observed among stratified rocks. When this occurs among unaltered strata it is usually among those which have been chemically formed, as in gypsum, where, as observed by Mr. Jukes in the Paris Basin, some beds are divided from top to bottom by vertical hexagonal prisms. A columnar structure has often been superinduced upon stratified rocks by contact with intrusive igneous masses. Sandstones, shale, and coal may be observed in this condition. The columns diverge perpendicularly to the surface of the injected and altering substance, so that when the later is vertical the columns are horizontal, or when it undulates the columns follow its curvatures. Beautiful examples of this character occur among the coal-seams of Ayrshire.

2. *In Crystalline* (*Igneous*) *Rocks.*—While in stratified rocks the divisional planes consist of lines of bedding and of joint, cutting each other usually at a high if not a right angle, in massive igneous rocks they include joints only; and as these do not as a rule present the same parallelism as lines of bedding, unstratified rocks, even though as full of joints, have not the same regularity of arrangement as in the stratified formations. Granite, for example, is traversed by two sets of chief or "master-joints," cutting each other somewhat obliquely. Their effect is to divide the rock into long quadrangular, rhomboidal, or even polygonal columns. But a third set may usually be noticed cutting across the columns, though less continuous and dominant than the others. When these transverse joints are few in number or occasionally absent, columns many feet in length can be quarried out entire. Such monoliths have been from early times employed in the construction of obelisks and pillars.

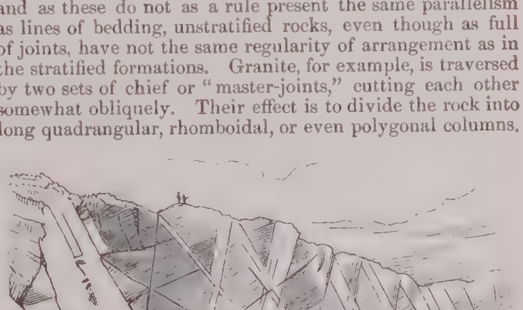

FIG. 16.—Joints in granite, Killiney Hill, Dublin. (G. V. Du Noyer.)

In rocks of finer grain than granite, such as many diorites and dolerites, the numerous perpendicular joints give the rock a prismatic character. The prisms, however, are unequal in dimensions, as well as in the number and proportions of their sides, a frequent diameter being 2 or 3 feet, though they may sometimes be observed three times thicker, and extending up the face of a cliff for 300 or 400 feet. It is by means of joints that precipitous faces of rock are produced and retained, for, as in the case of those in stratified masses, they serve as openings into which frost drives every year its wedges of ice, whereby huge slices are stripped off. They likewise give rise to the formation of those fantastic pinnacles and fretted buttresses so generally to be observed among igneous rocks in which they occur.

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[1] See an interesting series of experiments by M. Daubrée (*Comptes Rendus*, lxxxvi., 1878) on the production of faults and joints.

But undoubtedly the most striking series of joints to be found among igneous rocks is in the regularly columnar, or as it is often called, basaltic structure. This structure has been already (*ante*, p. 222) described in connection with modern volcanic rocks. It may be met with in rocks of all ages. It is as well displayed among the felsites of the Lower Old Red Sandstone, and the basalts of the Carboniferous Limestone in central Scotland, as among the Tertiary lavas of Auvergne or the Vivarais.

3. *In foliated Rocks.*—The schists likewise possess their joints, which approximate in character to those among the massive igneous rocks, but they are on the whole less distinct and continuous, while their effect in dividing the rocks into oblong masses is considerably modified by the transverse lines of foliation. These lines play somewhat the same part as those of stratification do among the stratified rocks, though with less definiteness and precision.

III. INCLINATION OF ROCKS.

The most casual observation is sufficient to satisfy us that the rocks now visible at the earth's surface are seldom in their original position. We meet with sandstones and conglomerates composed of water-worn particles, yet forming the angular scarps of lofty mountains; shales and clays full of the remains of fresh-water shells and land-plants, yet covered by limestones made up of marine organisms, and these limestones rising into great ranges of hills, or undulating into fertile valleys, and passing under the streets of busy towns. Such facts, now familiar to every reader, and even to many observers who know little or nothing of systematic geology, point unmistakably to the conclusion that the rocks have in many cases been formed under water, sometimes in lakes, more frequently in the sea, and that they have been elevated into land.

But further examination discloses other and not less convincing evidence of movement. Judging from what takes place at the present time on the bottoms of lakes and of the sea, we confidently infer that when the strata now constituting so much of the solid framework of the land were formed, they were laid down either horizontally or at least at low angles. When, therefore, we find them inclined at all angles, and even standing on end, we conclude that they have been disturbed. Over wide spaces they have been upraised bodily with little alteration of their original horizontality; but in most places some departure from that original position has been effected.

The inclination thus given to rocks is termed their dip. Its amount is expressed in degrees measured from the plane of the horizon. Thus a set of rocks half-way between the horizontal and vertical position would be said to dip at an angle of 45°, while if vertical they would be marked with the angle of 90°. The edges of strata, where they come up to the surface, are termed their *outcrop* or *basset.* When they *crop out*, that is, rise to the surface, along a perfectly level piece of ground, the outcrop runs at a right angle to the dip. But any inequalities of the surface, such as valleys, ravines, hills, and ridges, will cause the outcrop to describe a circuitous course, even though the dip should remain perfectly steady all the while. If a line of precipitous gorge should run directly with the dip, the outcrop will there be coincident with the dip. The occurrence of a gently shelving valley in that position will cause the outcrop to descend on one side and to mount in a corresponding way on the other, so as to form a V-shaped indentation in its course. A ridge, on the other hand, will produce a deflexion in the opposite direction. Hence a series of parallel ridges and valleys running in the same direction as the dip of the strata underneath would cause the outcrop to describe a widely serpentinous course. Again, should the rocks be vertical, the outcrop will necessarily correspond with the dip, and continue to do so irrespective altogether of any irregularities of the ground. The lower, therefore, the angle of inclination the greater is the effect of surface inequalities upon the line of outcrop; the higher the angle the less is that influence, till when the beds stand on end it ceases.

A line drawn at a right angle to the dip is called the *strike* of the rocks. From what has just been said this line must coincide with outcrop when the surface of the ground is quite level, and also when the beds are vertical. At all other times they are not strictly coincident, but the outcrop wanders to and fro across the strike according to the changes in the angle of inclination and in the form of the ground. The strike may be a straight line or may curve rapidly in every direction, according to the behavior of the dip. If, for instance, a set of beds dips for half a mile continuously to the north, the strike will run for that distance as a straight east and west line. If the dip gradually changes to north-west and west, and then by south-west to south, it is obvious that the strike must curve round by north-east, north, and north-west till it once more becomes parallel with its former course. Both of the parallel lines of strike run in an east-and-west direction, but in the one the dip is to the south, and in the other to the north.

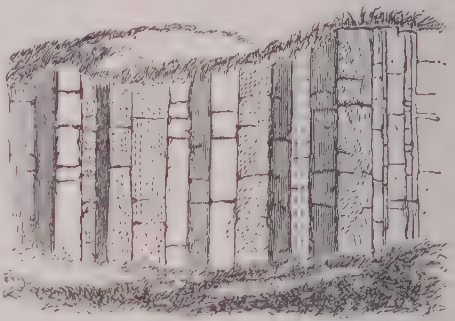
FIG. 17.—Vertical strata, originally deposited horizontally or at low angles.

The strike may be conceived as always a level line on the plane of the horizon, so that no matter how much the ground may undulate, or the outcrop may vary, or the dip may change, the strike will remain level. Hence in mining operations it is commonly spoken of as the *level-course* or *level-bearing.* A level or underground road-way, driven through a coal-seam at right angles to the dip, will undulate in its course if the dip changes in direction, but it may be made perfectly level and kept so throughout a whole coal-field so long as it is not interfered with by any dislocations or other disturbances of the regularity of the rocks.

The accompanying figures (figs. 18 and 19) will serve to show some of these terms as expressed on maps and sections. Fig. 18 represents a geological map in which a series of strata dips in a south-south-easterly direction (S. 28° E.). The angle of inclination increases from 35° at the northern to 50° at the southern end of the beach. On the flat shore (AA) outcrop and strike coincide, but along the inner margin, where the ground ascends in a line or cliff (BB) to the inland country (CC), the outcrop is seen to be deflected a little so as to cross the plateau along a slightly more northerly line than on the beach. A section drawn at a right angle to the strike along the line DD would show the structure represented in fig. 19. Such a section, expressing graphically the result of careful measurement in the field, would give not only the order of succession of beds at the surface, but their actual depth at any point beneath it. Thus a bore or shaft sunk at the point marked *d* on the map would have to pass through rather more than 425 feet of rock before reaching the stratum *b.* The total thickness of rock measured at right angles to the dip in fig. 19 is somewhat more than 850 feet. These various strata, if restored to their original position, would lie one over the other to that depth. If they were on end they would occupy exactly that breadth of ground. But the inclined position of strata makes them cover more horizontal space; in the present instance it increases that space to 1200 feet.

A convenient rule was given many years ago by the late Mr. Charles Maclaren of Edinburgh for estimating the thickness of strata inclined at angles of less than 45°. The real thickness of a mass of inclined strata is $\frac{1}{12}$th of its apparent thickness for every 5° of dip. Thus if a set of beds dip steadily in one direction at 5° for a horizontal space of 1200 feet measured across the strike, their actual thickness will be $\frac{1}{12}$th or 100 feet. If the dip be 15° the true thickness will be $\frac{3}{12}$ths or 300 feet, and so on.

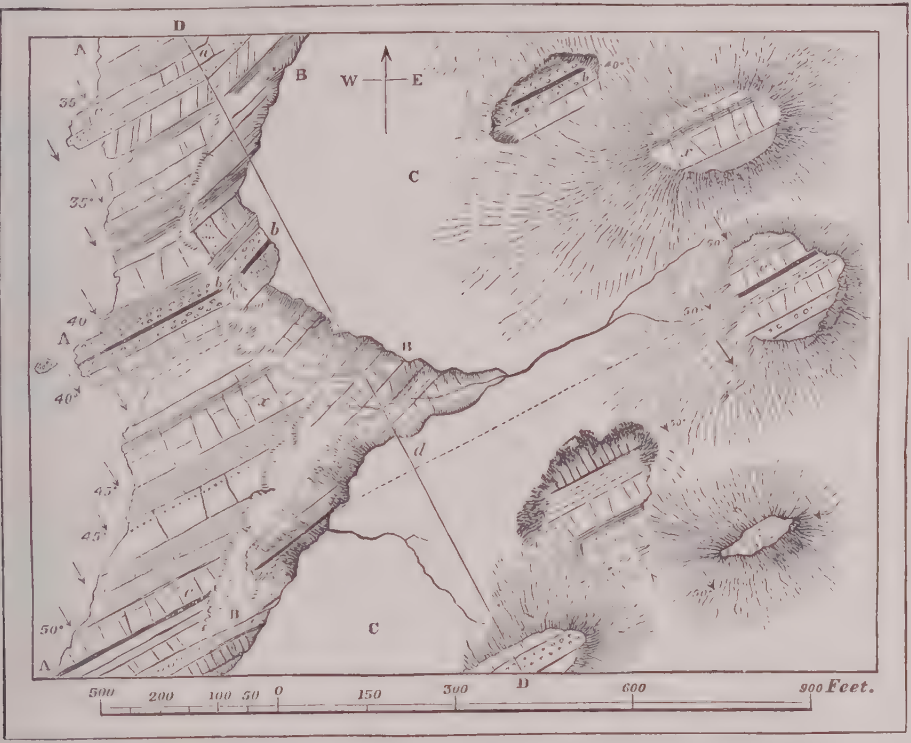

FIG. 18.—Geological map of a portion of a rocky coast-line and the country inland. (J. B. Jukes.)

IV. CURVATURES OF ROCKS.

A little reflection will show that though, so far as regards the trifling portions of the rocks visible at the surface, we might regard the inclined surfaces of the strata as parts of straight lines, they must nevertheless be parts of large curves. Take, for example, the section given in fig. 19. At the north end of that section we observe the beds to plunge one after another into the earth at an angle of 35°. By degrees the inclination increases until it reaches 50°. As there is no dislocation or abrupt change of angle, but a gradual transition, it is evident that the beds at the north end cannot proceed indefinitely downward at the same angle which they have at the surface, but must bend round to accommodate themselves to the higher inclination which sets in southwards. By prolonging the lines of the beds for some way beneath the sea-level, we can show graphically the nature of the curve. In every instance therefore where, in walking over the surface, we traverse a series of strata which gradually, and without dislocations, increase or diminish in inclination, we cross part of a great curvature in the strata of the earth's crust.

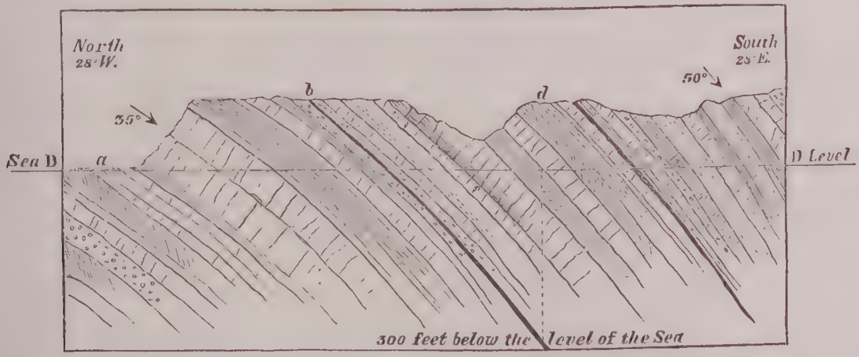

FIG. 19.—Section along the line DD on fig. 18.

Such foldings, however, can often be distinctly seen, either on some cliff or coast-line, or in the traverse of a piece of hilly or mountainous ground. The observer cannot long continue his researches in the field without discovering that the rocks of the earth's crust have been almost everywhere thrown into curves, usually so broad and gentle as to escape observation except when specially looked for. The outcrop of beds at the surface is commonly the truncation of these curves. The strata must once have risen above the present surface, and in many cases may be found descending to the surface again with a contrary dip, the intervening portion of the undulation having been worn away.

If then the inclination of rocks is so closely connected with their curvature, a corresponding relation must hold between their strike and curvature. In fact, the prevalent strike of a region is determined by the direction of the axes of the great folds into which the rocks have been thrown. If the curves are gentle and inconstant there will be a corresponding variation in the strike. But should the rocks be strongly plicated, there will necessarily be the most thorough coincidence between the strike and the direction of the plication.

The curvature occasionally shows itself among horizontal or gently inclined strata in the form of an abrupt inclination, and then an immediate resumption of the previous flat or sloping character. The strata are thus bent up and continue on the other side of the tilt at a higher level. Such bends are called *monoclines* or *monoclinal folds*, because they present only one fold, or one half of a fold, instead of the two which we see in an arch or trough. The most notable instance of this structure in Britain is that of the Isle of Wight, of which a section is given in fig. 20. The Cretaceous rocks on the south side of the island rapidly rise in inclination till they become nearly vertical. The Lower Tertiary strata follow with a similar steep dip, but rapidly flatten down towards the north coast. Some remarkable cases of the same structure have been brought to light by Mr. J. W. Powell in his survey of the Colorado region.

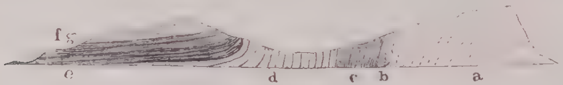

FIG. 20.—Section of the Isle of Wight—a monoclinal curve. *a*, Chalk; *b*, Woolwich and Reading beds; *c*, London clay; *d*, Bagshot series; *e*, Headon series; *f*, *g*, Osborne and Bembridge series.

It much more frequently happens that the strata have been bent into arches and troughs, so that they can be seen dipping under the surface on one side of the axis of a fold, and rising up again on the other side. Where they dip away from the axis of movement the structure is termed an *anticline* or *anticlinal fold;* where they dip towards the axis, it is a *syncline* or *synclinal fold*. The diagram in fig. 21 may be taken to represent a series of strata (1–17) thrown into an anticline (AA′) and syncline (BB′). A section drawn across these folds in the line CD would show the structure given in fig. 22. Here we see that, at the part of the anticlinal axis (A) where the section crosses, bed No. 4 forms the crown of the arch, Nos. 1, 2, and 3 being concealed beneath it. On the east side of the axis the strata follow each other in regular succession as far as No. 13, which, instead of passing here under the next in order, turns up with a contrary dip and forms the centre of a trough or syncline (B). From underneath No. 13 on the east side, the same beds rise to the surface which passed beneath it on the west side. The particular bed marked EF has been entirely removed by denudation from the top of the anticline, and is buried deep beneath the centre of the syncline.

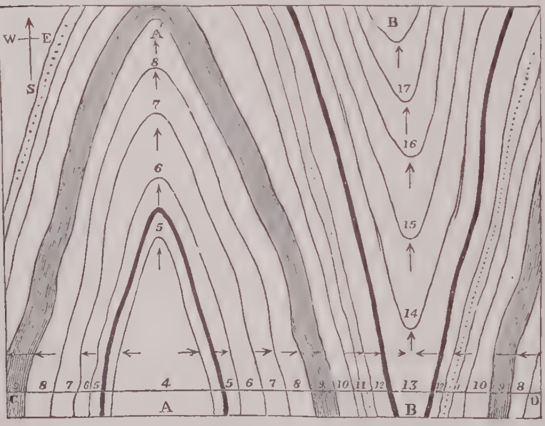

FIG. 21.—Plan of anticlinal and synclinal folds.

Such foldings of strata must always die out unless they are abruptly terminated by dislocations. In the cases given in fig. 21, both the arch and trough are represented as diminishing, the former towards the north, the latter towards the south. The observer in passing northwards along the axis of that anticline finds himself getting into progressively higher strata, as the fold sinks down. On the other hand, in advancing southwards along the synclinal axis, he loses stratum after stratum and gets into lower portions of the series. When a fold diminishes in this way it is said to "nose out." In fig. 21 there is obviously a general inclination of the beds towards the north, besides the outward dip from the anticline and the inward dip from the syncline. Hence the anticline noses out to the north and the syncline to the south.

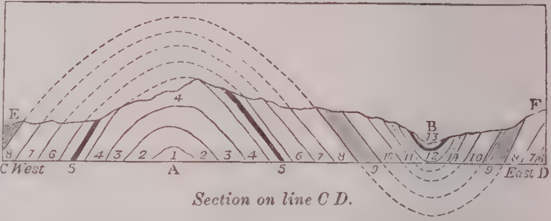

FIG. 22.—Section of anticlinal and synclinal folds on the line CD (fig. 21).

It occasionally happens that the maximum movement either of upheaval or subsidence has taken place not along a line of axis but at some one point. Hence arise, on the one hand, dome-shaped elevations of strata where the dip is outward from a centre (quaquaversal), round which the beds are disposed in successive parallel layers or rings, and, on the other hand, circular basin-shaped depressions, towards the centre of which there is a general inclination of the rocks.

So great has been the compression to which rocks have been subjected during the process of curvature that the folds may often be found inverted. This has taken place abundantly in regions of great plication. The Silurian uplands of the south of Scotland, for instance, have the arches and troughs tilted in one direction for miles together, so that in one half of each of them the strata lie bottom upwards. It is in large mountain-chains, however, that inversion can be seen on the grandest scale. The Alps furnish numerous striking illustrations. On the north side of that chain the older Tertiary rocks have been so completely turned over for many miles that the lowest beds now form the tops of the hills, while the highest lie deep below them. Individual mountains, such as the Glärnisch, present stupendous examples of inversion, great groups of strata being folded over and over above each other as we might fold carpets.

Where curvature has been carried so far, we may nearly always discover localities at which it has been so intensified that the strata have been corrugated and crumpled till it becomes almost impossible to follow out any particular bed through the disturbance. On a small scale instances of such extreme contortion may now and then be found at landslips, where fissile shales have been pressed forward by advancing heavy masses of more solid rock. But it is of course among the more plicated parts of mountain-chains that the structure receives its best illustrations. Few travellers who have passed the upper end of the Lake of Lucerne can have failed to notice the remarkable cliffs of contorted rocks near Fluelen. But innumerable examples of equal or even superior grandeur may be observed among the more precipitous valleys of the Swiss Alps. No more impressive testimony could be given to the potency of the force by which mountains were upheaved.

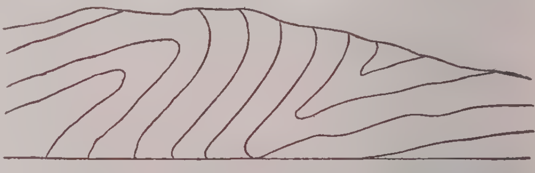

FIG. 23.—Section of inclined axes, showing consequent inversion of strata.

V. Dislocations of Rocks.

The movements which the crust of the earth has undergone have not only folded and corrugated the rocks, but have fractured them in all directions. These dislocations may be either simple *fissures*, that is, rents without any vertical displacement of the mass on either side, or *faults*, that is, rents where one side has been pushed up or has sunk down. It is not always possible in a shattered rock to discriminate between joints and true fissures. The joints indeed have sometimes served as lines along which fissuring has taken place. It is common to meet with traces of friction along the walls of fissures even when no proof of actual vertical displacement can be gleaned. The rock is more or less shattered on either side, and the contiguous faces present numerous slickensided surfaces. Mineral deposits may also commonly be observed encrusting the cheeks of a fissure, or filling up, together with broken fragments of rock, the space between the two walls.

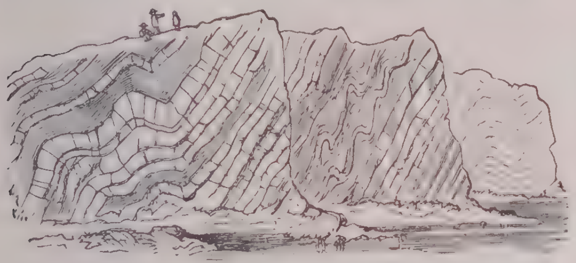
Fig. 24.—Curved and contorted rocks, near Old Head of Kinsale. (Du Noyer.)

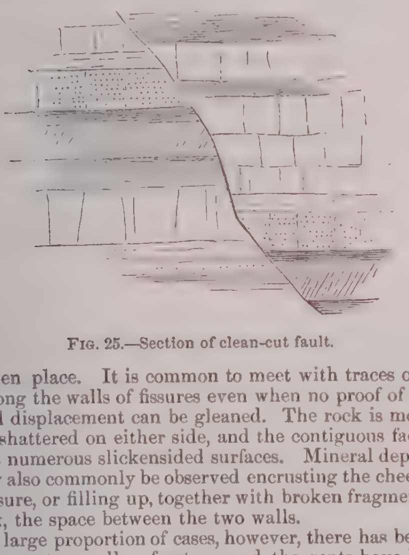
Fig. 25.—Section of clean-cut fault.

In a large proportion of cases, however, there has been displacement as well as fracture, and the rents have become faults as well as fissures. Faults on a small scale are sometimes sharply-defined lines, as if the rocks had been sliced through and fitted together again after being shifted (fig. 25). In such cases, however, the harder portions of the dislocated rocks will usually be found slickensided. More frequently some disturbance has occurred on one or both sides of the fault. Sometimes in a series of strata the beds on the side which has been pushed up are bent down against the fault, while those on the opposite side are bent up (fig. 26). Most commonly the rocks on both sides are considerably broken, jumbled, and crumpled, so that the line of fracture is marked by a belt or wall-like mass of fragmentary rock. Where a dislocation has occurred through materials of very unequal hardness, such as solid limestone bands and soft shales, or where its course has been undulating, the relative shifting of the two sides has occasionally brought opposite prominences together so as to leave wider interspaces, as in fig. 27. The actual breadth of a fault may vary from a mere chink into which the point of a knife could hardly be inserted up to a band of broken rock many yards wide. But in these latter cases we may usually suspect that so great a breadth of fractured materials has been produced not by a single fault but by a series of closely adjoining and parallel faults.

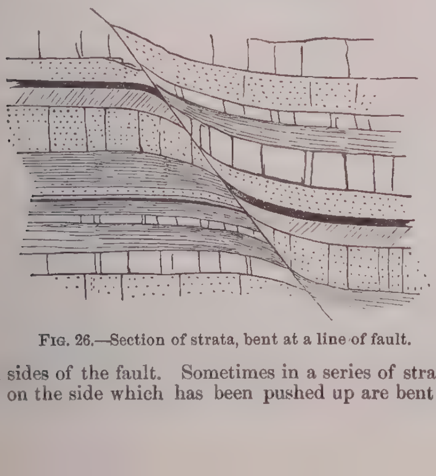
Fig. 26.—Section of strata, bent at a line of fault.

Faults are sometimes vertical, but are generally inclined. The largest faults, that is, those which have the greatest vertical displacement, slope at high angles, while those of only a few feet or yards may be inclined as low as 18° or 20°. The inclination of a fault from the vertical is called its *hade*. In fig. 28, for example, the fault between A and C being vertical has no hade, but that between C and B hades at an angle of 70° from the vertical to the right hand. The amount of displacement is represented as the same in both instances, so that the level of the bed *a* is raised between the two faults at C above the uniform horizon which it retains beyond them.

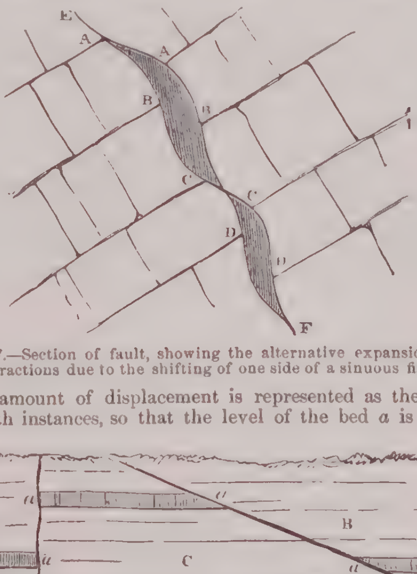

Fig. 27.—Section of fault, showing the alternative expansions and contractions due to the shifting of one side of a sinuous fissure.

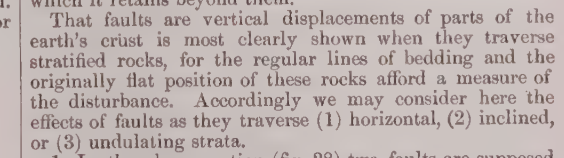

Fig. 28.—Section of a vertical and inclined fault.

That faults are vertical displacements of parts of the earth's crust is most clearly shown when they traverse stratified rocks, for the regular lines of bedding and the originally flat position of these rocks afford a measure of the disturbance. Accordingly we may consider here the effects of faults as they traverse (1) horizontal, (2) inclined, or (3) undulating strata.

1. In the above section (fig. 28) two faults are supposed to traverse a set of horizontal strata, and to displace them in opposite directions. Hence the portion between them appears as if it had been pushed up, or as if the part on either side had slipped down. The amount of vertical displacement is measured from the end of any given stratum say *a*, on one side of the fault, to its corresponding end on the other side. Suppose, for example, that the black band in fig. 29 represents a known stratum such as a seam of coal, which, having been explored in underground operations, is known to be cut by a fault at a depth of a hundred yards below the surface at A, and to lie 200 yards deep on the other side of the fault below B. The amount of displacement is the vertical distance between the two severed ends *a* and *b*. This is termed the *throw* of a fault. From these two sections

(figs. 28 and 29) we see that the horizontal distance to which the two ends of a faulted stratum may be separated does not depend upon the amount of throw but upon the angle of the hade. In the left-hand fault in fig. 28 there is no hade, for the fault is vertical; consequently there is no lateral displacement. In fig. 29, however, where the fault hades considerably, there is a lateral shift of the bed, the end *a* being 150 yards to the left of *b*. In this example the lateral shift is half as much again as the vertical. It is obvious that a fault of this kind must seriously affect the value of a coal-field; for while the coal-seam might be worked up to *a* on the one side and to *b* on the other, there would be a space of 150 yards of barren ground between these two points where the seam never could be found. The lower the angle of hade the greater the breadth of such barren ground. Hence the more nearly vertical the lines of fault, the better for the coal-fields.

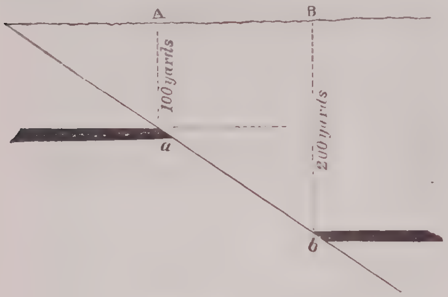

Fig. 29.—Measurement of the throw of a fault.

In the vast majority of cases faults hade in the direction of downthrow, in other words, they slope away from the side which has risen. Consequently the mere inspection of a fault in any natural or artificial section suffices in most cases to show which side has been elevated. In mining operations the knowledge of this rule is invaluable, for it decides whether a coal seam, dislocated by a fault, is to be sought for by going up or down. In fig. 29, for example, a miner working from the right and meeting with the fault at *b*, would know from its hading towards him that he must ascend to find the coal. On the other hand were he to work from the left and catch the fault at *a*, he would see that it would be necessary to descend. According to this rule a normal fault never brings one part of a bed below another part, so as to be capable of being pierced twice by the same vertical shaft. Exceptional cases, however, where the hade is reversed, do occasionally appear. In fig. 30 a series of strata, 1 to 11, are represented as folded in an inverted anticline, and broken through by a fault along the axis, the portion on the right side having been pushed up. The effect of the movement has been to make the ends of the beds on that side overlie higher beds on the other side. A shaft would thus pierce the same stratum twice. Instances of reversed faults are chiefly met with in much disturbed districts, such as mountain chains, where the rocks have been affected by great undulations and corrugations. But instances on a small scale, like that in fig. 31, may now and then be encountered even in lowland districts, where no great disturbance has taken place.

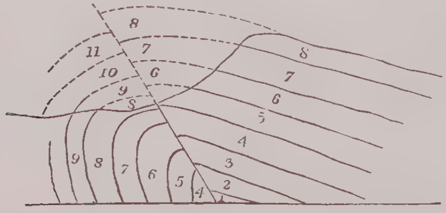

Fig. 30.—Inverted anticline and reversed fault.

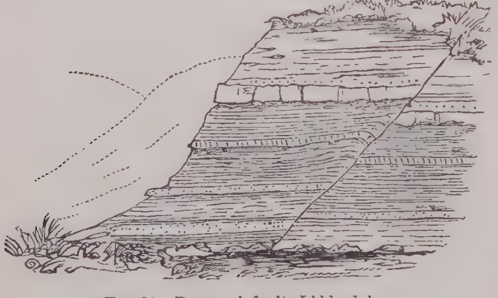
Fig. 31.—Reversed fault, Liddesdale.

2. Faults traversing inclined strata usually group themselves into two series, one running in the same general direction as the dip of the strata, the other approximating to the trend of the strike. They are accordingly classified as *dip-faults* and *strike-faults*. They are not always to be sharply marked off from each other, for the dip-faults will often be observed to deviate considerably from the normal direction of dip, and the strike-faults from the prevalent strike, so that in such cases they pass into each other.

A dip-fault produces at the surface the effect of a lateral shift of the strata. This effect increases in proportion as the angle of dip lessens. It ceases altogether when the beds are vertical. Fig. 32 may be taken as a plan of a dip-fault traversing a series of strata which dip northwards at 25°. The beds on the east side look as if they had been pushed horizontally southwards. That this apparent horizontal displacement is due really to a vertical movement, and to the subsequent planing down of the surface by denuding agents, will be clear if we consider what must be the effect of the vertical ascent or descent of the inclined beds on one side of a dislocation. Take the bed *a* in fig. 32, and suppose it to be still unbroken by the fault. It will then run in a straight east and west line. When the fault takes place, the part on the west side is pushed up, or, what comes to the same, that on the east side is let down. A horizontal plane cutting the dislocated stratum will show the portion on the west side lying to the north of that on the east side of the fracture. The effect of denudation has usually been practically to produce such a plane, and thus to exhibit an apparently lateral shift. This surface displacement has been termed the *heave* of a fault. Its dependence upon the angle of dip of the strata may be seen by a comparison of figs. 33 and 34. In the former figure the bed *a*, once prolonged above the present surface (marked by the horizontal line), is represented as having dropped from *db* to *ec*, the angle of inclination being 25°. The heave amounts to the horizontal distance between *b* and *e*. But if the angle should rise to 60°, as in fig. 34, though the amount of throw or vertical displacement remains the

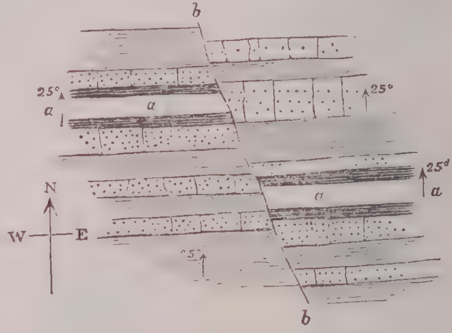

Fig. 32.—Plan of strata, cut by a dip-fault.

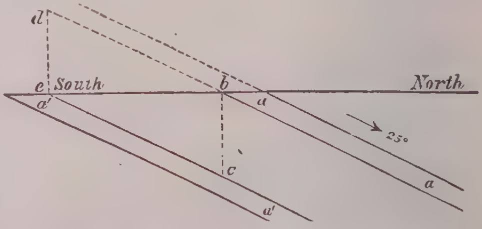

Fig. 33.—Section along the line of a fault in strata dipping at 25°.

same, we see that the heave or horizontal shift diminishes to about a quarter of what it is in fig. 33. This diminution would continue with every increase of inclination in the strata till among vertical beds there would be no heave at all.

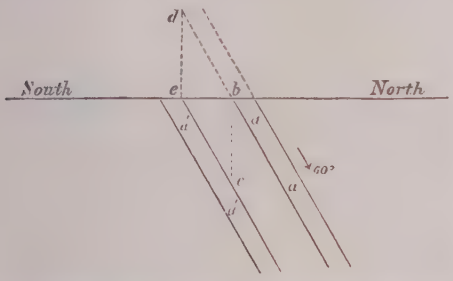

Fig. 34.—Section along the line of a fault in strata dipping at 60°.

Strike-faults, where they exactly coincide with the strike, may sometimes remove the outcrop of some strata by never allowing them to reach the surface. Fig. 35 shows a plan of one of these faults (FF), having a downthrow to the north. In crossing the ground from north to south we pass successively over the edges of all the beds, except Nos. 3 and 4, which are cut out by the fault as shown in fig. 36, which is a section drawn across the ground at a right angle to the strike. It seldom happens, however, that such strict coincidence between faults and strike continues for more than a short distance. The dip is apt to vary a little even among comparatively undisturbed strata, and every such variation causes the strike to undulate and thus to be cut more or less obliquely by the line of dislocation, which may nevertheless run quite straight. Moreover, any increase or diminution in the throw of a strike-fault will of course have the effect of bringing the dislocated ends of the beds against the line of dislocation. In fig. 37, for instance, which represents in plan another strike-fault, we see that the amount of throw is diminishing towards the left so as to allow lower beds to successively appear, until, at the extreme left side of the ground, the fault merely brings one part of the same bed (No. 5) against another part.

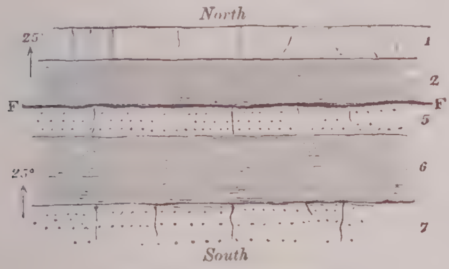

Fig. 35.—Plan of a strike-fault.

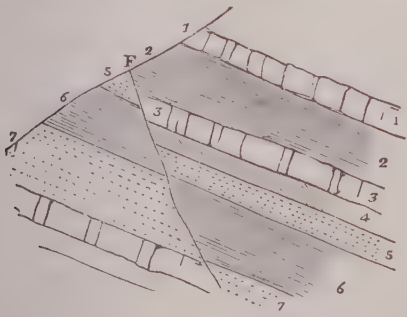

Fig. 36.—Section across the plan, fig. 35.

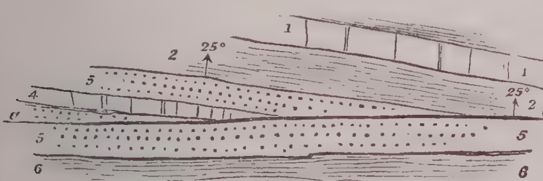

Fig. 37.—Plan of strata traversed by a diminishing strike-fault.

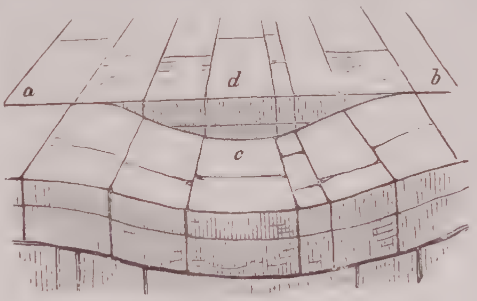

Fig. 38.—Curving of strata on one side of a fault.

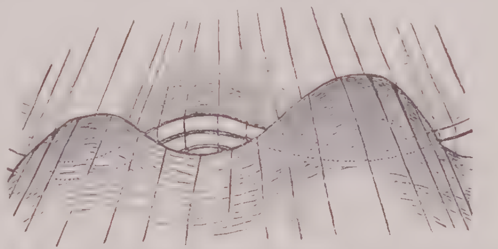

Fig. 39.—Diagram of gently undulating strata cut by a fault, with alternate throw in opposite directions.

3. Their effects become more complicated where faults traverse undulating and contorted strata. Sometimes we can distinctly trace an undulation as the result of a fault. In the flat limestone beds shown in fig. 38, for example, there can be no doubt that the gentle depression from *d* to *c* would not have taken place but for the existence of the fault *ab*. But in all countries where the rocks have been thrown into folds and corrugations these structures are traversed by faults. It then often happens that the same fault appears to be alternately a downthrow on opposite sides. Let us suppose a series of gently rolling strata to be cut by a transverse fault as in the diagram in fig. 39. At each of the two ridges on the near side of the fault the effect is an upthrow, while in the intervening valley it is a downthrow. On the opposite side of the fault each of these effects is reversed. It rarely happens, however, that a fault makes any such visible crack at the surface. The rocks have all been worn down so much that it is usually only by careful examination of their dip that the existence of faults can be determined.

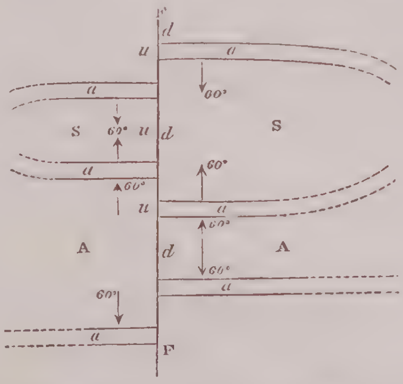

Fig. 40.—An anticline (A) and syncline (S), dislocated by a fault.

The influence of faults upon curvatures may be illustrated by a plan and sections of a dislocated anticline and syncline, which will also show clearly how the apparently lateral displacement of outcrop produced by dip-faults is due to vertical movement. Fig. 40 represents a plan of strata thrown into an anticlinal fold AA and a synclinal fold SS, and traversed by a fault FF, which is an upthrow to the left hand. We have seen that a dip-fault always shifts the outcrop to the dip on the upthrow side, and this will be observed to be the case here. Beginning at the upper side of the diagram, which may be called north, we notice that the bed *aa*, dipping towards the lower side or south at 60°, is truncated by the fault at *u*, and that the portion on the upthrow side is shifted forwards or southward. Crossing the syncline we meet with the same bed, and as the upthrow of the fault still continues on the same side we must go some way southwards on the downthrow side before we meet with its continuation. On the southern slope of the anticline the same bed once more appears, and again is shifted forwards as before. A section along the left or upcast side (*uu*) of the fault would give the structure represented in fig. 41; while one along the downcast side (*dd*) would be as in fig. 42. These two sections clearly prove that the shifting of the outcrops at the surface can be simply explained by a mere vertical movement. They also show that faults which cross anticlinal and synclinal folds narrow the anticlines but widen the synclines on the downthrow side, while they widen the anticlines and narrow the synclines on the upthrow side.

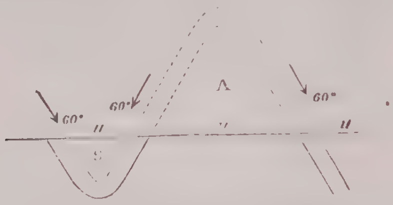

FIG. 41.—Section along the upcast side of the fault in fig. 40.

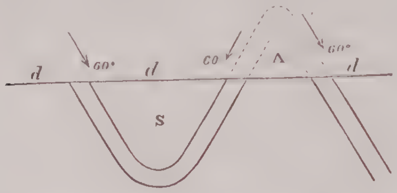

FIG. 42.—Section along the downcast side of same fault.

FIG. 43.—Plan of single fault.

Dislocation may take place either by a single fault or as the combined effects of two or more. Where there is only one fault, as in fig. 43, one of its sides may be pushed up or let down, or there may be a simultaneous opposite movement on either side. In such cases, there must be a gradual dying out of the dislocation towards either end; and there will usually be one or more points where the displacement has reached a maximum. Sometimes, as shown in fig. 44, a fault with a considerable maximum throw (35 feet, yards, or fathoms, in the drawing) splits into minor faults at the terminations. Examples of this kind occur not unfrequently in coal-workings. In other cases the offshoots take place along the line of the main fissure (fig. 45). Exceedingly complicated examples occur in some coal-fields, where the connected faults become so numerous that no one of them deserves to be called the main or leading dislocation.

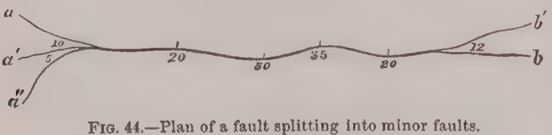

FIG. 44.—Plan of a fault splitting into minor faults.

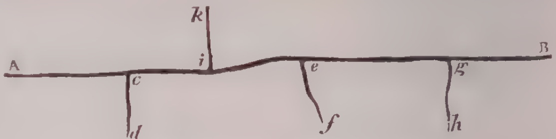

FIG. 45.—Plan of main fault, with branches.

The subsidence or elevation of a large mass or block of rock has more usually taken place by a combination of faults. If we suppose two fissures to meet at a point, as at *b* in fig. 46, and to die out respectively at *a* and *c*, the intervening triangular mass *ed* may be moved upwards or downwards, or it may remain stationary while the surrounding ground is displaced. The maximum displacement in such an instance would be sought for towards *b*; in the direction *e* there would be no displacement at all.

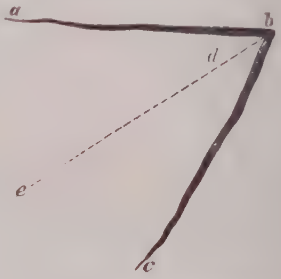

FIG. 46.—Plan of two fissures.

It often happens that, by a succession of parallel and adjoining faults, a series of strata is so dislocated that a given stratum which may be near the surface on one side is carried down by a series of steps to some distance below. Excellent examples of these *step-faults* (fig. 47) are to be seen in the coal-fields on both sides of the upper part of the estuary of the Forth. Instead, however, of having the same downthrow, parallel faults frequently show a movement in opposite directions. If the mass of rock between them has subsided relatively to the surrounding ground, they are *trough-faults* (fig. 48). They enclose wedge-shaped masses, of which the apices, formed by the junction of two faults, point downwards. In the accompanying section (fig. 49) of a portion of the thick coal of South Staffordshire, drawn to scale by Mr. Johnson of Dudley (*Records of Geol. Survey*, vol. i. part 2, p. 313), the commencement of a trough-fault is shown in the centre of the figure.

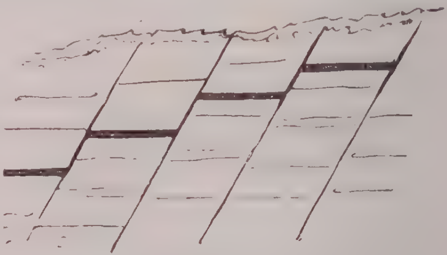

FIG. 47.—Section of strata cut by step-faults.

The late Mr. Jukes carefully described this interesting section, and showed that the coal must once have been more arched than now, and that on the cessation of the elevatory process the fractured pieces adjusted themselves to their new position by means of dislocations. The mass of higher beds (A) driven as a wedge into the coal, has hindered the bed from regaining its horizontality, and at the same time has caused the adjacent parts of the coal (BB) to be so crushed by the enormous pressure as to have been reduced to "a paste of coal dust and very small coal" (*Memoir on South Staffordshire Coal-field*, 2d ed., p. 194).

It will be observed that the hade of the faults is towards the downthrow side, and that the wedge-shaped masses with broad bottoms have risen, while those with narrow bottoms and broad tops have sunk.

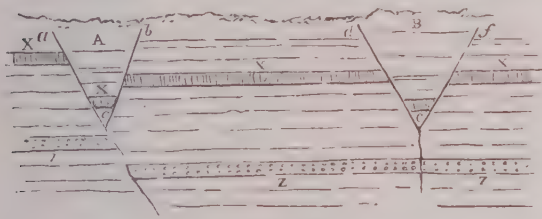

FIG. 48.—Trough-faults.

It has been already (*ante*, p. 233) pointed out that faults are traceable to the effects of elevation. The general hade or inclination of faults towards the side of downthrow was satisfactorily explained by the late Mr. Jukes in the last edition of the present work.

"Suppose," he says, "that in diagram fig. 50 we have a portion of the earth's crust, of which AB is the surface, and CD a plane acted on by some widespread force of expansion tending to bulge upwards the part ABCD. If then a fracture takes place along the line EF, it is obvious that the expanding force will, on the side of AC, have the widest base CF to act upon, while it will have a proportionately less mass to move in the part AECF, which grows gradually smaller towards the surface, than on the other side of the fault, where, with the smaller base FD, the mass FDBE continually grows larger towards the surface. The mass G will consequently be much more easily raised into the position A*e*C*f*, than the mass H into the position D*f*′B*e*′, the elevation of which could hardly take place without leaving a great open gap along the line of fault between FE and *f*′*e*′, and, moreover, without leaving the projecting piece *e*′ overhanging without any support.

"This is yet more clearly perceptible if we suppose two such fissures, as in fig. 51, inclining towards each other, since, if we suppose the included piece I to be elevated into the position indicated by the dotted lines, it becomes utterly unsupported unless we suppose huge dykes or ejections of igneous rock to issue out along each fault. But this would remove the case from the class of fractures we are at present considering."

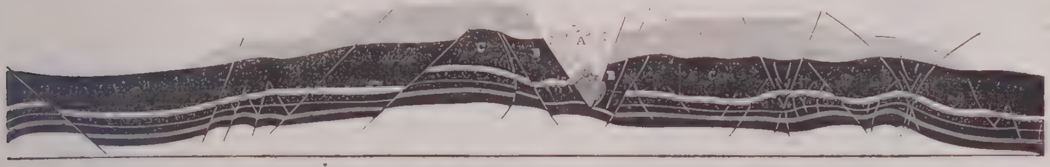

FIG. 49.—Section of a faulted part of the thick coal of South Staffordshire.

Trough-faults offer at first some difficulty. In fig. 48, for example, it is evident that in both the wedge-shaped masses (A and B) there has been subsidence. The bed X is cut by four faults. In the space B two of these faults hade towards each other, and as they have the same amount of throw the level of the bed remains unchanged on either side. In the other trough, however, the fault *a* has a throw twice as much as that of *b* which it completely cuts off. The two faults *d* and *f* neutralize each other, and are connected with a vertical fissure without any throw. The fault *a* however descends with its persistent hade and dislocates the bed Z and the other strata below. Mr. Jukes proposed the following satisfactory explanation of this kind of structure.

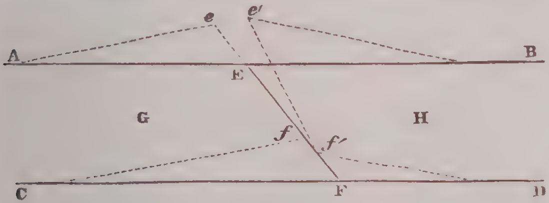

FIG. 50.

"Suppose the beds AA, BB, etc. (fig. 52), to have been formerly in a state of tension, arising from the bulging tendency of an internal force, and one fissure, FE, to have been formed below, which on its course to the surface splits into two, ED and EC. If the elevatory force were then continued, the wedge-like piece of rock W between these two fissures, being unsupported, as the rocks on each side separated, would settle down into the gap as in fig. 53. If the elevatory action were greater near the fissure than farther from it, the single fissure below would have a tendency to gape upwards, and swallow down the wedge, so that eventually this might settle down, and become fixed at a point much below its previous relative position. Considerable friction and destruction of the rocks, so as to cut off the corner *gh* (fig. 53) on either side, would probably take place along the sides of the fissures, and thus widen the gap, and allow the wedge-shaped piece W to settle down still further.

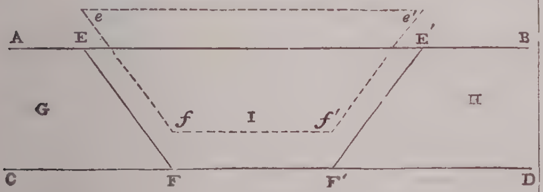

FIG. 51.

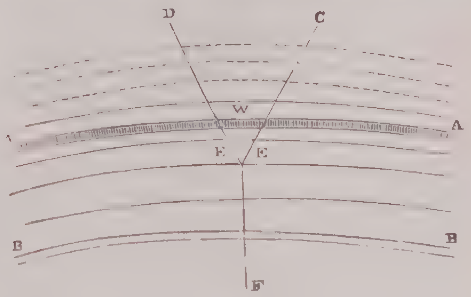

FIG. 52.

"When the forces of elevation were withdrawn, the rocks would doubtless have a tendency to settle down again, but these newly-included wedge-shaped, and other masses, would no longer fit into the old spaces, so that great compression and great *lateral* pressure might then take place."

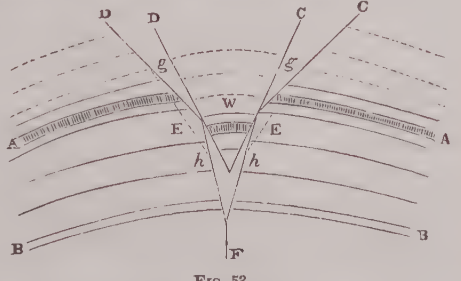

FIG. 53.

In fig. 49 an excellent illustration is afforded of how an arched mass of strata has been faulted, and how trough-faults have been formed.

VI.—CLEAVAGE.

There is yet another system of divisional planes, termed *cleavage*, by which rocks are sometimes traversed. When this structure is well developed it divides a rock into parallel laminæ, which run at a high angle quite independently of stratification or any other divisional planes. It is most perfect in proportion to the fineness of grain of the material in which it occurs. Hence fine argillaceous rocks show it admirably. An ordinary roofing slate may be taken as an illustration of a cleaved rock; its opposite surfaces are *cleavage-planes*, while the opposite faces of a slab of shale would be stratification-planes. Though most perfectly exhibited by clay-slate, cleavage occurs in other rocks, even in old lavas and tuffs, limestones, and sandstones or greywackes; but as the texture increases in coarseness the cleavage lines become more undecided and further apart. The structure may be observed to vary in distinctness in the same face of rock, being well defined among bands of slate, but becoming faint or even disappearing in intercalated beds of sandstone or grit.

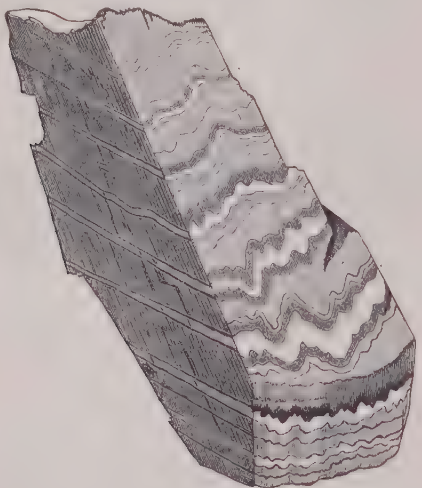

FIG. 54.—Sketch (by the late Mr. Du Noyer) of a block of variegated slate from Devil's Glen, county Wicklow. The crumpled bands mark the bedding, and the fine perpendicular striæ in front are the cleavage planes; the fine lines on the darkened side merely represent *shadow*, and must not be taken for planes of division in the rock. It will be observed that the cleavage planes do not pass through the white bands.

The direction of cleavage usually remains persistent over considerable regions, and, as was shown by Sedgwick, corresponds on the whole with the strike of the rocks. It is, however, independent of bedding. Among curved rocks the cleavage planes may be seen traversing the contortions without sensible deflexion from their normal direction, parallelism, and high angle. Mr. Jukes pointed out that over the whole of the south of Ireland the trend of the cleavage seldom departs 10° from the normal direction E. 25° N., no matter what may be the differences in character and age of the rocks which it crosses. Some of the more obvious characters of cleavage are shown in fig. 54, which represents a block of cleaved variegated slate about 18 inches in height. The left side of the block which is in shadow is formed by a smooth cleavage plane, and the whole block might be split into laminæ parallel to that plane as shown by the cleavage lines in front. The lines of stratification are marked by the white and dark contorted bands, the axes of which evidently correspond nearly with the direction of the cleavage. These bands are commonly marked in nature by zones of different color, and sometimes of texture. In the present instance the white bands are more sandy than the rest of the mass, and the cleavage-planes only partially enter them. This specimen is further interesting as it bears witness by its puckered bedding to the great lateral pressure in virtue of which, as we have already seen (*ante*, p. 232), the cleavage structure has been produced.

VII. IGNEOUS ROCKS AS PART OF THE STRUCTURE OF THE EARTH'S CRUST.

In this section we shall consider the part taken by igneous rocks in the architecture of the earth's crust. Their lithological differences having already been described in part ii., it is their larger features in the field that now require attention—features which in some cases can be well illustrated by reference to the action of modern volcanoes, and in other cases bring before us parts of the economy of volcanoes which can never be reached in any recent cone. A study of the igneous rocks of former ages thus serves to augment our knowledge of volcanic action.

At the outset an obvious distinction must be drawn between those igneous masses which reached the surface and consolidated there, like modern lava streams or showers of ashes, and those which we must believe never found their way to the surface but consolidated at a greater or less depth beneath it. There must be the same division to be drawn in the case of every active volcano of the present day. But we can examine only the materials which reach the surface, and we can but speculate as to the nature and arrangement of what still lies underneath. In the revolutions to which the crust of the earth has been subjected, however, the subterranean continuations of volcanic sheets have often been laid bare, and not only so, but sections have been opened into the very heart of masses which, though molten and eruptive, seem never to have been directly connected with actual volcanic outbursts. All those subterranean intruded masses, which are now revealed at the surface only after the removal of the depth of rock which once covered them, may be grouped together into one division under the names *plutonic*, *intrusive*, or *subsequent*. On the other hand, all those which came up to the surface as ordinary volcanic rocks, whether molten or fragmental, and were consequently contemporaneously interstratified with the formations which happened to be in progress on the surface at the time, may be classed in a second group under the names *volcanic*, *interbedded*, or *contemporaneous*.

It is obvious of course that these are only relative terms. Every truly volcanic mass which, by being poured out as a lava-stream at the surface, came to be regularly interstratified with contemporaneous accumulations, must have been directly connected below with molten matter which did not reach the surface. One part of the total mass therefore would be included in the second group, while another portion, if ever exposed by geological revolutions, would be classed with the first group. Seldom, however, can the same masses which flowed out at the surface be traced directly to their original underground prolongations. It is evident that an intrusive rock, though necessarily subsequent in age to the rocks through which it has been thrust, need not be long subsequent. Its relative date can only be certainly affirmed with reference to the rocks through which it has broken. It may be older than other rocks through which it has not been intruded, but which lie almost immediately above it. The probable geological date of its eruption must be decided by the evidence to be obtained from the grouping of the rocks all around. Its intrusive character can only certainly determine the limit of its antiquity. We know that it must be younger than the rocks it has invaded; how much younger must be otherwise determined. On the other hand, an interbedded or contemporaneous igneous rock has its date precisely fixed by the geological horizon on which it lies. A lava-bed or tuff intercalated among strata containing *Sphenopteris affinis*, *Lepidodendron veltheimianum*, *Leperditia*, and other associated fossils, would unequivocally prove the existence of volcanic action at the surface during the Lower Carboniferous period, and at that particular part of the period represented by the horizon occupied by the volcanic bed. An interbedded and an intrusive mass found on the same platform of strata would not necessarily be coeval. On the contrary, the latter, if clearly intruded along the horizon of the former, would necessarily be posterior in date. It will be understood then that the two groups have their respective limits determined solely by their relations to the rocks among which they may happen to lie.

The value of this classification for geological purposes is great. It enables the geologist to place and consider by themselves the granites, quartz-porphyries, and other crystalline masses which, though lying sometimes perhaps at the roots of ancient volcanoes, and therefore intimately connected with volcanic action, yet owe their special characters to their having consolidated under pressure at some depth within the earth's crust; while he arranges in another series the lavas and tuffs which, thrown out to the surface, bear the closest resemblance to the ejected materials from modern volcanoes. He is thus presented with the records of hypogene igneous action in the one group, and with those of superficial volcanic action in the other. He is furnished with a method of chronologically arranging the volcanic phenomena of past ages, and is thereby enabled to collect materials for a history of volcanic action over the globe.

In adopting this classification for unravelling the geological structure of a region where igneous rocks abound, the geologist will encounter instances where it may be difficult or impossible to decide in which group a particular mass of rock must be placed. He will bear in mind, however, that after all, such schemes of classification are proposed only for convenience in systematic work, and that there are no corresponding hard and fast lines in nature. He will recognize that all crystalline or glassy igneous rocks whether the portion visible be interbedded or intrusive, must be intrusive at a greater or less depth from the surface. Every contemporaneous sheet has proceeded from some internal pipe or mass, so that though interbedded and contemporaneous with the strata at the top, it is intrusive in relation to the strata below. But we cannot always assert that an intrusive mass must have been connected with an outflowing interbedded sheet above.

Section I.—Plutonic, Intrusive, or Subsequent Igneous Rocks.

Under this section we have to consider the part played by igneous rocks which, either possessing a crystalline (sometimes glassy or felsitic) structure have been injected in a fluid or at least viscous condition into other rocks, or having been blown into fragments have consolidated in volcanic pipes. After some practice in the field the geologist learns to recognize these rocks, and to distinguish them from the similar masses which must be placed in the contemporaneous series. As a rule their crystalline texture is coarser than in that series; only in a few rare cases does a cellular or amygdaloidal character appear, and the fragmental accompaniments so characteristic of the contemporaneous sheet are only found in the actual vents of eruption. Granite, syenite, felsite, diorite, basalt, and agglomerate occur in this form.

The general law which has governed the intrusion of igneous rock within the earth's crust may be thus stated: every fluid mass impelled upwards by pressure from below, or by the expansion of its own imprisoned vapor, has sought egress along the line of least resistance. What that line was to be has depended in each case upon the structure of the terrestrial crust and the energy of eruption. In many instances it has been determined by an already existent dislocation; in others by the planes of stratification, or by the surface of junction of two unconformable formations, or by irregular cracks and rents, or by other more complex lines of weakness. Sometimes the intruded mass has actually fused and obliterated some of the rock which it has invaded, incorporating this portion into its own substance. The shape of the channel of escape has necessarily determined the form of the intrusive rock, as the mould regulates the form assumed by a mass of cast-iron. This offers a very convenient means of classifying the intrusive rocks. According to the shape of the mould in which they have solidified, they may be arranged as—(1) amorphous masses, (2) sheets, (3) veins and dykes, and (4) necks.

I. Amorphous Masses.—These consist chiefly of crystalline coarse-textured rocks. Granite and syenite are the most conspicuous, but there are to be included also various quartz-porphyries, felsites, diorites, etc. Where rocks occur in this form which also are found in sheets and dykes as well as contemporaneous beds, it is commonly observed that they are more coarsely crystalline in the form of amorphous masses than in any other. Doleritic rocks afford many examples of this characteristic.

Granitic Bosses.—It was once a firmly-held tenet that granite is the oldest of rocks, the foundation on which all other rocks have been laid down. This idea no doubt originated in the fact that granite is found rising from beneath gneiss, schist, and other crystalline masses which in their turn underlie very old stratified formations. The intrusive character of granite, shown by its numerous ramifying veins, proved it to be later than at least those rocks which it had invaded. Nevertheless the composition and structure of gneiss and mica-schist were believed to be best explained by supposing these rocks to have been derived from the waste of granite, and thus, though the existing intrusive granite had to be recognized as posterior in date, it was regarded as only a subsequent protrusion of the vast underlying granitic crust. In this way the idea of the primeval or fundamental nature of granite held its ground.

From what has already (*ante*, p. 229) been said regarding the fusion and consolidation of rocks, and the evidence supplied on this subject by granite itself, it will readily be understood that the first or original crust could hardly have been one of granite. That rock, so far as can be made out by careful microscopic examination, appears to have always consolidated under considerable pressure, and in the presence of superheated water and even of liquid carbonic acid—conditions which probably never obtained at the earth's immediate surface. The original crust may have been of a glassy character like some of the vitreous lavas; but whatever it was, no trace of it has ever been or is ever likely to be found.

The presence of granite at the existing surface must in all cases be due to the removal by denudation of the masses of rock under which it originally consolidated. The fact that, wherever extensive denudation of an ancient series of crystalline rocks has taken place, a subjacent granite nucleus is apt to appear does not prove that rock to be of a primeval origin. It shows, however, that the lower portions of crystalline rocks very generally assume a granitic type, and it suggests that if at any part of the earth we could bore deep enough into the crust we should probably come to a granitic layer. That this layer, even if general round the globe, is not always of the highest geological antiquity is abundantly clear from the fact that in many cases it can be proved to be of later date than fossiliferous formations the geological position of which is known; that is, the granitic layer has invaded these formations, rising up through them, and probably melting down portions of them in its progress. This is true not only of ancient Palæozoic but of other stratified rocks of various much more recent ages. So that we must conclude that granite does not belong exclusively to the earliest nor to any one geological period, but rather that it has been formed at various epochs, and may even be forming now, wherever the conditions required for its production have existed. As a matter of fact granite occurs much more frequently in association with older and therefore lower than with newer and higher rocks. But a little reflection shows us that this must be the case. Granite having a deep-seated origin must rise through the lower and more ancient masses before it can reach the overlying more recent formations. But many protrusions of granite would doubtless never ascend beyond the lower rocks. Subsequent denudation would be needed to reveal these protrusions, and this very process would remove the later formations and at the same time any portions of the granite which might have reached them.

Granite frequently occurs in the central parts of mountain chains; sometimes it forms there a kind of core round which the various gneisses, schists, and other crystalline rocks are arranged with more or less irregularity. More frequently it appears in large eruptive bosses which traverse indifferently the rocks on the line of which they rise. Sometimes it even overlies the schistose and other rocks, as in the Piz de Graves in the upper Engadine, where a wall-like mass of granite, with syenite, diorite, and altered rocks, may be seen resting upon schists. In the Alps and other mountain ranges it is found likewise in large bed-like masses which run in the same general direction as the rocks with which they are associated.

Many of the most characteristic features of granitic bosses can be admirably studied where the rock has risen through contorted sedimentary formations, which form undulating or hilly ground rather than mountains. The granite of the south-east and east of Ireland, the south of Scotland, and the south-west of England may be taken as illustrative examples.

In the south-east of Ireland a mass of granite 70 miles in length and from 7 to 17 in width stretches from north-east to south-west, nearly along the strike of the Lower Silurian rocks. These strata, however, have not been upraised by it in such a way as to expose their lowest beds dipping away from the granite. On the contrary, they seem to have been contorted prior to the appearance of that rock; at least they often dip towards it, or lie horizontally or undulate upon it, apparently without any reference to movements which it could have produced. As Mr. Jukes has shown, the Silurian strata are underlaid by a vast mass of Cambrian rocks, all of which must have been invaded by the granite before it could have reached its present horizon. He infers that the granite must have slowly and irregularly eaten its way upward through the Silurian rocks, absorbing much of them into its own mass as it rose. For a mile or more the stratified beds next the granite have been altered into mica-schist, and are pierced by numerous veins from the invading rock. Within the margin of the granitic mass belts or rounded irregular patches of schist are enclosed; but in the central tracts where the granite is widest, and where, therefore, we may suppose the deepest parts of the mass have been laid bare, no such included patches of altered rock occur. From the manner in which the schistose belt is disposed round the granite, it is evident that the upper surface of the latter rock where it extends beneath the schists must be very uneven. Doubtless it rises in some places much nearer to the present surface of the ground than at others, and sends out veins and strings which do not appear above ground. If, as Mr. Jukes supposes, a thousand feet of the schists could be restored at some parts of the granite belt, no doubt the belt would there be entirely buried; or if, on the other hand, the same thickness of rock could be stripped off some parts of the band of schist, the solid granite underneath would be laid bare. The extent of granite surface exposed must thus be largely determined by the amount of denudation, and by the angle at which the upper surface of the granite is inclined beneath the schists. Where the inclination is high, prolonged denudation will evidently do comparatively little in widening the belt. But where the slope is gentle, and especially where the surface undulates, the removal for some distance of a comparatively slight thickness of rock may uncover a large breadth of underlying granite.[1]

Recent observations by Professor Hull and Mr. Traill of the Geological Survey have shown that in the Mourne Mountains a mass of granite has in some parts risen up through highly inclined Silurian rocks, which consequently seem to be standing almost upright upon an underlying boss of granite. The strata are sharply truncated by the crystalline mass, and are indurated but not otherwise altered. The intrusive nature of the granite is well shown by the way in which numerous dykes of dark melaphyre are cut off when they reach that rock.[2]

In the Lower Silurian tract of the south of Scotland several large intrusive bosses of granite occur. The strata do not dip away from them on all sides, but with trifling exceptions maintain their normal N. E. and S. W. strike up to the granite on one side, and resume it again on the other. The granite indeed occupies the place of so much Silurian greywacke and shale. There is usually a metamorphosed belt of variable width in which, as they approach the granite, the stratified rocks assume a schistose or gneissoid character. Numerous small, dark, often angular patches or fragments of mica-schist may be observed along the marginal parts of the granite. Similar features are presented by the granite bosses of Devon and Cornwall which have risen through Devonian strata.

The manner in which some bosses of granite penetrate the rocks among which they occur strongly reminds one of the structure of volcanic necks or pipes. The granite is found as a circular or elliptical mass which seems to descend vertically through the surrounding rocks without seriously altering or disturbing them, as if a tube-shaped opening had been blown out of the crust of the earth up which the granite had risen. Several of the granite masses of the south of Scotland exhibit this character very strikingly. That granite and granitoid rocks have actually been associated with volcanic action is shown by the way in which they occur in connection with the Tertiary volcanic rocks of Skye, Mull, and other islands in the Inner Hebrides. As Mr. Jukes suggested many years ago, granite or granitoid masses may lie at the roots of volcanoes, and may be the source whence the more silicated lavas, such as trachyte and liparite, proceed.[3]

That some granite, however, is of metamorphic origin, that is to say, has been produced by the gradual softening and recrystallization of other rocks at some depth within the crust of the earth, seems to be now satisfactorily established. Such granite may be looked upon as the extreme of metamorphism, the various schists and gneisses being less advanced stages of the process. Provided the chemical composition of the altered rock be the same as that of granite, it is not necessary that the granite resulting from its alteration should be supposed to differ in any noteworthy particular from ordinary intrusive or igneous granite. The members of the Geological Survey of Ireland have indeed distinguished two granites in Galway, one of which they regard as metamorphic, the other as igneous. The former is characterized by the occurrence of two felspars (orthoclase and oligoclase); the latter contains only one (orthoclase). More recently, however, in the east of the country they have separated two groups of granites, of which the intrusive masses are composed of dark-colored quartz, orthoclase, albite, and black mica (Mourne Mountains), while the metamorphic variety is formed of grey felspar, quartz, and black mica. The mineralogical composition of granite formed by the metamorphism of other and specially sedimentary rocks must necessarily vary with that of the masses out of which it has arisen. In some cases there is a regular gradation from true granite outward into the schistose and gneissose masses. But this passage need not always occur, for if the granite was subject to unequal pressure (which it assuredly would in most cases be) it would in its soft, pasty condition undoubtedly be squeezed into any rents made in the surrounding rocks, and would thus imitate exactly a truly igneous mass, which in actual fact it would then be. When a mass of granite rises through unaltered or only locally altered strata, it may fairly be assumed to be igneous and intrusive. When, on the other hand, it is intimately associated with extensive masses of schist and gneiss, many of which can only be distinguished from it by their foliated structure, its metamorphic origin may at least be strongly suspected. Fundamentally, indeed, igneous and metamorphic granite seem to be due only to different modifications of the same subterranean processes. A mass of originally sedimentary rocks may be depressed to a depth of several thousand feet within the earth's crust, subjected there to vast pressure and considerable heat in presence of interstitial water or steam, and may thus be metamorphosed into crystalline schists. A portion of this mass, undergoing extreme alteration, may so completely lose all trace of its original fissile structure as to become amorphous crystalline granite, some of which may even be thrust as veins into the less highly changed parts above and around. One stage further would bring before us a connection opened between the surface and such a deep-seated granitic mass, and the consequent ascent and outburst of acid lavas and their fragmental accompaniments.

Amorphous Masses of Diorite, etc.—On a smaller scale usually than granite, other crystalline rocks assume the condition of amorphous bosses. Syenite, diorite, quartz-porphyry, and members of the basalt family have often been erupted in irregular masses, partly along fissures, partly along the bedding, but often involving and apparently melting up portions of the rocks through which they have made their way. Such bosses have frequently tortuous boundary-lines, since they send out veins into or cut capriciously across the surrounding rocks. In Wales, as shown by the maps and sections of the Geological Survey, the Lower Silurian formations are pierced by huge bosses of different crystalline rocks, mostly included under the old term "greenstone," which, after running for some way with the strike of the strata, turn round and break across it, or branch and traverse a considerable thickness of stratified rock. In central Scotland numerous masses of dolerite and quartziferous diabase have been intruded among the Lower Carboniferous formations. One horizon on which they are particularly abundant lies about the base of the Carboniferous Limestone series. Along that horizon they rise to the surface for many miles, sometimes ascending or descending in geological position, and breaking here and there abruptly across the strata. There can be little doubt that they have actually melted down some parts of the stratified rocks, particularly the limestone. Considerable petrographical differences occur among them which may perhaps be in some measure due to the incorporation of such extraneous material into their mass. Gaps occur where these intrusive rocks do not rise to the surface, but as they resume their position again not far off, it may be presumed that they are really connected under these blank intervals.

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[1] See Jukes's *Manual of Geology*, 3d ed., p. 243.

[2] *Horizontal Section, No. 22, Geol. Surv. Ireland.*

[3] *Manual of Geology*, 2d ed., p. 93; Geikie, *Trans. Geol. Soc. Edin.*, ii. 301; Judd, *Quart. Journ. Geol. Soc.*, xxx. 220.

The amount and nature of the alteration produced on contiguous rocks by the invasion of an intrusive boss vary necessarily with the character and bulk of the igneous mass, as well as with the susceptibility of the surrounding rock to metamorphism. Induration is generally traceable; shales are hardened into porcelain, jasper, Lydian stone, or some other flinty argillaceous rock. Sandstones are converted into a kind of lustrous quartz-rock. Limestones are made to assume a granular or crystalline texture, passing into marble or sometimes into dolomite. Under favorable conditions crystals of garnet, analcime, pyrite, and other minerals are developed in the surrounding altered rock.

There can be little doubt that, though the portions of these rocks now visible consolidated under a greater or less depth of overlying rock, they must in many cases have been directly connected with superficial volcanic action. Some of them may have been underground ramifications of the ascending molten rock which poured forth at the surface in streams of lava. Others may mark the position of intruded masses which were arrested in their ascent in the unsuccessful attempt to open a new volcanic vent.

II. Sheets.—These are masses of crystalline rock which have been intruded as sheets between other rocks, and now appear as more or less regularly defined beds. In almost all cases it will be found that these intrusions have taken place between the planes of stratification. The ascending mass of molten matter, after breaking across the rocks, or rather after ascending through fissures either previously formed or opened at the time of the outburst, has at last found its path of least resistance to lie along the bedding planes of the strata. Accordingly it has thrust itself between the beds, raising up the overlying mass and solidifying as a nearly or exactly parallel cake or bed.

It is evident that one of these intercalated intrusive sheets of igneous rock must present such points of resemblance to a truly contemporaneous bed of lava as to make it occasionally a somewhat difficult matter to determine its true character, more especially when, owing to extensive denudation, only a small portion of the rock can now be seen. The following characters mark intrusive sheets, though they must not be supposed to be all present in every case. (1.) They do not rigidly conform to the bedding, but sometimes break across it and run along on another platform. (2.) They catch up and involve portions of the surrounding strata. (3.) They are commonly most close-grained at their upper and under surfaces, and most coarsely crystalline in the central portions. (4.) They are very rarely cellular or amygdaloidal. (5.) The rocks both above and below them are usually hardened and otherwise more or less altered.

Many of the older volcanic rocks occur in this form, as felstone, quartz-porphyry, diorite, melaphyre, diabase, dolerite, basalt, and others. The remarks above made regarding the connection of intrusive bosses with volcanic action may be repeated with even greater definiteness here. Intrusive sheets abound in old volcanic districts intimately associated with dykes and surface outflows, and thus bringing before our eyes traces of the underground mechanism of the volcanoes.

The same kinds of alteration may be observed along the line of junction of intrusive sheets with the adjacent rocks as in the case of amorphous masses; but as the boundary lines are often very sharply defined they present the process of alteration in a more generally accessible and interesting form. Sandstone, for example, besides being indurated and acquiring the distinct lustre of quartzite, may occasionally be seen to possess a distinctly prismatic structure—the prisms or columns diverging at right angles to the line of junction with the igneous rock. Even microscopic black microlites, like those which occur in basalt-rocks, have been detected in altered sandstone, in the minute fissures of which they may be supposed to have been sublimed from the molten injected mass. Argillaceous rocks are commonly converted into hard flinty textures to which the names of flinty-slate, Lydian-stone, jasper, and porcellanite have been applied. Coal-seams when invaded by intruded sheets of igneous matter assume different aspects according to the thickness and nature of the invading sheet, the depth of the coal-seam, and probably to other less easily recognizable causes. In some cases the coal has been fused and has acquired a blistered or vesicular texture, the gas cavities being either empty or filled with mineral matter such as calcite. In other cases it has nearly disappeared, the remaining portion being a black soot or ash. In others it has become hard and brittle, and has been converted into a kind of anthracite or "blind-coal," owing to the loss of its more volatile portions. In the Ayrshire coal-fields the coal seams have sometimes become beautifully columnar owing to the intrusion of a sheet of basalt along them. The hexagonal and pentagonal columns diverge like rows of stout pencils from the surfaces of the basalt. In one coal-field of that county a seam of coal has been converted into graphite. The accompanying section (fig. 55) by the late Mr. Jukes represents one of the numerous sheets of "white-rock" intruded into the South Staffordshire coal-fields. The horizontal distance shown in this section is more than 100 yards. The coal (*b*) resting on sandstone (*c*) is traversed by irregular strings and sheets (*a*) of what the miners term "white-rock," which proceed from the large basalt masses of the district. The coal has there become dull and anthracitic, and is not worth being extracted.

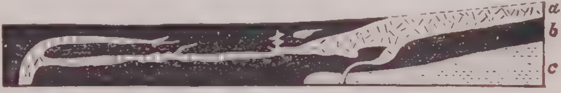

Fig. 55.—Sheets and strings of intrusive rock in the Ten-yard Coal, South Staffordshire.

When a coal-field is much invaded by igneous rocks the seams of coal are usually found to have suffered more than the other strata, not merely because they are specially liable to alteration from the proximity of heated surfaces, but because they have presented lines of more easy escape for the igneous matter pressed from below. The molten rock has very generally insinuated itself along the coal-seams, sometimes taking the lower, sometimes the upper surface, and not infrequently forcing its way along the centre.

In the destruction or alteration of coal and bituminous shales a process of subterranean distillation must often have been set in progress. The gases evolved would find their way to the surface through joints and pores of the overlying rock. The liquid products, on the other hand, would be apt to collect in fissures and cavities. In central Scotland, where the coal-fields have been so abundantly pierced by igneous masses, petroleum and asphaltum are of frequent occurrence in many districts, sometimes in chinks and veins of sandstones and other sedimentary strata, sometimes in the cavities of the igneous rocks themselves.

It is a remarkable fact that, striking as is the change produced by the intrusion of basalt into coals and bituminous shales, it is hardly more conspicuous than the alteration effected on the invading masses themselves. A compact crystalline black heavy basalt or dolerite, when it sends sheets and veins into a coal or highly carbonaceous shale, becomes yellow or white, earthy, and friable, loses weight, ceases to have any apparent crystalline texture, and in short passes into what any observer would at first unhesitatingly pronounce to be a mere clay. It is only when the distinctly intrusive character of this substance is recognized in the veins and fingers which it sends out, and in its own irregular course in the coal, that its true nature is made evident (see fig. 55). Microscopical examination shows that this "white-rock" or "white-trap" is merely an altered form of basalt, wherein the felspar crystals though much decayed, can yet be traced, the augite, olivine, and magnetite being more or less completely changed into a mere pulverulent earthy substance. A specimen of this altered rock was analyzed by Mr. Henry with the following results:—

Silica	38·830
Alumina	13·250
Lime	3·925
Magnesia	4·180
Soda	0·971
Potash	0·422
Protoxide of iron	13·830
Peroxide of iron	4·335
Carbonic acid	9·320
Water	11·010
	100·073

It is evident that most of the alkalies and much of the silica have been removed, and that most of the iron exists as carbonate of the protoxide.

In connection with the alteration produced by igneous sheets upon their contiguous stratified rocks, reference may here be made to the lithological differences traceable within the igneous masses. The close grain already referred to as characteristic of the upper and under portions of an intrusive sheet evidently depends upon more rapid cooling towards the surface of contact with the adjacent cold rocks. When thin slices of these marginal parts are placed under the microscope, they sometimes show abundant black microlites which disappear as the rock is traced away from the margin. They may be regarded as incipient stages in the crystallization of the magnetite, arrested in their development by the rapid consolidation of the outer parts of the rock. In the central portions they have had an opportunity of coalescing into octahedra or groups of definite isometric crystals. A series of sections of a rock, from the outer edge where the arrested crystallites occur to the centre where definitely-built crystals appear, brings in this way before us a history of the stages in the consolidation of the mass.

But considerable differences in composition may also be detected in different portions of the same intrusive sheet. A rock which at one place gives under the microscope a coarsely crystalline texture with the petrographical elements of dolerite will at a short distance show abundant orthoclase and free quartz—minerals which do not belong to normal dolerite. These differences, like those above referred to as noticeable among amorphous bosses, seem too local and sporadic to be satisfactorily referred to original differences in the composition of various parts of the molten mass, or to segregation by gravitation or otherwise. They suggest rather that the great intrusive sheets, in their passage through the rocks underneath, have here and there involved and melted down portions of these rocks, and have thus acquired locally an abnormal composition.

III. Veins and Dykes.—Veins of igneous rock may occur indifferently in igneous, aqueous, or metamorphic rocks. They may range in diameter from mere thread-like filaments up to huge bands many feet or yards broad. In regard to their origin they may be grouped into two series —(1) veins of segregation, and (2) veins of intrusion.

Veins of Segregation.—These include most of what were formerly and not very happily termed "contemporaneous veins." They are peculiar to crystalline rocks. They abound in many granites, likewise in some gneisses and schists. They may not infrequently be observed in sheets of diorite, dolerite, and diabase. They run as straight, curved, or branching ribands, seldom exceeding a foot in thickness. Most frequently they are finer in texture than the rock which they traverse, though now and then the reverse is the case, more especially in granite. Close examination of them shows that they are not sharply defined by a definite junction line with the enclosing rock, but that on the contrary they are welded into that rock in such a way that they cannot easily be broken along the plane of union. This welding is found to be due to the mutual protrusion of the component crystals of the vein and of the surrounding rock—a structure sometimes admirably revealed under the microscope. Veins of this kind are evidently to be referred to the earliest condition of the rocks in which they occur. They point to some process still unexplained, whereby into rents formed in the deeply buried, and at least partially consolidated or possibly colloid, mass there was a transfusion or exosmosis of some of the crystallizing minerals.

Veins of Intrusion.—These are portions of once-melted or at least pasty matter which have been injected into rents of previously solidified rocks. When traceable sufficiently far they may be seen to swell out and merge into their large parent mass, while in the opposite direction they may become attenuated into mere threads. Sometimes they run for many yards in tolerably straight lines, and when this takes place along the stratification they look like beds. At these parts, they are of course really intrusive sheets. But they may frequently be found to start suddenly upward or downward, and to break across the bedding in a very irregular manner. In fig. 56 *t* represents an intrusive igneous rock running through horizontal strata *s*. If we saw merely the horizontal portion below or above, the really igneous and intrusive nature of the rock *t* might escape us, but the intermediate connecting vein makes its character at once apparent.

No rock exhibits so admirably as granite the varieties assumed by veins. In many cases the veins which traverse the granite itself must be regarded as segregation or infiltration veins, as already described. But where they proceed from the granite, and traverse surrounding rocks, they are probably in most cases intrusive, though where granite and highly granitic gneiss are in contact we may conceive that some of the veins traversing both rocks may be segregation veins. Most large masses of granite send veins into the surrounding rocks. Frequently the veins so abound as to form a complicated net-work. They vary in breadth from several feet or even yards down to fine filaments at the ends of the smaller branches. They frequently cross each other, not only outside of the granite mass, but even within it. They vary much in texture and in composition. Sometimes they are coarsely crystalline; but probably most of the veins of this kind are due rather to segregation than intrusion. Most frequently granite veins traversing granite are finer-grained than the main mass. Veins which are clearly intrusive are not only finer in grain than the parent granite, but sometimes present considerable differences in mineralogical composition. The mica, for example, may be reduced to exceedingly minute and not very abundant flakes, and may almost disappear. The quartz also occasionally assumes a subordinate place, and the rock of the veins passes into eurite, elvanite, or one of the varieties of porphyry.

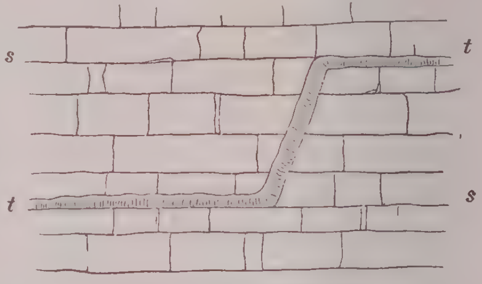

Fig. 56.—Intrusive igneous rock.

The rocks surrounding a granite mass and traversed by granite veins are almost always more or less metamorphosed in a belt varying in breadth from a few yards up to a mile or more. It is in this zone that the granite veins typically occur. The altered rocks have assumed the characters of gneiss, mica-schist, or other metamorphic product, but resume their usual condition as we trace them away from the granite. Curious angular portions of them may often be observed within the granite veins and in the main granite mass. In Cornwall the granite and surrounding slates are traversed by veins of quartz-porphyry termed *elvans*, which are most numerous near the granite. They vary in width from a few inches or feet to 50 fathoms, their central portions being commonly more crystalline than the sides. In the great granite region of Leicester Mr. Jukes traced some of the elvans for several miles running in parallel bands, each only a few feet thick, with intervals of 200 or 300 yards between them. Many of the other intrusive rocks likewise present the phenomena of veins; diorite, diabase, melaphyre, and basalt furnish numerous illustrations.

Dykes are wall-like masses of igneous rock, filling vertical or highly-inclined fissures. They differ therefore from veins in the greater parallelism of their sides, their verticality, and their greater regularity of breadth and persistence of direction. They present as great a variety of thickness as that which is shown by veins. Sometimes they occur as mere plates of rock not more than an inch or two in thickness; at other times they attain a breadth of ten or twelve fathoms. The smaller or thinner dykes can seldom be traced more than a few yards; but the larger examples may be followed sometimes for miles. Thus in the south of Scotland a remarkable series of basalt-dykes can be traced across all the geological formations of that region and even across powerful faults. They run parallel to each other in a general north-west and south-east direction for distances of 20 and 30 miles. A remarkable dyke crosses the north of England from the coast of Yorkshire for fully 60 miles inland.

The name dyke is applied to these masses of igneous rock on account of their resemblance to walls (*Scotice*, dykes). Their sides are often as parallel and perpendicular as those of a piece of masonry. Moreover, the resemblance to human workmanship is sometimes brought out still more by the numerous joints which, intersecting each other along the face of a dyke, remind us of well-fitted masonry. Where the surrounding rock has decayed, the dykes may be seen projecting above the ground exactly like walls; indeed in many parts of the west of Scotland they are made use of for enclosures. The material of the dykes has in other cases decayed, and deep ditch-like hollows are left to mark their sites. The coast-lines of many of the Inner Hebrides and of the Clyde Islands furnish numerous admirable examples of both kinds of scenery.

While veins have been injected into irregular branching cracks, dykes have been formed by the welling upwards of liquid rock in vertical or steeply inclined fissures. Sometimes the line of escape has been along a fault. In Scotland, however, which may be regarded as a typical region for this kind of geological structure, the vast majority of dykes rise along fissures which have no throw, and are therefore not faults. On the contrary the dykes may be traced across some of the largest faults in the midland counties.

While the term dyke might be applied to some of the wall-like intrusions of porphyry, elvanite, and even of granite, it is more typically illustrated among the augitic igneous rocks, such as basalt, diabase, etc., though also among diorites, porphyries, pitchstones, etc. The central parts of a dyke are usually most crystalline. Towards the margin the grain becomes finer, and even sometimes passes into a vitreous condition. Many of the basalt dykes in different parts of Scotland are coated along the sides with a film or crust of black vitreous tachylite. Lines of amygdaloidal kernels may not infrequently be traced along the centre of a dyke.

When the rock on one side is freshly stripped off, the dyke is usually observed to present a system of polygonal jointing. The joints start from each face or cheek, and either go right across to the opposite side, or branch and lose themselves about the centre. They thus divide the dyke into irregular prisms which, when the dyke is vertical, lie of course in a horizontal position, whence they depart in proportion as the dyke is inclined. Occasionally the prisms are as well-formed as in any columnar bed of basalt. A less prominent set of joints runs parallel with the two cheeks of a dyke.

There is usually some alteration of the stratified rocks in contact with a dyke; but the nature and amount of the change vary within a wide range. The most sensitive material to this influence is undoubtedly coal. A seam of coal 6 or 8 feet in thickness may be observed to grow dull and brittle at a distance of 50 yards from a large dyke, becoming what is termed "blind coal," as it then burns without flame. Still nearer to the intrusive mass the coal passes into a kind of pyritous cinder scarcely half the original thickness of the seam. At the actual contact with the dyke it becomes by degrees a kind of caked soot not more perhaps than a few inches thick. Sandstones are hardened into a kind of lustrous quartzite, and sometimes made columnar, shales into flinty slate or porcellanite; limestones are occasionally rendered crystalline and even dolomitic. Occasionally a segregation of new minerals has taken place in the rocks adjoining a dyke. But cases are by no means infrequent where dykes have produced little or no appreciable change upon the contiguous rocks.

IV. Necks.—Under this term are included the filled-up pipes or funnels of former volcanic vents. Every series of volcanic sheets poured out at the surface must have been connected with one or more orifices which, on the cessation of the eruptions, would remain more or less completely filled with lava or with fragmentary matter. But unless subsequent denudation should remove the overlying cone and its surrounding piles of lava and tuff, these vents must remain buried under the materials which came out of them. So extensive, however, has been the waste of the surface in many old volcanic regions that the sites of the vents have been laid bare. In the study of these we have before us some of the more deep-seated phenomena of volcanic action never to be seen in any modern volcano.

A neck is of a circular or elliptical, but occasionally of a more irregular branching form. It varies in diameter from a few yards up to a mile, or even more. It descends into the earth perpendicularly to the stratification of the formation to which it belongs. Thus, if a neck was formed and filled up during the accumulation of a certain group of strata, it would rise on the whole vertically through these strata, and its ejected lava or tuff would spread out conformably among them. Should the rocks be subsequently tilted the neck would of course be thrown out of the vertical. As a rule, however, the vertical descent of the necks into the earth's crust has been comparatively little interfered with.

The materials filling up ancient volcanic orifices are sometimes crystalline, sometimes fragmental. The neck may be occupied by some form of lava, as felstone, quartz-porphyry, diabase, porphyrite, basalt; or by the fragmentary materials which fell back into the throat of the volcano and finally solidified there; or by both kinds of rock combined. Among the Palæozoic volcanic districts of Britain the necks not infrequently are filled with some siliceous crystalline rock, such as a quartz-porphyry or felstone, even where the surrounding lavas are basic. Necks of agglomerate and fine tuff abound among the Carboniferous and Permian volcanic regions of Scotland.

The fragmentary materials consist mainly of different lava-form rocks imbedded in a gravelly *peperino*-like matrix of more finely comminuted debris of the same rocks: but they also contain, sometimes in abundance, fragments of the strata through which the necks have been drilled. Pieces of fine stratified tuff not infrequently appear in the agglomerates. This fact, coupled with the not uncommon occurrence of a tumultuous fractured and highly-inclined bedding of the materials in the necks, appears to show that the pipes were partly filled up by the subsidence of the tuff consolidated in beds within the crater and at the upper part of the funnel. Veins of basalt abound in many of the necks of Carboniferous age in central Scotland.

The strata round a neck are usually somewhat hardened. The sandstones have acquired sometimes a vitreous lustre; argillaceous beds have been indurated into porcellanite; coal-seams have been burnt and rendered unworkable. These changes may be due partly to the heat of the ascending column of molten rock or ejected fragments, partly to the ascent of heated vapors, even for a long time subsequently to the volcanic explosions. Proofs of a metamorphism probably due to the latter cause may sometimes be seen within the area of a neck. It is where the altered materials are of a fragmentary character that the nature and amount of this change can be best estimated. What was originally volcanic dust has been converted into a crystalline and even porphyritic mass, through which, however, the likewise intensely altered blocks interspersed through the agglomerate are still recognizable. Such blocks as, from the nature of their substance, must have offered most resistance to change—pieces of sandstone or quartz, for example—stand out prominently in the altered mass, though even they have undergone more or less modification, the sandstone being converted into vitreous quartz-rock.

Section II.—Volcanic, Interbedded, or Contemporaneous Igneous Rocks.

The rocks comprised in this section have all been ejected to the surface like the lava-streams and showers of ashes of modern volcanoes. It is evident that on the whole they must agree in lithological characters with those rocks, described in the previous section, which have been extravasated by volcanic efforts though not quite reaching the surface. Yet they have some well-marked general characters, of which the most important may be thus stated. (1.) They occur as beds or sheets which conform to the bedding of the strata among which they are intercalated. (2.) They do not break into or involve portions of the overlying beds. (3.) The upper and under portions of the lava sheets present commonly a scoriaceous or vesicular character, which may even be found extending throughout the whole of a sheet. (4.) Beds of tuff are frequently interstratified with the crystalline sheets.

I. Crystalline.—While the underground course of a protruded mass of molten igneous rock has widely varied according to the shape of the channel through which it proceeded, and in which, as in a mould, it solidified, the behavior of the rock, once poured out at the surface, has been much more uniform. As in modern lava, the erupted rock has rolled along, varying in thickness and other minor characters, but retaining the broad general aspect of a bed or sheet. A comparison of such a bed with one of the intrusive sheets already described shows that in several important respects they differ from each other. An intrusive sheet is closest in grain near its upper and under surfaces. A contemporaneous bed or true lava-flow, on the contrary, is there usually most open and scoriaceous. In the one case we rarely see vesicles or amygdules, in the other they often abound. However rough the upper surface of an interbedded sheet may be, it never sends out veins into nor encloses portions of the superincumbent rocks, which, however, sometimes contain portions of it, and wrap round its hummocky irregularities, as shown in fig. 57. Occasionally it may be observed to be full of rents which have been filled up with sandstone or other sedimentary material. In these cases we see that the lava cracked in solidifying, and that sand was washed into the fissures where it consolidated. The amygdaloidal cavities throughout an interbedded sheet, but more especially at the top, may often be noticed with an elongated form, and even pulled out into tube-like hollows in one general direction, which was obviously the line of movement of the yet viscous mass.

Some kinds of rock when occurring in interbedded sheets are apt to assume a system of columnar jointing. Basalt in particular is distinguished by the frequency and perfection of its columns. The Giant's Causeway and the cliffs of Staffa, of Ardtun in Mull, and of Loch Staffin in Skye are well-known examples. The columns are set perpendicularly to the two cooling surfaces, that is, to the top and bottom of the bed. Any inclination from the horizontal in the disposition of the bed will cause a corresponding departure from the vertical on the part of the columns. Sometimes the columns are arched or curved, as in the Clam-shell Cave, Staffa.

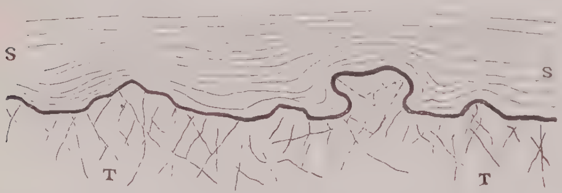

Fig. 57.—Section of the upper surface of an interbedded sheet T, showing how its unevennesses are wrapped round and covered by the sedimentary rocks S.

A single interbedded sheet of crystalline rock seldom occurs by itself without any other volcanic accompaniment. It is usually associated at least with bands of tuff showing that the emission of lava was not unattended with fragmentary ejections. In the majority of cases it will be found to form part of a series of interbedded sheets with intercalated tuffs. Vast piles of such consecutive flows, reaching a total depth of several thousand feet, remain to witness the energy of former volcanic vents.

II. Fragmental.—The rocks embraced under this term include all the fragmentary volcanic ejections which enter into the composition of the earth's crust, from the coarsest agglomerate to the finest tuff. They differ in lithological character, according to the nature of the lavas with which they are associated and from which they have been derived. Thus in a region of trachyte-lavas, we have trachyte-tuffs, trachyte-breccias; in one of basalts, we find basalt-breccias, basalt-agglomerates, basalt-tuffs; in one of obsidians, we meet with pumiceous tuffs and breccias. The fragmentary matter has been ejected from volcanic vents, and has fallen partly back into the funnels of discharge, partly over the surrounding area. It is therefore apt to be more or less mingled with ordinary sedimentary detritus. We find it indeed passing insensibly into sandstone, shale, limestone, and other strata.

Great differences occur in the texture of fragmental rocks even in the same volcanic districts. They are often coarse and tumultuous at or near the vents, and fine-grained at a distance. Alternations of gravelly *peperino*-like tuff with a very fine-grained "ash" may frequently be observed. Large blocks of lava-form rock, as well as of the strata through which the volcanic explosions have taken place, occur in the tuffs of most old volcanic districts.

It has been already pointed out that agglomerate and tuff are not infrequently to be met with occupying the sites of the vents of eruption. Their most common disposition, however, is in beds either alone or associated with interbedded lavas. Masses of fine or gravelly tuff several hundreds of feet in thickness, without the intervention of any lava-bed, may be observed in the volcanic districts of the Old Red Sandstone and Carboniferous systems in Scotland. On the other hand, in these same areas thin seams of tuff may be seen interlaminated with ordinary sandstone, shale, or limestone. In the one case we have evidence of long-continued and powerful volcanic action, during which fragmentary materials were showered out and spread over the water-basins to the exclusion of ordinary sediment. In the other we have proof of feeble intermittent volcanic explosions, whereby light showers of dust were discharged, which settled down quietly amidst the sand, mud, or limestone accumulating around at the time. Under these latter circumstances tuffs often became fossiliferous; they enclose the remains of such plants and animals as might be lying on the lake-bottom or sea-floor over which the showers of volcanic dust fell, and thus they form a connecting link between aqueous and igneous rocks.

VIII.—Metamorphic Rocks as Parts of the Architecture of the Earth's Crust.

In part ii. (*ante*, p. 210) some account has been given of the composition of certain foliated rocks frequently met with in the central portions of mountain chains and elsewhere, lying beneath geological formations of high antiquity. In part iii., in the discussion of the hypogene causes of change within the earth's crust, reference was again made to these rocks, and they were alluded to as examples of the effects of subterranean processes altering the original character of large mineral masses (*ante*, p. 234). They were there cited as *metamorphic* rocks, but their characters as integral parts of the earth's crust were reserved for discussion in the present part of this article.

At the outset some caution must be employed as to the exact meaning in which the terms "metamorphism" and "metamorphosed" are employed. In a certain sense it may be said that all or nearly all rocks have been metamorphosed, since it is exceptional to find any, at least among such as are not in a geological sense of modern date, which do not show, when closely examined, proofs of having been altered by the action of percolating water or other daily acting metamorphic agent. Even a solid crystalline mass which, when viewed on a fresh fracture with a good lens, seems to consist of unchanged crystalline particles will usually betray under the microscope unmistakable evidence of alteration. And this alteration may go on until the whole internal organization of the rock has been readjusted, though the external form may still remain such as hardly to indicate the change, or to suggest that any new name should be given to the recomposed rock. Among many igneous rocks, particularly the more basic kinds, as basalts, diorites, olivine rocks, etc., metamorphism of this kind may be studied in all its stages.

But it is not to alteration of this nature, effected at the surface by meteoric water, that the term metamorphism is properly applied. That word is reserved for the process of subterranean change above treated of (*ante*, p. 230), whereby a more or less complete transformation has been effected throughout vast mineral masses which, while undergoing crystalline rearrangement, have usually suffered simultaneously enormous compression. Gneiss, mica-schist, and the other schistose or foliated rocks are typical examples of the results of this metamorphic process.

Three antagonistic opinions are at present entertained regarding the origin of these rocks. Some geologists regard the crystalline schists as plutonic rocks representing the early cooled crust of the earth, and suppose that a similar schistose structure has occasionally been superinduced by plutonic action on later sedimentary formations. Again, by some recent writers the Wernerian notion of chemical precipitation has been revived, and the idea of metamorphism has been discarded. These authors suppose that the schistose rocks, in common with many pyroxenic and hornblendic rocks (diabases, diorites, etc.), as well as masses in which serpentine, talc, chlorite, and epidote are prevailing minerals, have been deposited "for the most part as chemically-formed sediments or precipitates, and that the subsequent changes have been simply molecular, or at most confined in certain cases to reactions between the mingled elements of the sediments, with the elimination of water and carbonic acid." To support this view, it is necessary to suppose that the rocks in question were formed during a period of the earth's history when the ocean had a considerably different relative proportion of mineral substances dissolved in its waters, and consequently that they must be assigned to a very early geological period, anterior indeed to what are usually termed the Palæozoic, ages And it becomes further needful to discredit the belief that any gneiss or schist can by possibility belong to one of the later stages of the geological record. The more thorough-going advocates of the pristine or "eozic" date and original chemical deposition of the so-called "metamorphic" rocks do not hesitate to take this step, and endeavor, by ingenious explanations, to show that the majority of geologists have mistaken the geological structure of the districts where these rocks have been supposed to be metamorphosed equivalents of what elsewhere are Palæozoic, Secondary, or Tertiary strata.[1] Prevalent opinion supports the third or metamorphic theory, according to which the schistose rocks are held to be crystalline transformations of ordinary sedimentary strata. The problem whether or not certain masses of gneiss or schist represent equivalent unaltered sedimentary rocks of other districts is mainly one of structural geology. It must be decided by the geologist rather than the chemist. It has been answered in the affirmative by the great majority of stratigraphical geologists all over the world. We may not be entitled to assert that every mass of gneiss or schist is a metamorphosed sedimentary rock. Possibly some foliated rocks of extreme antiquity may have originated directly from chemical precipitation. But when it can be shown that ordinary stratified rocks have been converted into schist and gneiss, it seems permissible to hold that all such rocks have had a similar origin, at least until good reasons can be adduced against that view.

It is evident that if the so-called metamorphic rocks can anywhere be seen to graduate into unaltered strata, it is there that they ought to be specially studied, and that light may be expected to be cast on their origin and history. It is customary to speak of metamorphism as being either local or regional, that is, being confined to one limited portion of a mass of rock, or as extending throughout the whole of the rock and over wide districts. It is doubtless from the first of these developments that we may hope to learn most regarding metamorphic changes.

Local (*Contact*) *Metamorphism.*—The simplest and most obvious examples of this kind of alteration occur where a mass of igneous rock has invaded sedimentary strata, which have in consequence been affected in lithological character along the margin of contact with the intrusive rock. Allusion has already been made to changes of this kind effected by intrusive sheets and dykes, and likewise traceable round the edges of ancient volcanic vents. Sandstones are converted into a lustrous crystalline quartz-rock; shales and argillaceous strata are indurated into porcellanite, jasper, flinty-slate, or some analogous product. Limestones are made crystalline; coals are charred, turned into anthracite, and sometimes even into graphite. These metamorphisms extend to very variable distances from the intrusive rock. Sometimes they are scarcely perceptible at all, and disappear within a space of a few inches. In other cases they extend for some feet, and in the case of some coal-seams even to 50 yards or more.

It is around bosses of granite however that the most marked examples of local metamorphism can be observed. On a previous page some account has been given of the way in which the Silurian rocks of Ireland and the south of Scotland are pierced by large masses of granite, and how, as they approach the granite even at a horizontal distance of a mile or more, they begin to assume a micaceous foliated texture which becomes more and more marked until, along the margin of the granite, they pass into true mica-schist and gneiss. The identity of origin between these schistose masses and the greywackes and shales beyond the metamorphic zone does not admit of any question. The unaltered rocks can be followed step by step into and through the stages of alteration, until they are found to have acquired the genuine gneissic or schistose structure. Moreover, it may be observed that all the bands of sedimentary rock do not give rise to the same kinds of metamorphic products. Some kinds of strata are more prone to alteration than others, and give rise to more perfect schists. In the south of Scotland, for example, certain greywackes, and grits formed of a granular mixture of quartz-sand, felspar, clay, and various decomposition products have been metamorphosed into perfect mica-schist, while some bands of black anthracitic and graptolitic shale have merely been intensely indurated and shattered. Many districts in Scotland, in Ireland, in the lake country of England, and in Wales might be cited as furnishing examples of this gradual conversion of ordinary sedimentary rocks into true schists.

Regional Metamorphism.—If then it can be proved that over limited areas thoroughly foliated rocks have been produced by the transformation of ordinary sedimentary strata, a presumption is established in favor of a similar mode of origin for foliated rocks elsewhere and over wider regions. There occur many vast spaces of the earth's surface occupied by foliated rocks. In Finland, Scandinavia, and the Scottish Highlands tracts many thousands of square miles in extent consist of gneiss, mica-schist, hornblende-rock, and other members of the same great family of rocks. A large portion of British North America lies upon similar mineral masses. Rocks of this type commonly rise also along the core of great mountain ranges, as in the Alps and in the Rocky Mountains. If these rocks which cover such vast areas were originally ordinary sedimentary rocks, they must have been metamorphosed, not by mere local protrusions of igneous matter, but by some general process.

Gradations of Metamorphism.—We have seen above that the nature and extent of the alteration experienced by rocks have been regulated, not merely by the vigor of the metamorphic process, but by the composition and structure of the rocks themselves. A siliceous sandstone, for instance, containing little or no aluminous or other admixture, seems to be capable of retaining much of its original character, while surrounding or intercalated less purely quartzose beds have been completely changed. It is converted into quartz-rock, but still shows the rounded quartz grains of the original sand. In proportion as the sand has been mixed with clay it has produced a rock more susceptible of change. The argillaceous (or magnesian) cement has been attacked, and in the process of change the quartz-sand has been affected. Mica in one or other of its various forms, aluminous or magnesian, has very generally appeared, and in proportion to its development has the foliated structure been made apparent. Hence we may obtain every gradation from a quartz-rock or grit into a true mica-schist or gneiss.

Production of Foliation.—The term "foliation" means the separation of a rock into approximately parallel or lenticular crystalline layers or folia of different mineral composition. It implies a segregation and crystallization of mineral matter along distinct planes. Those who maintain the original chemical precipitation of the most ancient gneisses and schists believe that the folia mark the stratification of the successive layers of deposit. Those, on the other hand, who hold that all the schistose rocks about the origin of which any satisfactory conclusion can be reached were originally mechanical sediments of ordinary kinds, regard the folia as coincident generally with the stratification of these sediments.

The folia of a gneiss or schist are crystalline aggregates which along their planes of mutual contact are as it were welded or felted into each other by the interlacing of their several component crystals. They are destitute, as a rule, of the parallelism, flatness, and persistence so characteristic of stratification. On the contrary they are apt to swell out into thick concretionary aggregations and to die out rapidly; they exhibit a wavy, crumpled, or puckered arrangement traceable in vast folds on the side of a mountain, and yet descending even to such minute corrugation as can only be detected by the microscope.

Foliation occurring in altered sedimentary rocks must be due to a crystallization and rearrangement of the chemical constituents of these rocks along certain lines. On a former page (*ante*, p. 234) it was pointed out that this kind of metamorphism would as a rule proceed along the lines of stratification. Doubtless in the vast majority of cases the planes of foliation are coincident with the general direction of this stratification. The metamorphic rocks of the Scottish Highlands furnish admirable proofs of this fact. Bands of quartz-rock and schist alternate with each other and with zones of limestone, precisely as beds of sandstone, shale, and limestone do in unaltered formations. Thin seams of pebbly grit with well-rounded water-worn pebbles may be observed running parallel with the folia of a schist, as a seam of fine grit or conglomerate may be seen to do in a series of shales. Nay, even the false-bedding so characteristic of mechanical sediment may be observed among these metamorphic rocks. The metamorphism is not uniform in these regions. Here and there it becomes intensified, and the rocks assume a thoroughly crystalline and much disturbed aspect. But as they recede from these areas they are found to lose much of their foliated character, and indeed to present such slight traces of metamorphism that they can be at once recognized as greywackes, grits, and shales. Moreover, they have been thrown into anticlinal and synclinal folds, and in these and other larger features of geological structure they differ in no essential respect from ordinary unaltered strata. Lastly, fossiliferous limestones containing Silurian shells have been found at their base, so that they have all been formed long after the seas over the area of Britain had been tenanted by living organisms.

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[1] See Sterry Hunt's *Chemical Essays*, p. 283 *sq.*

Professor Sedgwick and Mr. Darwin pointed out many years ago that a crystalline rearrangement of mineral matter has in some cases taken place along the planes of cleavage. We have already observed that the water which has been the great agent of metamorphism must always have followed the dominant divisional planes of a rock. If these planes were those of cleavage, the foliation would doubtless be produced along them, irrespective of the original laminæ of deposit. So long as the rock remained tolerably homogeneous in chemical composition, there seems no reason why foliation along the cleavage should differ in any material respect from that along stratification. But it may be doubted whether a cleavage foliation could run without sensible and even very serious interruptions over wide areas. For, in the first place, in most large masses of sedimentary matter we encounter alternations of different kinds of sediment, which could not but produce distinct kinds of rock under the influence of metamorphic change. In the second place, cleavage depends for its perfection and continuity on the fineness of grain of the rock through which it runs. While exceedingly perfect in a mass of argillaceous strata, it becomes feebler or even dies out in a coarse sandy or gritty rock. Hence, where foliation coincides with cleavage over large tracts, there will almost certainly be bands, more or less distinct, coincident with the original stratification, and running oblique to the general foliation, like bedding and cleavage, save where these two kinds of structure may happen to coalesce.

In a region of intense metamorphism the foliation of the schists may be observed to become here and there somewhat indefinite, until it disappears altogether, and the rocks assume a thoroughly granitic character. Between gneiss and granite there is no difference in mineralogical composition; in the one rock the minerals are arranged in folia, in the other they have no definite arrangement. Gneiss might be called a foliated granite; granite might be termed a non-foliated gneiss. The two rocks may be observed to graduate into each other. In Aberdeenshire, for example, the common grey mica-schist and gneiss may be seen to pass insensibly into the ordinary grey granite. In such cases it has been naturally concluded that granite is the ultimate stage of metamorphism. Judged merely from their composition and microscopic structure, an intrusive granite connected with igneous protrusions and a metamorphic granite representing the thorough transformation of stratified rock cannot be distinguished from each other.

There is thus nothing improbable in the idea that the same mineral particles may have gone through many successive cycles of change. We may suppose them to have been originally part of a granite mass, and to have been subsequently exposed at the surface by enormous denudation. Worn away from their parent granite they would be washed down with other particles, and spread out under water as parts of sandy or muddy deposits. Buried under a gradual accumulation of sedimentary material thousands of feet in thickness they might be depressed deep beneath the surface, and be thus brought within the influence of metamorphism. Gradually recomposed, crystallized, and converted into schistose rock, they might be eventually reduced to the condition of granite, and protruded into some of the overlying less metamorphosed masses in the form of granite veins. Or we may conceive, as already (*ante*, p. 274) suggested, that a communication was opened between the granite thus produced and the surface, and that the original mineral particles, whose vicissitudes we have been tracing, were erupted to the surface as part of a stream of lava.

Possible Metamorphism of Igneous Rocks.—In most large tracts of foliated rocks there occur masses less distinctly foliated or quite granitoid in texture formed mainly of hornblende or of that mineral in combination with others. Zones or bosses of hornblende-rock and hornblende-schist frequently appear among gneiss and mica-schist. Varieties of quartz-porphyry occur in a similar way. Bands of fine unctuous chloritic schists may also often be traced. It is not easy to understand how such rocks, at least those containing a large percentage of magnesia, could be produced by the metamorphism of ordinary sediment. The difficulty may perhaps be removed if we regard them as having originally been igneous rocks, either erupted at the surface or intrusively injected among the surrounding rocks previous to metamorphism. Such mineral masses as varieties of syenite and diorite, rich in hornblende or other magnesian silicates, might have been the original condition of many of the rocks here referred to. The fine magnesian schists might be regarded as having been at first tuffs associated with the lava-form masses.

Structure of Metamorphic Rocks in the Field.—As the series of metamorphic rocks ranges from scarcely altered sedimentary strata on the one hand to crystalline amorphous granitic masses on the other, they must obviously possess a great range of structure as parts of the architecture of the solid land. In particular they must under different circumstances present the features now of aqueous and now of igneous rocks. The most typical form of metamorphism being foliation, we may consider the structure of foliated rocks as the most characteristic. From what has been said above, it is evident that the planes of foliation give the rocks a general resemblance to stratified sedimentary masses. But these planes are seldom so definite and persistent as those of stratification. They do not impart to the rocks the same tendency to split up into well-marked parallel beds. On the contrary they are often so felted or welded together, especially in the coarse and most crystalline gneisses, that they hardly serve as divisional planes at all, but leave the firm tough rock to split up along other lines.

With care and patience lines of anticlinal and synclinal fold may often be traced among foliated as well as among unaltered rocks. But the unravelling of these and other features of structure is much more difficult than among ordinary stratified formations. This arises partly from the frequent absence of conspicuous and persistent bands which could be used as horizons in working out geological structure, partly from the abundant crumpling which most foliated rocks have undergone, whereby the continuity of the individual bands is much disturbed or entirely destroyed.

The joints among foliated rocks to which the regular and parallel folia impart a marked fissility resemble those among sedimentary strata. Where, however, the foliation is of a more massive kind, as in the coarser varieties of gneiss, the system of jointing approximates to that of granite or one of the more crystalline igneous rocks.

IX. Mineral Veins.

The fissures which so abundantly traverse the crust of the earth have in many instances served as places for the deposit of mineral matter quite distinct from that of the rocks through which they run. As metallic ores frequently occur among the minerals so deposited, and have been extensively worked, a large amount of information has been obtained by mining operations regarding these fissures, or, as they are termed, *mineral veins*. A general though not invariable relation exists between the nature of the minerals in the fissures and that of the contiguous rocks. When the latter are calcareous, calcite usually forms a conspicuous feature in the veins; among siliceous rocks quartz is abundant. These and the other minerals are for the most part well crystallized or at least largely crystalline in the veins, even when the adjoining rocks are granular or amorphous. They are termed *vein-stones*. Since the joints, faults, and fissures which have been filled with new mineral substances are commonly highly inclined or vertical, mineral veins generally run as steep wall-like bands across the rocks in which they occur. Their minerals are arranged in strips, which on the whole run parallel with the walls of the vein (fig. 58).

Mineral veins become *metalliferous*, when among their vein-stones there occur detached crystals or particles, or branching strings and threads, or concretionary masses or parallel bands of native metal, or of the sulphides, oxides, or other ores of metals. The association of these various substances within the two walls or cheeks of a vein is often in a double set of parallel bands, those in one-half of the vein being repeated in the other. The middle of the vein, for example, may consist of galena flanked and partially mixed up with zinc-blende and pyrites. On either side of this central rib there may be a layer of some vein-stone, perhaps fluor spar, then a duplicate band of another vein-stone, such as barytes or quartz, and so on, to the outer edge of the vein (fig. 58). In other cases, as in auriferous veins of quartz, the vein consists wholly or almost wholly of one vein-stone through which the ore is disseminated in minute grains and strings, so that the vein-stone must be extracted and crushed to obtain the metal by washing.

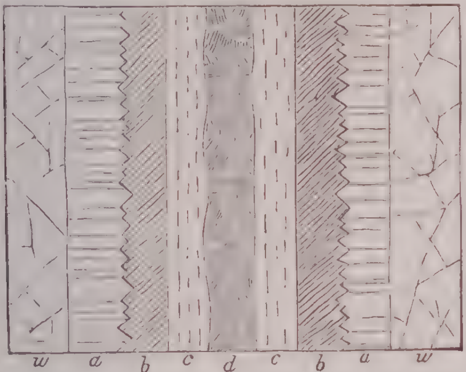

FIG. 58.—*a*, Coating of one mineral, say quartz; *b*, coating of a second mineral, say fluor spar; *c*, coating of first mineral, or of a third, say sulphate of baryta; *d*, rib of ore, as copper or lead; *w*, *w*, walls of the lode.

Mineral veins (*lodes*, *rake-veins*) vary in thickness from only an inch or less up to many fathoms. Extraordinary variations may be traced even in the course of the same vein, a breadth of several feet or yards rapidly diminishing until the two walls nearly or quite meet, to the exclusion of the minerals of the vein. Similar diversities may be observed in the horizontal extent of veins, some being traceable for miles, others disappearing in a few yards.

They sometimes occupy fissures without any throw, but most frequently seem to occur along lines of fault. In some cases indeed it can be shown that dislocation has taken place after some portion of the vein had been formed, but before the completion of the process. They usually send out branches, and in some mining districts do this to such an extent that it becomes hardly possible to identify the main vein among its numerous offshoots.

The direction of the veins varies in different districts. Two series may often be traced,—a principal series running in one general direction, and a minor set crossing the first at right angles or obliquely. Great differences in the richness of a metallic lode may be observed as it is worked vertically and horizontally, some of these depending in a way not easily explained upon the nature of the surrounding rock. Among the Cornish lodes, for example, some contain copper only where they traverse the Devonian slates, and lose it where they enter the granite, where tin takes its place. In the lead tracts of the north of England the metal diminishes where the veins lie in shale, and augments where they run through limestone.

In some rocks, more especially in limestones, large subterranean cavities have been filled with vein-stones and ores. The iron mines of the English lake district, for example, lie in the Carboniferous Limestone, where tunnels and caverns anciently dissolved out of the rock by percolating or running water have been subsequently filled up with hæmatite. In the lead districts of the north of England also, similar cavities have received a plentiful deposit of vein-stones and galena with its accompanying ores.

Various theories have been proposed to account for the infilling of mineral veins. Of these the most noteworthy are—(1) the theory of lateral segregation,—which teaches that the substances in the veins have been derived from the adjacent rocks by a process of solution and redeposit; and (2) the theory of infilling from below,—according to which the minerals and ores were introduced from below dissolved in water or steam, or by sublimation, or by igneous fusion and injection.

The fact that the nature and amount of the minerals, and especially of the ores, in a vein vary with the nature of the surrounding rocks seems to show that these rocks have had a certain influence on the precipitation of mineral matter in the fissures passing through them. But that this mineral matter came chiefly from below appears almost certain. The phenomena of the ascent of hot water in volcanic districts afford a close analogy to what has occurred in mineral veins. It is known that at the present time various minerals, including silica, both crystalline and calcedonic, and various metallic sulphides, are being deposited in fissures up which hot water rises. At the same time it is conceivable that to some extent there may be a decomposition of the rocks on either side of a fissure, and that a portion of the mineral matter abstracted may be laid down in another form along the walls of the fissure, or, on the other hand, that the rocks on either side of the fissure may be permeated for some distance by the ascending waters, and that some of the mineral substances carried up in solution may be deposited in the pores and cavities of these rocks as well as in the fissure itself.

X. UNCONFORMABILITY.

Where one series of rocks, whether of aqueous or igneous origin, has been laid down continuously and without disturbance upon another series, they are said to be *conformable*. Thus in fig. 59 the sheets of rock numbered 1, 2, 3, and 4 have succeeded each other in regular order, and exhibit a perfect conformability. They overlap each other, however, No. 2 extending beyond the edge of No. 1, No. 3 beyond that of No. 2, and so on. As already explained (p. 262), this structure points to a gradual subsidence and enlargement of the area of deposit. But all these conformable beds repose against the older platform A, with which they have no direct connection. That platform may consist of horizontal or inclined strata, or contorted schist, or crystalline igneous rocks. In any case there is a complete break between it and the overlying rocks, which rest successively on different parts of the older mass. This relation is termed an unconformability. The upper conformable beds in fig. 59 are said to lie unconformably upon A.

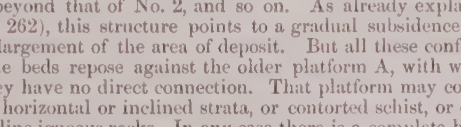

FIG. 59.—Overlap of conformable strata.

It is evident that this structure may occur in ordinary stratified, or in igneous, or in metamorphic rocks, or between any two of these great series. It is most familiarly displayed among stratified masses, and can there be most satisfactorily studied. The lines of bedding furnish a ready means of detecting differences of inclination and discordance of superposition. But even among igneous protrusions and in ancient metamorphic masses, distinct evidence of unconformability is not always difficult to trace.

Though conformable rocks may usually be presumed to have followed each other continuously without any great disturbance of geographical conditions, we cannot always be safe in such an inference. But an unconformability leaves no room to doubt that it marks a decided break in the continuity of deposit. Hence no kind of geological structure is of higher importance in the interpretation of the history of the stratified formations of a country. In rare cases an unconformability may occur between two horizontal groups of strata. In fig. 60, for instance, a set of beds C is shown to lie conformably for some distance upon an older series *d*. Were nothing more to be seen than what appears towards the right hand, we might justifiably conclude the whole of the rocks to be conformable. By passing to the left, however, we should find evidence of the older group having been upraised and unequally denuded before the deposition of the newer. The denudation would show that the conformability was accidental, that the older rocks had really been upraised and worn down before the formation of the newer. In such a case the upheaval must have been so equable as not to disturb the horizontality of the lower rocks.

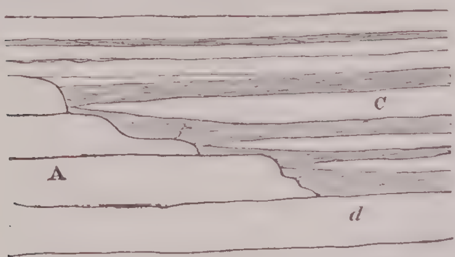

FIG. 60.—Unconformability among horizontal beds.

As a rule, however, it seldom happens that movements of this kind have taken place over an extensive area so equably as not to produce a want of conformability somewhere between the older and newer rocks. Most frequently the older formations have been disturbed, tilted at various angles, or even placed on end. They have likewise been irregularly and enormously worn down. Hence, instead of lying parallel, the younger beds run transgressively across the upturned denuded ends of the older. The greater the disturbance of the older rocks the more marked is the unconformability. In fig. 61, for instance, the series of beds A is unconformably covered by the series C. At both sides of the arch the unconformability is strongly marked, but at the centre *d* the two series seem to be conformable. An unconformability forms one of the great breaks in the geological record. In the foregoing figure, by way of illustration, we see at once that a notable hiatus in deposition, and therefore in geological chronology, must exist between series A and C. The older rocks had been deposited, folded, upheaved, and worn down before the accumulation of the newer series upon their denuded edges. These changes must have demanded a considerable lapse of time. Yet, looking merely at the structure in itself, we have evidently no means of fixing, even relatively, the length of interval marked by an unconformability. The mere violence of contrast between a set of vertical beds below and a horizontal group above it is no reliable criterion of the relative lapse of time between their deposition, for an older portion of a given formation might be tilted on end and be overlaid unconformably by a later part of the same formation. A set of flat rocks of high geological antiquity might, on the other hand, be covered by a formation of comparatively recent date, yet in spite of the want of discordance between the two, they might have been separated by a large portion of the total sum of geological time. It is by the evidence of organic remains that the relative importance of unconformabilities must be measured, as will be explained in part v.

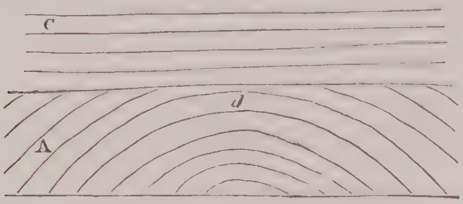

FIG. 61.—Section of unconformable rocks.

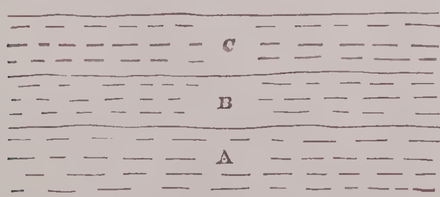

FIG. 62.—Section showing the groups of fig. 61 in conformable sequence, with the intervening blank (B) supplied.

Paramount though the effect of unconformability may be in the geological structure of a country, it must nevertheless be in almost all cases local. The disturbance by which it was produced can have affected but a comparatively circumscribed region, beyond the limits of which the continuity of sedimentation may have been undisturbed. We may therefore always expect to be able to fill up the gaps in one district from the more complete geological formations of another. In fig. 61 we see that something is wanting between A and C. But in the structure of another country or a different part of the same country we might discover the complete succession, as in fig. 62, where the whole of the rocks succeed each other conformably, and where the gap between A and C marked by the unconformability in fig. 61 is bridged over by the intermediate group of strata B.

PART V.—PALÆONTOLOGICAL GEOLOGY.

Palæontology is the science which treats of the structure, affinities, classification, and distribution in time of the forms of plant and animal life embedded in the rocks of the earth's crust. In one sense it may be regarded as a branch of zoology and of botany, its claim in this view to rank as a separate science resting almost solely on the fact that of the forms with which it deals but a small proportion belongs to the living world. In another aspect it may be looked upon as a branch of geology, seeing that its assistance is absolutely indispensable in many of the most familiar and fundamental problems of the latter science. It is under this last aspect that we have to regard it here. We shall consider merely those leading features of palæontological inquiry without some knowledge of which progress in modern geology would be impossible.

Fossils.—Palæontological geology, then, deals with the *fossils* or organic remains preserved in the rocks, and endeavors to gather from them information as to the history of the globe and its inhabitants. The term "fossil," meaning literally anything "dug up," was formerly applied indiscriminately to any mineral substance taken out of the earth's crust, whether organized or not. Ordinary minerals and rocks were thus included as fossils. For many years, however, the meaning of the word has been restricted, so as to include only the remains or traces of plants and animals preserved in any natural formation whether hard rock or superficial deposit. The idea of antiquity or relative date is not necessarily involved in this conception of the term. Thus the bones of a sheep buried under gravel and silt by a modern flood, and the obscure crystalline traces of a coral in ancient masses of limestone, are equally fossils.

Nor has the term fossil any limitation as to organic grade. It includes not merely the remains of organisms, but also whatever was directly connected with or produced by these organisms. Thus the resin which was exuded from trees of long-perished forests is as much a fossil as any portion of the stem, leaves, flowers, or fruit, and in some respects is even more valuable to the geologist than more determinable remains of its parent trees, because it has often preserved in admirable perfection the insects which flitted about in the woodlands. The burrows and trails of a worm preserved in sandstone and shale claim recognition as fossils, and indeed are commonly the only indications to be met with of the existence of annelide life among old geological formations. The droppings of fishes and reptiles, called coprolites, are excellent fossils, and tell their tale as to the presence of vertebrate life in ancient waters. The little agglutinated cases of the caddis-worm remain as fossils in formations from which perchance most other traces of life may have passed away. Nay, the very handiwork of man, when preserved in any natural manner, is entitled to rank among fossils; as where his flint-implements have been dropped into the prehistoric gravels of river-valleys, or where his canoes have been buried in the silt of lake-bottoms.

The term fossil, moreover, suffers no restriction as to the condition or state of preservation of any organism. In some rare instances the very flesh, skin, and hair of a mammal have been preserved for thousands of years, as in the case of the mammoths entombed within the frozen mud cliffs of Siberia. In most cases all or most of the original animal matter has disappeared, and the organism has been more or less completely mineralized or petrified. It often happens that the whole organism has decayed, and a mere cast in amorphous mineral matter, as sand, clay, ironstone, silica, or limestone remains; yet all these variations must be comprised in the comprehensive term fossil.

Conditions for the Preservation of Organic Remains.—At the outset the question naturally suggests itself how the remains of plants and animals come to have been preserved in rocks at all. If we observe what takes place at the present day, and argue that it may fairly be taken as an indication of what has been the ordinary condition of things in the geological past, we see that there must have been so many chances against the conservation of either animal or plant remains that their occurrence among stratified formations should be regarded as exceptional, and as the result of various fortunate accidents.

I. Consider, in the first place, what chances exist for the preservation of remains of the present fauna and flora of a country. The surface of the land may be densely clothed with forest, and abundantly peopled with animal life. But the trees die and moulder into soil. The animals, too, disappear, generation after generation, and leave no perceptible traces of their existence. If we were not aware from authentic records that central and northern Europe was covered with vast forests at the beginning of our era, how could we know this fact? What has become of the herds of wild oxen, the bears, wolves, and other denizens of primeval Europe? How could we prove from the examination of the surface soil of any country that those creatures had once abounded there? We might search in vain for any such superficial traces, and would learn by so doing that the law of nature is everywhere "dust to dust."

The conditions for the preservation of any relics of the plant and animal life of a terrestrial surface must therefore be always exceptional. They are supplied only where the organic remains can be protected from the air and superficial decay. Hence they may be observed in

1. *Lakes.*—Over the floor of a lake deposits of silt, peat, marl, etc., are formed. Into these the stems, branches, leaves, flowers, fruits, or seeds of plants from the neighboring land may be carried, together with the bodies of land animals, insects, and birds. An occasional storm may blow the lighter debris of the woodlands into the water. Such portions of the wreck as did not float and were not washed ashore again, might sink to the bottom. Of these the larger part would in most cases probably rot away, so that, in the end, only a very small fraction of the whole vegetable matter cast over the lake by the wind would be covered up and preserved at the bottom. In like manner the animal remains swept by winds or by river floods into the lake would run so many risks of dissolution that only a proportion of them, and probably merely a small proportion, would be preserved. When we consider these chances against the conservation of the vegetable and animal life of the land, we must admit that, at the best, lake-bottoms can contain but a meagre and imperfect representation of the abundant life of the adjacent hills and plains.

But lakes have a distinct flora and fauna of their own. Their aquatic plants may be entombed in the gathering deposits of the bottom. Their mollusks, of characteristic types, sometimes form, by the accumulation of their remains, sheets of soft calcareous marl, in which many of the undecayed shells are preserved. Their fishes, likewise distinctly lacustrine, no doubt must often be entombed in the silt or marl.

2. *Peat-mosses.*—Wild animals venturing on the more treacherous watery parts of a peat-bog are sometimes engulphed or "laired." The antiseptic qualities of the peat preserves such remains from decay. Hence from European peat-mosses numerous remains of deer and oxen have been exhumed. Evidently the larger beasts of the forest ought chiefly to be looked for in these localities.

3. *Deltas at River Mouths.*—From what has been said in previous pages (*ante*, pp. 245–7) regarding the geological operations of rivers, it is obvious that to some extent both the flora and the fauna of the land may be buried among the sand and silt of deltas. When we consider, however, that though occasional or frequent river-floods sweep down trees, herbage, and the bodies of land animals, the remains so transported run every risk of decaying or being otherwise destroyed while still afloat, and that even if they reach the bottom they will tend to dissolution there unless speedily covered up and protected by fresh sediment, we must perceive that delta formations can scarcely be expected to give us more than a meagre outline of the varied terrestrial flora and fauna.

4. *Caverns.*—These are eminently adapted for the preservation of the higher forms of terrestrial life. Most of our knowledge of the prehistoric mammalian fauna of Europe is derived from what has been disinterred from *bone-caves*. As these recesses lie for the most part in limestone or in calcareous rock, their floors are commonly coated with stalagmite from the drip of the roof; and as this deposit is of great closeness and durability it has effectually preserved whatever it has covered or enveloped. The caves have in many instances served predatory beasts, like the hyæna, cave-lion, and cave-bear, as dens in which they slept, and into which some of them dragged their prey. In other cases they have been merely holes into which different animals crawled to die, or into which they fell or were swept by inundations. Under whatever circumstances the animals left their remains in these subterranean retreats, the result has been that the bones have been covered up and preserved. Still, we must admit that after all but a mere fraction even of the mammals of the time would enter the caves, and therefore that the evidence of the cavern-deposits, profoundly interesting and valuable as it is, presents us with merely a glimpse of one aspect of the life of the land.

II. In the next place, if we turn to the sea, we find certainly many more favorable conditions for the preservation of organic forms, but also many circumstances which operate against it. While the level of the land remains stationary, there can be but little effective entombment of marine organisms in littoral deposits; for only a limited accumulation of sediment will be formed until subsidence of the sea-floor takes place. In the trifling beds of sand or gravel thrown up on a stationary shore, only the harder and more durable forms of life, such as gasteropods and lamellibranchs, which can withstand the triturating effects of the beach waves, are likely to remain uneffaced.

Below tide-marks, along the margin of the land where sediment is gradually deposited, the conditions are favorable for the preservation of marine organisms. Sheets of sand and mud are there laid down. In those sediments the harder parts of many forms of life may be entombed and protected from decay. But only a small proportion of the total marine fauna may be expected to occur in such deposits. At the best, merely littoral and shallow-water forms will occur, and even under the most favorable conditions they will represent but a fraction of the whole assemblage of life in these juxta-terrestrial parts of the ocean. As we recede from the land the rate of deposition of sediment on the sea-floor must become feebler, until in the remote central abysses it reaches a hardly appreciable minimum. Except, therefore, where organic deposits, such as ooze, are forming in these more pelagic regions, the conditions must be on the whole unfavorable for the preservation of any adequate representation of the deep-sea fauna. Hard enduring objects, such as teeth and bones, may slowly accumulate and be protected by a coating of peroxide of manganese, or of some of the silicates above (p. 256) referred to as now forming here and there over the deep sea-bottom. But such a deposit, if raised into land, would supply but a meagre picture of the life of the sea.

We must conclude therefore that of the whole sea-floor the area best adapted for preserving a varied suite of marine organic exuviæ is that belt which, running along the margin of the land, is ever receiving fresh layers of sediment transported by rivers and currents from the adjacent shores. The most favorable conditions for the accumulation of a thick mass of marine fossiliferous strata will arise when the area of deposit is undergoing a gradual subsidence. If the rate of depression and that of deposit were equal, or nearly so, the movement might proceed for a vast period without producing any great apparent change in marine geography, and even without seriously affecting the distribution of life over the sea-floor within the area of subsidence. Hundreds or thousands of feet of sedimentary strata might in this way be heaped up round the continents, containing a fragmentary series of organic remains belonging to those forms of shallow-water life which had hard parts capable of preservation.

There can be little doubt that such has in fact been the history of the main mass of stratified formations in the earth's crust. These piles of marine strata have unquestionably been laid down in comparatively shallow water within the area of deposit of terrestrial sediment. Their great depth seems only explicable by prolonged and repeated movements of subsidence, interrupted, however, as we know, by other movements of a contrary kind. These geographical changes affected at once the deposition of inorganic materials and the succession of organic forms. One series of strata is sometimes abruptly succeeded by another of a very different character, and we generally find a corresponding contrast between their respective organic contents.

It follows from these conclusions that representatives of the abyssal deposits of the central oceans are not likely to be met with among the geological formations of past times. Thanks to the great work done by the "Challenger" expedition, we now know what are the leading characters of these abyssal deposits of the present day. They have absolutely no analogy among the formations of the earth's crust. They differ, indeed, so entirely from any formation which geologists considered to be of deep-water origin as to indicate that, from early geological times, the present great areas of land and sea have remained on the whole where they are, and that the land consists mainly of strata formed at successive epochs of terrestrial debris laid down in the surrounding shallow sea.

Relative Value of Organic Remains as Fossils.—As the conditions for the preservation of organic remains exist more favorably under the sea than on land, marine organisms must be far more abundantly conserved than those of the land. This is true to-day, and has been true in all past geological time. Hence for the purposes of the geologist the fossil remains of marine forms of life far surpass all others in value. Among them there will necessarily be a gradation of importance regulated chiefly by their relative abundance. Now, of all the marine tribes which live within the juxta-terrestrial belt of sedimentation, unquestionably the *Mollusca* stand in the place of pre-eminence as regards their aptitude for becoming fossils. In the first place they almost all possess a hard durable shell, capable of resisting considerable abrasion, and readily passing into a mineralized condition. In the next place they are extremely abundant both as to individuals and genera. They occur on the shore within tide mark, and range thence down into the abysses. Moreover, they appear to have possessed those qualifications from early geological times. In the marine *Mollusca*, therefore, we have a common ground of comparison between the stratified formations of different periods. They have been styled the alphabet of palæontological inquiry. It will be seen, as we proceed, how much in the interpretation of geological history depends upon the testimony of sea-shells.

Looking at the organisms of the land, we perceive that, as a rule, the abundant terrestrial flora has a comparatively small chance of being well represented in a fossil state, that indeed, as a rule, only that portion of it of which the leaves, twigs, flowers, and fruits are blown into lakes is likely to be partially preserved. Terrestrial plants, therefore, occur in comparative rarity among stratified rocks, and furnish in consequence only limited means of comparison between the formations of different ages and countries. Of land animals the vast majority perish and leave no permanent trace of their existence. Predatory and other forms whose remains may be looked for in caverns or peat-mosses, must occur more numerously in the fossil state than birds, and are correspondingly more valuable to the geologist for the comparison of different strata.

Relative Age of Fossils.—Although absolute dates cannot be fixed in geological chronology, it is not difficult to determine the relative age of different strata, and consequently of their enclosed organic remains. For this purpose the fundamental law is based on what is termed the "order of superposition." This law may be thus defined:—in a series of stratified formations the older must underlie the younger. It is not needful that we should actually see the one lying below the other. If a continuous conformable succession of strata dips steadily in one direction we know that the beds at the one end must underlie those at the other, because we can trace the whole succession of beds between them. Rare instances occur where strata have been so folded by great terrestrial disturbance that the younger are made to underlie the older. But this inversion can usually be made quite clear from other evidence. The true order of superposition is decisive of the relative ages of stratified rocks.

If, therefore, formations lie regularly above each other, B upon A, C upon B, D upon C, and so on, it is evident that the organic remains found in A must have lived and died before those in B were entombed; the latter must have been covered up before those in C, and these again before those in D. The chronological sequence of fossils must be determined first of all by the order of superposition of their enclosing strata. There is nothing in the fossils themselves, apart from experience, to fix their date. Unless, for example, we knew from observation or testimony that *Rhynchonella pleurodon* is a shell of the Carboniferous Limestone, and *Rhynchonella tetrahedra* is a shell of the Lias, we could not, from mere inspection of the fossils themselves, pronounce as to their real geological position. It is quite true that by practice a palæontologist has his eye so trained that he can make shrewd approximations to the actual horizon of fossils which he may never have seen before; but he can only do this by availing himself of a wide experience based upon the ascertained order of appearance of fossils as determined by the law of superposition. For geological purposes, therefore, and indeed for all purposes of comparison between the faunas and floras of different periods, it is absolutely essential first of all to have the order of superposition of strata rigorously determined. Unless this is done the most fatal mistakes may be made in palæontological chronology. But when it has once been done in one typical district, the order thus established may be held as proved for a wide region where, from paucity of sections, or from geological disturbance, the true succession of formations cannot be satisfactorily determined.

Uses of Fossils in Geology.—There are two main purposes to which fossils may be put in geological research:—(1) to throw light upon former conditions of physical geography, such as the presence of land, rivers, lakes, and seas, in places where they do not now exist, changes of climate, and the former distribution of plants and animals; and (2) to furnish a guide in geological chronology whereby rocks may be classified according to relative date, and the facts of geological history may be arranged and interpreted as a connected record of the earth's progress.

1. A few examples will suffice to show the manifold assistance which fossils furnish to the geologist in the elucidation of ancient geography.

(*a.*) Former land-surfaces are revealed by the presence of tree-stumps in their positions of growth, with their roots branching freely in the underlying stratum, which, representing the ancient soil, often contains leaves, fruits, and other sylvan remains, together with traces of the bones of land animals, remains of insects, land-shells, etc. Ancient woodland surfaces of this kind are found between tide-marks, and even below low-water line, round different parts of the British coast. They unequivocally prove a subsidence of the land. Of more ancient date are the "dirt-beds" of Portland, which, by their layers of soil and tree-stumps, show that woodlands of cycads sprang up over an upraised sea-bottom and were buried beneath the silt of a river or lake. Still further back in geological history come the numerous coal-growths of the Carboniferous period, pointing to wide jungles of terrestrial or aquatic plants, like the modern mangrove swamps, which were submerged and covered with sand and silt.

(*b.*) The former existence of lakes can be satisfactorily proved from beds of marl or lacustrine limestone full of fresh-water shells, or from fine silt with leaves, fruits, and insect remains. Such deposits are abundantly forming at the present day, and they occur at various horizons among the geological formations of past times. The well-known nagelflue of Switzerland—a mass of conglomerate attaining a thickness of fully 6000 feet—can be shown from its fossil contents to be essentially a lacustrine formation.

(*c.*) Old sea-bottoms are vividly brought before us by beds of marine shells and other organisms. Layers of water-worn gravel and sand, with rolled shells of littoral and infra-littoral species, unmistakably mark the position of a former shore line. Deeper water is indicated by finer muddy sediment, with relics of the fauna which prevails beneath the reach of waves and ground-swell. Limestones full of corals, or made up of crinoids, point to the slow continuous growth and decay of generation after generation of organisms in clear sea-water.

(*d.*) Variations in the nature of the water or of the sea-bottom may sometimes be shown by changes in the size or shape of the organic remains. If, for example, the fossils in the central and lower parts of a limestone are large and well-formed, but in the upper layers become dwarfed and distorted, we may reasonably infer that the conditions for their continued existence at that locality must have been gradually impaired. The final complete cessation of these favorable conditions is shown by the replacement of the limestone by shale, indicative of the water having become muddy, and by the disappearance of the fossils, which had shown their sensitiveness to the change.

(*e.*) That the sea-floor represented by a fossiliferous stratum was not far from land is sufficiently proved by mere lithological characters, as has been already explained; but the conclusion may be further strengthened by the occurrence of leaves, stems, and other fragments of terrestrial vegetation which, if found in some numbers among marine organisms, would make it improbable that they had been drifted far from land.

(*f.*) The existence of different conditions of climate in former geological periods is satisfactorily demonstrated from the testimony of fossils. Thus an assemblage of the remains of palms, gourds, and melons, with bones of crocodiles, turtles, and sea-snakes, proves a sub-tropical climate to have prevailed over the south of England in the time of the older Tertiary formations. On the other hand the presence of an intensely cold or arctic climate far south in Europe during post-Tertiary time can be shown from different kinds of evidence, such as the existence of the remains of arctic animals even as far as the south of England and of France.

This is a use of fossils, however, where great caution must be used. We cannot affirm that, because a certain species of a genus lives now in a warm part of the globe, every species of that genus must always have lived in similar circumstances. The well-known example of the mammoth and woolly rhinoceros having lived in the cold north, while their modern representatives inhabit some of the warmest regions of the globe, may be usefully remembered as a warning against any such conclusions. When, however, we find that not one fossil merely, but the whole assemblage of fossils in a formation has its modern analogue in a certain general condition of climate, we may at least tentatively infer that the same kind of climate prevailed where that assemblage of fossils lived. Such an inference would become more and more unsafe in proportion to the antiquity of the fossils and their divergence from existing forms.

2. When the order of superposition has been determined in a great series of stratified formations, it is found that the fossils at the bottom are not quite the same as those at the top of the series. As we trace the beds upward we discover that species after species of the lowest platforms disappears, until perhaps not one of them is found. With the cessation of these older species others make their entrance. These in turn are found to die out and to be replaced by newer forms. After patient examination of the rocks, it is ascertained that every well-marked formation is characterized by its own species or genera, or by a general assemblage or *facies* of organic forms. This can only, of course, be determined by actual practical experience over an area of some size. When the typical fossils of a formation are known, they serve to identify that formation in its progress across a country. Thus, as we trace the formation into tracts where it would be impossible to determine the true order of superposition, owing to the want of sections, or to the disturbed condition of the rocks, we can employ the fossils as a means of identification, and speak with confidence as to the succession of the rocks. We may even demonstrate that in some mountainous ground the beds have been turned completely upside down, if we can show that the fossils in what are now the uppermost strata ought properly to lie underneath those in the beds below them.

Observations made over a large part of the surface of the globe have enabled geologists to divide the stratified part of the earth's crust into systems, formations, and groups or series. These subdivisions are frequently marked off from each other by lithological characters. But mere lithological differences would afford at the best but a limited and local ground of separation. Two masses of sandstone, for example, having exactly the same general external and internal characters, might belong to very different geological periods. On the other hand, a series of limestones in one locality might be the exact chronological equivalent of a set of sandstones and conglomerates at another, and of a series of shales and clays at a third.

It is by their characteristic fossils that the divisions of the stratified rocks can be most satisfactorily made. Each formation being distinguished by its own assemblage of organic remains, it can be followed and recognized even amid the crumplings and dislocations of a disturbed region. The same general succession of organic types can be observed over a large part of the world, though, of course, with important modifications in different countries. This similarity of succession has been termed *homotaxis*—a term which expresses the fact that the order in which the leading types of organized existence have appeared upon the earth has been similar even in widely separated regions.

It is evident that in this way a method of comparison is furnished whereby the stratified formations of different parts of the earth's crust can be brought into relation with each other. We find, for example, that a certain series of strata is characterized in Britain by certain genera and species of corals, brachiopods, lamellibranchs, gasteropods, and cephalopods. A group of rocks in Bohemia, differing more or less from these in lithological aspect, contains on the whole the same genera, and many even of the same species. In Scandinavia a set of beds may be seen unlike, perhaps, in external characters to the British type, but yielding many of the same fossils. In Canada and many parts of the northern United States, other rocks enclose many of the same, and of closely allied genera and species. All these groups of strata are classed together as *homotaxial*, that is, as having been deposited during the same relative period in the general progress of life in each region.

It was at one time believed, and the belief is still far from extinct, that groups of strata characterized by this community or resemblance of organic remains were chronologically contemporaneous. But such an inference rests upon most insecure grounds. We may not be able to disprove the assertion that the strata were strictly coeval, but we have only to reflect on the present conditions of zoological and botanical distribution, and of modern sedimentation, to be assured that the assertion of contemporaneity is a mere assumption. Consider for a moment what would happen were the present surface of any portion of central or southern Europe to be submerged beneath the sea, covered by marine deposits, and then re-elevated into land. The river-terraces and lacustrine marls formed before the time of Julius Cæsar could not be distinguished by any fossil tests from those laid down in the days of Victoria, unless, indeed, traces of human implements were obtainable whereby the progress of civilization during 2000 years might be indicated. So far as regards the shells, bones, and plants preserved in the various formations, it would be absolutely impossible to discriminate their relative dates; they would be classed as "geologically contemporaneous," that is, as having been formed during the same period in the history of life in the European area; yet there might be a difference of 2000 years or more between many of them. Strict contemporaneity cannot be asserted of any strata merely on the ground of similarity or identity in fossils.

But the phrase "geologically contemporaneous" is too vague to have any chronological value except in a relative sense. To speak of two formations as in any sense contemporaneous which may have been separated by thousands of years seems rather a misuse of language, though the phraseology has now gained such a footing in geological literature as probably to be inexpugnable. If we turn again for suggestions to the existing distribution of life on the earth we learn that similarity or identity of species and genera holds good on the whole only for limited areas, and consequently, if applied to wide geographical regions, ought to be an argument for diversity rather than for similarity of age. If we suppose the British seas to be raised into dry land, so that the organic relics preserved in their sands and silts could be exhumed and examined, a general common facies or type would be found, though some species would be more abundant in or entirely confined to the north, while others would show a greater development in the opposite quarter. Still there would be such a similarity throughout the whole that no naturalist would hesitate to regard the organisms as those of one biological province, and belonging to the same great geological period. The region is so small, and its conditions of life so uniform and uninterrupted, that no marked distinction is possible between the forms of life in its different parts.

Widening the area of observation, we perceive that as we recede from any given point the forms of life gradually change. Vegetation alters its aspect from climate to climate, and with it come corresponding transformations in the character of insects, birds, and wild animals. A lake bottom would preserve one suite of organisms in England, but a very different group at the foot of the Himalaya Mountains, yet the deposits at the two places might be absolutely coeval, even as to months and days. Hence it becomes apparent that while strict contemporaneity cannot be predicated of deposits containing the same organic remains, it may actually be true of deposits in which they are quite distinct.

If, then, at the present time, community of organic forms obtains only in districts, regions, or provinces, it may have been more or less limited also in past time. Similarity or identity of fossils among formations geographically far apart, instead of proving contemporaneity, ought rather to be looked upon as indicative of great discrepancies in the relative epochs of deposit. For in any theory of the origin of species, the spread of any one species, still more of any group of species, to a vast distance from the original centre of dispersion, must in most cases have been inconceivably slow. It must have occupied so prolonged a time as to allow of almost indefinite changes in physical geography. A species may have disappeared from its primeval birthplace while it continued to flourish in one or more directions in its outward circle of advance. The date of the first appearance and final extinction of that species would thus differ widely according to the locality at which we might examine its remains.

The grand march of life, in its progress from lower to higher forms, has unquestionably been broadly alike in all quarters of the globe. But nothing seems more certain than that its rate of advance has not everywhere been the same. It has moved unequally over the same region. A certain stage of progress may have been reached in one quarter of the globe thousands of years before it was reached in another; though the same general succession of organic forms might be found in each region.

The geological formations form the records of these ages of organic development. In every country where they are fully displayed, and where they have been properly examined, they can be separated out from each other according to their organic contents. Their relative age within a limited geographical area can be demonstrated by the mere law of superposition. When, however, the formations of distant countries are compared, all that we can safely affirm regarding them is that those containing the same or a representative assemblage of organic remains belong to the same epoch in the history of biological progress in each area. They are *homotaxial;* but we cannot assert that they are contemporaneous, unless we are prepared to include within that term a vague period of perhaps thousands of years.

Doctrine of Colonies.—M. Barrande, the distinguished author of the *Système Silurien de la Bohême*, drew attention more than a quarter of a century ago to certain remarkable intercalations of fossils in the series of Silurian strata of Bohemia. He showed that, while these strata presented a normal succession of organic remains, there were nevertheless exceptional bands, which, containing the fossils of a higher zone, were yet included on different horizons among inferior portions of the series. He termed these precursory bands "colonies," and defined the phenomena as consisting in the partial co-existence of two general faunas, which, considered as a whole, were nevertheless successive. He supposed that during the later stages of his second Silurian fauna in Bohemia the first phases of the third fauna had already appeared, and attained some degree of development in some neighboring but yet unknown region. At intervals, corresponding doubtless to geographical changes, such as movements of subsidence or elevation, volcanic eruptions, etc., communication was opened between that outer region and the basin of Bohemia. During these intervals a greater or less number of immigrants succeeded in making their way into the Bohemian area, but as the conditions for their prolonged continuance there were not yet favorable, they soon died out, and the normal fauna of the region resumed its occupancy. The deposits formed during these partial interruptions, notably graptolitic schists, accompanied by igneous sheets, contain, besides the invading species, remains of some of the indigenous forms. Eventually, however, on the final extinction of the second fauna, and, we may suppose, on the ultimate demolition of the physical barriers hitherto only occasionally and temporarily broken, the third fauna, which had already sent successive colonies into the Bohemian area, now swarmed into it, and peopled it till the close of the Silurian period.

This original and ingenious doctrine has met with much opposition on the part of geologists and palæontologists. Of the facts cited by M. Barrande there has been no question, but other explanations have been suggested for them. It has been said, for example, that the so-called colonies are merely bands of the Upper Silurian rocks or third fauna, which by great plications have been so folded with the older rocks as to seem regularly interstratified with them. But the author of the *Système Silurien* very justly contends that of such foldings there is no evidence, but that, on the contrary, the sequence of the strata appears normal and undisturbed. Again it has been urged that the difference of organic contents in these so-called colonies is due merely to a difference in the conditions of water and sea-bottom, particular species appearing with the conditions favorable to their spread, and disappearing when these ceased. But this contention is really included in M. Barrande's theory. The species which disappear and reappear in later stages must have existed in the mean while outside of the area of deposit, which is precisely what he has sought to establish. Much of the opposition which his views have encountered has probably arisen from the feeling that if they are admitted they must weaken the value of palæontological evidence in defining geological horizons. A palæontologist, who has been accustomed to deal with certain fossils as unfailing indications of particular portions of the geological series, is naturally unwilling to see his generalizations upset by an attempt to show that the fossils may occur on a far earlier horizon.

If, however, we view this question from the broad natural history platform from which it was regarded by M. Barrande, it is impossible not to admit that such phenomena as he has sought to establish in Bohemia must have constantly occurred in all geological periods and in all parts of the world. No one now believes in the sudden extinction and creation of entire faunas. Every great fauna in the earth's history must have gradually grown out of some pre-existing one, and must have insensibly graduated into that which succeeded. The occurrence of two very distinct faunas in two closely consecutive series of strata does not prove that the one abruptly died out and the other suddenly appeared in its place. It only shows, as Darwin has so well enforced, the imperfection of the geological record. In the interval between the formation of two such contrasted groups of rocks the fauna of the lower strata must have continued to exist elsewhere, and gradually to change into the newer facies which appeared when sedimentation recommenced with the upper strata. Distinct zoological provinces have no doubt been separated by narrow barriers in former geological periods, as they still are to-day. There seems, therefore, every probability that such migrations as M. Barrande has supposed in the case of the Silurian fauna of Bohemia have again and again taken place. Two notable examples will be given in later pages, one in the Lower and one in the Upper Old Red Sandstone of Scotland.

Gaps in the Geological Record.—The history of Life has been very imperfectly preserved in the stratified parts of the earth's crust. Apart from the fact that, even under the most favorable conditions, only a small proportion of the total flora and fauna of any period could be preserved in the fossil state, enormous gaps occur where no record has been preserved at all. It is as if whole chapters and books were missing from an historical work. Some of these lacunæ are sufficiently obvious. Thus, in some cases, powerful dislocations have thrown considerable portions of the rocks out of sight. Sometimes extensive metamorphism has so affected them that their original characters, including their organic contents, have been destroyed. Oftenest of all, denudation has come into play, and vast masses of fossiliferous rock have been entirely worn away. That this cause has operated frequently is shown by the abundant unconformabilities in the structure of the earth's crust.

While the mere fact that one series of rocks lies unconformably on another proves the lapse of a considerable interval between their respective dates, the relative length of this interval may sometimes be demonstrated by means of fossil evidence and by this alone. Let us suppose, for example, that a certain group of formations has been disturbed, upraised, denuded, and covered unconformably by a second group. In lithological characters the two may closely resemble each other, and there may be nothing to show that the gap represented by their unconformability is not of a trifling character. In many cases, indeed, it would be quite impossible to pronounce any well-grounded judgment as to the amount of interval, even measured by the vague relative standards of geological chronology. But if each group contains a well-preserved suite of organic remains, it may not only be possible, but easy, to say exactly how much of the geological record has been left out between the two sets of formations. By comparing the fossils with those obtained from regions where the geological record is more complete, it may be ascertained perhaps that the lower rocks belong to a certain platform or stage in geological history which for our present purpose we may call D, and that the upper rocks can in like manner be paralleled with stage H. It would be then apparent that at this locality the chronicles of three great geological periods E, F, and G were wanting, which are elsewhere found to be intercalated between D and H. The lapse of time represented by this unconformability would thus be equivalent to that required for the accumulation of the three missing formations in those regions where sedimentation went on undisturbed.

But fossil evidence may be made to prove the existence of gaps which are not otherwise apparent. As has been already remarked, changes in organic forms must, on the whole, have been extremely slow in the geological past. The whole species of a sea-floor could not pass entirely away, and be replaced by other forms, without the lapse of long periods of time. If then among the conformable stratified formations of former ages we encounter sudden and abrupt changes in the facies of the fossils, we may be certain that these must mark omissions in the record, which we may hope to fill in from a more perfect series elsewhere. The complete contrasts between unconformable strata are sufficiently explicable. It is not so easy to give a satisfactory account of those which occur where the beds are strictly conformable, and where no evidence can be observed of any considerable change of physical conditions at the time of deposit. A group of strata having the same general lithological characters throughout may be marked by a great discrepance between the fossils above and below a certain line. A few species may pass from the one into the other, or perhaps every species may be different. In cases of this kind, when proved to be not merely local but persistent over wide areas, we must admit, notwithstanding the apparently undisturbed and continuous character of the original deposition of the strata, that the abrupt transition from the one facies of fossils to the other must represent a long interval of time which has not been recorded by the deposit of strata. Professor Ramsay, who called attention to these gaps, termed them "breaks in the succession of organic remains." He showed that they occur abundantly among the Palæozoic and Secondary rocks of England. It is obvious, of course, that these breaks, even though traceable over wide regions, were not general over the whole globe. There have never been any universal interruptions in the continuity of the chain of being, so far as geological evidence can show. But the physical changes which caused the breaks may have been general over a zoological district or minor region. They no doubt often caused the complete extinction of genera and species which had a small geographical range.

From all these facts it is clear that the geological record, as it now exists, is at the best but an imperfect chronicle of geological history. In no country is it complete. The lacunæ of one region must be supplied from another. Yet in proportion to the geographical distance between the localities where the gaps occur and those whence the missing intervals are supplied, the element of uncertainty in our reading of the record is increased. The most desirable method of research is to exhaust the evidence for each area or province, and to compare the general order of its succession as a whole with that which can be established for other provinces. It is, therefore, only after long and patient observation and comparison that the geological history of different quarters of the globe can be correlated.

Subdivisions of the Geological Record by means of Fossils.—As fossil evidence furnishes a much more satisfactory and widely applicable means of subdividing the stratified rocks of the earth's crust than mere lithological characters, it is made the basis of the geological classification of these rocks. Thus we may find a particular stratum marked by the occurrence in it of various fossils, one or more of which may be distinctive, either from occurring in no other bed above and below, or from special abundance in that stratum. These species might therefore be used as a guide to the occurrence of the bed in question, which might be called by the name of the most abundant species. In this way a geological horizon or zone would be marked off, and geologists would thereafter recognize its exact position in the series of formations. But before such a generalization can be safely made, we must be sure that the species in question really never does appear on any other platform. This evidently demands wide experience over an extended field of observation. The assertion that a particular species occurs only on one horizon manifestly rests on negative evidence as much as on positive. The palæontologist who makes it cannot mean more than that he knows the fossil to lie on that horizon, and that, so far as his own experience and that of others goes, it has never been met with anywhere else. But a single example of the occurrence of the fossil on a different zone would greatly damage the value of his generalization, and a few such cases would demolish it altogether. Hence all such statements ought at first to be made tentatively. To establish a geological horizon on limited fossil evidence, and then to assume the identity of all strata containing the same fossils, is to reason in a circle and to introduce utter confusion into our interpretation of the geological record. The first and fundamental point is to determine accurately the order of superposition of the strata. Until this is done detailed palæontological classification may prove to be worthless. But when once the succession of the rocks has been fixed palæontological evidence may become paramount.

From what has been above advanced it must be evident that, even if the several groups in a formation or system of rocks in any district or country have been minutely subdivided by means of their characteristic fossils, and if, after the lapse of many years, no discovery has occurred to alter the established order of succession of these fossils, nevertheless the subdivisions can only be held good for the region in which they have been made. They must not be supposed to be strictly applicable everywhere. Advancing into another district or country where the petrographical characters of the same formation or system indicate that the original conditions of deposit must have been very different, we ought to be prepared to find a greater or less departure from the first observed or what might be regarded as the normal order of organic succession. There can be no doubt that the appearance of new organic forms in any locality has been in large measure connected with such physical changes as are indicated by diversities of sedimentary materials and arrangement. The Upper Silurian formations, for example, as studied by Murchison in Shropshire and the adjacent counties, present a clear sequence of strata well defined by characteristic fossils. But within a distance of 60 miles it becomes impossible to establish these subdivisions by fossil evidence. If we examine corresponding strata in Scotland, we find that they contain some fossils which never rise above the Lower Silurian formations in Wales and the west of England. Again, in Bohemia and in Russia we meet with still greater departures from the order of appearance in the original Silurian area, some of the most characteristic Upper Silurian organisms being there found far down beneath strata replete with records of Lower Silurian life. Nevertheless the general succession of life from Lower to Upper Silurian types remains distinctly traceable. Such facts warn us against the danger of being led astray by an artificial precision of palæontological detail. Even where the palæontological sequence is best established, it rests probably in most cases not merely upon the actual chronological succession of organic forms, but also, far more than is usually imagined, upon original accidental differences of local physical conditions. As these conditions have constantly varied from region to region, it must hardly ever happen that the same minute palæontological subdivisions, so important and instructive in themselves, can be identified and paralleled, except over comparatively limited geographical areas.

It cannot be too frequently stated, nor too prominently kept in view, that, although gaps occur in the succession of organic remains as recorded in the rocks, there have been no such blank intervals in the progress of plant and animal life upon the globe. The march of life has been unbroken, onward and upward. Geological history, therefore, if its records in the stratified formations were perfect, ought to show a blending and gradation of epoch with epoch, so that no sharp divisions of its events could be made. But the progress has been constantly interrupted; now by upheaval, now by volcanic outbursts, now by depression. These interruptions serve as natural divisions in the chronicle, and enable the geologist to arrange his history into periods. As the order of succession among stratified rocks was first made out in Europe, and as many of the gaps in that succession were found to be widespread over the European area, the divisions which experience established for that portion of the globe came to be regarded as typical, and the names adopted for them were applied to the rocks of other and far distant regions. This application has brought out the fact that some of the most marked breaks in the European series do not exist elsewhere, and, on the other hand, that some portions of that series are much more complete than in other regions. Hence, while the general similarity of succession may remain, different subdivisions and nomenclature are required as we pass from continent to continent.

A bed, or limited number of beds, characterized by one or more distinctive fossils, is termed a *zone* or *horizon*, and, as already mentioned, is often known by the name of a typical fossil, as the different zones in the Lias are by their special species of ammonite. A series of such zones, united by the occurrence among them of a number of the same species or genera, is called a *group*. A series of groups similarly related constitute a *formation*, and a number of formations may be united into a *system*. The terminology employed in this classification will be discussed in the following part.

PART VI.—STRATIGRAPHICAL GEOLOGY.

This branch of the science arranges the rocks of the earth's crust in the order of their appearance, and interprets the sequence of events of which they form the records. Its province is to cull from all the other departments of geology the facts which may be needed to show what has been the progress of our planet, and of each continent and country, from the earliest times of which the rocks have preserved any memorial. Thus from mineralogy and petrography it obtains information regarding the origin and subsequent mutations of minerals and rocks. From dynamical geology it learns by what agencies the materials of the earth's crust have been formed, altered, broken, upheaved, and melted. From structural geology it understands how these materials were put together so as to build up the complicated crust of the earth. From palæontological geology it receives in well-determined fossil remains a clue by which to discriminate the different stratified formations, and to trace the grand onward march of organized existence upon this planet. Stratigraphical geology thus gathers up the sum of all that is made known by the other departments of the science, and makes it subservient to the interpretation of the geological history of the earth.

The leading principles of stratigraphy may be summed up as follows:—

1. In every stratigraphical research the fundamental requisite is to establish the order of superposition of the strata. Until this is accomplished it is impossible to arrange the dates and make out the sequence of geological history.

2. The stratified portion of the earth's crust, or geological record, as it has been termed, may be subdivided into natural groups or formations of strata, each marked throughout by some common genera or species, or by a general resemblance in the type or character of its organic remains.

3. Many living species of plants and animals can be traced downward through the more recent geological formations; but they grow fewer in number as they are followed into more ancient deposits. With their disappearance we encounter other species and genera which are no longer living. These in turn may be traced backward into earlier formations, till they too cease, and their places are taken by yet older forms. It is thus shown that the stratified rocks contain the records of a gradual progression of organic forms. A species which has once died out does not seem ever to have reappeared. But as has been already pointed out in reference to Barrande's doctrine of colonies, a species may within a limited area appear in a formation older than that of which it is characteristic, having temporarily migrated into the district from some neighboring region where it had already established itself.

4. When the order of succession of organic remains among the stratified rocks has been determined, they become an invaluable guide in the investigation of the relative age of rocks and the structure of the land. Each zone and formation, being characterized by its own species or genera, may be recognized by their means, and the true succession of strata may thus be confidently established even in a country which has been shattered by dislocation, or where the rocks have been folded and inverted.

5. The relative chronological value of the divisions of the geological record is not to be measured by mere depth of strata. While it may be reasonably assumed that a great thickness of stratified rock must mark the passage of a long period of time, it cannot safely be affirmed that a much less thickness elsewhere represents a correspondingly diminished period. This may sometimes be made evident by an unconformability between two sets of rocks, as has already been explained. The total depth of both groups together may be, say 1000 feet. Elsewhere we may find a single unbroken formation reaching a depth of 10,000 feet; but it would be utterly erroneous to conclude that the latter represents ten times the length of time shown by the two former. So far from this being the case, it might not be difficult to show that the minor thickness of rock really denoted by far the longer geological interval. If, for instance, it could be proved that the upper part of both the sections lay on one and the same geological platform, but that the lower unconformable series in the one locality belonged to a far lower and older system of rocks than the base of the thick conformable series in the other, then it would be clear that the gap marked by the unconformability really indicated a longer period than the massive succession of deposits.

6. Fossil evidence furnishes the chief means of comparing the relative value of formations and groups of rock. A break in the succession of organic remains marks an interval of time often unrepresented by strata at the place where the break is found. The relative importance of these breaks, and therefore, probably, the comparative intervals of time which they mark, may be estimated by the difference of the facies of the fossils on each side. If, for example, in one case we find every species to be dissimilar above and below a certain horizon, while in another locality only half of the species on each side are peculiar, we naturally infer, if the total number of species seems large enough to warrant the inference, that the interval marked by the former break was very much longer than that marked by the second. But we may go further and compare by means of fossil evidence the relation between breaks in the succession of organic remains and the depth of strata between them.

Three formations of fossiliferous strata, A, C, and H, may occur conformably above each other. By a comparison of the fossil contents of all parts of A, it may be ascertained that, while some species are peculiar to its lower, others to its higher portions, yet the majority extend throughout the formation. If now it is found that of the total number of species in the upper portion of A only one-third passes up into C, it may be inferred with some probability that the time represented by the break between A and C was really longer than that required for the accumulation of the whole of the formation A. It might even be possible to discover elsewhere a thick intermediate formation B filling up the gap between A and C. In like manner were it to be discovered that, while the whole of the formation C is characterized by a common suite of fossils, not one of the species and only one half of the genera pass up into H, the inference could hardly be resisted that the gap between the two formations marks the passage of a far longer interval than was needed for the deposition of the whole of C. And thus we reach the remarkable conclusion that, thick though the stratified formations of a country may be, in some cases they may not represent so long a total period of time as do the gaps in their succession—in other words, that non-deposition was more frequent and prolonged than deposition, or that the intervals of time which have been recorded by strata have not been so long as those which have not been so recorded.

In all speculations of this nature, however, it is necessary to reason from as wide a basis of observation as possible, seeing that so much of the evidence is negative. Especially needful is it to bear in mind that the cessation of one or more species at a certain line among the rocks of a particular district may mean nothing more than that, owing to some change in the conditions of life or of deposition, these species were compelled to migrate or became locally extinct at the time marked by that line. They may have continued to flourish abundantly in neighboring districts for a long period afterward. Many examples of this obvious truth might be cited. Thus in a great succession of mingled marine, brackish-water, and terrestrial strata, like that of the Carboniferous Limestone series of Scotland, corals, crinoids, and brachiopods abound in the limestones and accompanying shales, but disappear as the sandstones, ironstones, clays, coals, and bituminous shales supervene. An observer meeting for the first time with an instance of the disappearance, and remembering what he had read about "breaks in succession," might be tempted to speculate about the extinction of these organisms, and their replacement by other and later forms of life, such as the ferns, lycopods, ganoid fishes, and other fossils so abundant in the overlying strata. But further research would show him that high above the plant-bearing sandstones and coals other limestones and shales might be observed, once more charged with the same marine fossils as before, and still farther overlying groups of sandstones, coals, and carbonaceous beds followed by yet higher marine limestones. He would thus learn that the same organisms, after being locally exterminated, returned again and again to the same area. After such a lesson he would probably pause before too confidently asserting that the highest bed in which we can detect certain fossils marked really their final appearance in the history of life. A break in the succession may thus be extremely local, one set of organisms having been driven to a different part of the same region, while another set occupied their place until the first was enabled to return.

7. The geological record is at the best but an imperfect chronicle of the geological history of the earth. It abounds in gaps, some of which have been caused by the destruction of strata owing to metamorphism, denudation, or otherwise, some by original non-deposition, as above explained. Nevertheless from this record alone can the progress of the earth be traced. It contains the registers of the births and deaths of tribes of plants and animals which have from time to time lived on the earth. But a small proportion of the total number of species which have appeared in past time have been thus chronicled, yet by collecting the broken fragments of the record an outline at least of the history of life upon the earth can be deciphered.

The nomenclature adopted for the subdivisions of the geological record bears witness to the rapid growth of geology. It is a patch-work in which no system nor language has been adhered to, but where the influences by which the progress of the science has been moulded may be distinctly traced. Some of the earliest names are lithological, and remind us of the fact that mineralogy and petrography preceded geology in the order of birth—Chalk, Oolite, Greensand, Millstone Grit. Others are topographical, and often recall the labors of the early geologists of England—London Clay, Oxford Clay, Purbeck, Portland, Kimeridge beds. Others are taken from local English provincial names, and remind us of the debt we owe to William Smith, by whom so many of them were first used—Lias, Gault, Crag, Cornbrash. Others of later date recognize an order of superposition as already established among formations—Old Red Sandstone, New Red Sandstone. By common consent it is admitted that names taken from the region where a formation or group of rocks is typically developed, are best adapted for general use. Cambrian, Silurian, Devonian, Permian, Jurassic, are of this class, and have been adopted all over the globe.

But whatever be the name chosen to designate a particular group of strata, it soon comes to be used as a chronological or homotaxial term, apart altogether from the stratigraphical character of the strata to which it is applied. Thus we speak of the Chalk or Cretaceous system, and embrace under that term formations which may contain no chalk; and we may describe as Silurian a series of strata utterly unlike in lithological characters to the formations in the typical Silurian country. In using these terms we unconsciously allow the idea of relative date to arise prominently before us. Hence such a word as chalk or cretaceous does not suggest so much to us the group of strata so called, as the interval of geological history which these strata represent. We speak of the Cretaceous, Jurassic, and Cambrian periods, and of the Cretaceous fauna, the Jurassic flora, the Cambrian trilobites, as if these adjectives denoted simply epochs of geological time.

The geological record is classified into five main divisions:—(1) the Archæan, Azoic (lifeless), or Eozoic (dawn of life) Periods; (2) the Primary or Palæozoic (ancient life) Periods; (3) the Secondary or Mesozoic (middle life) Periods; (4) the Tertiary or Cainozoic (recent life); and (5) the Quaternary or Post-Tertiary Periods. These divisions are further ranged into systems, each system into formations, each formation into groups, and each group or series into single zones or horizons. The subjoined generalized table exhibits the order in which the chief subdivisions appear.

Order of Succession of the Stratified Formation of the Earth's Crust.

	Britain.			Continental Europe.	North America.
Post-Tertiary or Quaternary.	Recent — Alluvium, peat, etc.			Alluvium.	Recent or Terrace.
	Pleistocene — *Cave deposits, Glacial drift.*			Diluvium.	Champlain. Glacial.
Tertiary or Cainozoic.	Pliocene — *Crag deposits of Norfolk and Suffolk.*			Pliocene—*Tegel, Dinotherium-Sand.*	Sumter.
	Miocene—*Lignite of Bovey Tracey, Mull, etc.*			Miocene — *Leithakalk, Upper Molasse.*	Yorktown.
				Oligocene — *Lower Molasse, Grès de Fontainebleau, etc.*	
	Eocene — *Tertiaries of Hampshire Basin and Isle of Wight.*			Eocene—*Nummulite-limestone, Flysch.*	Alabama. Lignitic.
Secondary or Mesozoic.	Cretaceous.		Upper.	Senonian — *Craie blanche et tuffeau, Upper Quadersandstein.*	Fox-Hills group. Upper Missouri Region.
				Turonian — *Plänerkalk.*	Pierre group.
				Cenomanian — *Grès vert.*	Niobrara group.
				Gault.	Benton group.
			Lower.	Neocomian.	Dakotah group.
	Jurassic.	Oolitic.	Upper.	Upper or White Jura (Malm).	Jurassic rocks appear to be but poorly developed in N. America.
			Lower.	Middle or Brown Jura (Dogger).	
		Liassic.		Lower or Black Jura (Lias).	
	Triassic.		Upper.	Rhætic beds, Keuper.	
				Muschelkalk.	Triassic.
			Lower.	Bunter.	
Primary or Palæozoic.	Permian.			Dyas or Permian *Zechstein, Rothliegendes.*	Permian.
	Carboniferous.	Coal-measures.		Terrain houiller, Steinkohlen.	Carboniferous.
		Millstone Grit.		Flötzleerer Sandstein.	Sub-Carboniferous.
		Carboniferous Limestone.		Calcaire Carbonifère, Kohlenkalk, Kulm.	
	Devonian and Old Red Sandstone.			Devonian.	Devonian.
	Silurian.			Silurian (Transition or Grauwacke system).	Silurian.
	Cambrian.			Primordial Silurian, older grauwacke and slate.	Primordial Silurian and Cambrian.
				Primitive schists.	Huronian.
Archæan or Azoic (Eozoic).	Fundamental gneiss.			Ur-gneiss.	Laurentian.

I. ARCHÆAN.

Underneath the oldest unaltered stratified and fossiliferous formations in Europe there occur masses of gneiss and other crystalline schistose rocks belonging perhaps to widely different geological periods, but, from want of satisfactory means of discrimination, necessarily united provisionally in one common series. That they are separated by a vast interval of time from the rocks which lie upon them is shown by the strong unconformability with which they are related to every formation of younger date than themselves. Everywhere thoroughly crystalline, they are disposed in rude, crumpled, often vertical beds, out of the ruins of which the overlying formations have been partly built.

BRITAIN.—In no part of the European area are these ancient rocks better seen than in the north-west of Scotland. Their position there, previously indicated by MacCulloch and Hay Cunningham, was first definitely established by Murchison, who showed that they possess a dominant strike to N. N. W., and are unconformably overlaid by all the other rocks of the Scottish Highlands. They consist of a tough massive gneiss usually hornblendic, with bands of hornblende-rock, hornblende-schist, quartz-felsite, granite, and other crystalline rocks. In two or three places they enclose bands of limestone, but neither in these nor in any other parts of their mass has the least trace of any organic structure been detected. It is impossible at present to offer any conjecture as to their probable thickness. It must be many thousand feet; but its approximate amount, if ever ascertainable, will only be made out after the region where they occur has been mapped in detail. These gneisses and schists possess a massiveness and rudeness of bedding which strongly distinguishes them from all the other and younger metamorphic rocks of Britain. They form nearly the whole of the Outer Hebrides, and occupy a variable belt of the western parts of the counties of Sutherland and Ross. Murchison proposed to term them the Fundamental or Lewisian Gneiss from the isle of Lewis—the chief of the Hebrides. Afterwards he called them Laurentian, regarding them as the equivalent of some part of the great Laurentian system of Canada.

In recent years Mr. Hicks and others have endeavored to show that in Wales there exist here and there protrusions of an old crystalline group of rocks from beneath the Cambrian system, and they have described these "pre-Cambrian" masses as overlaid unconformably by younger formations, as in the north-west of Scotland. Professor Ramsay, however, who with his colleagues in the Geological Survey mapped the Welsh areas in detail, contends that the supposed older gneiss is merely a metamorphosed portion of the Cambrian rocks.

CONTINENTAL EUROPE.—On the continent of Europe numerous areas of ancient gneiss rise from under the oldest fossiliferous formations. In Scandinavia the structure of part of the country resembles that of the north-west of Scotland: the fundamental-gneiss (*Urgneiss*), covering a large area, is overlaid unconformably by red sandstones which underlie the most ancient strata containing organic remains. The gneiss and its accompanying rocks range through Finland into the north-west of Russia, reappearing in the north-east of that vast empire in Petchora Land down to the White Sea, and rising in the nucleus of the chain of the Ural Mountains, and still further south in Podolia. In Central Europe they appear as islands in the midst of more recent formations. In the midst of the Carpathian Mountains they protrude at a number of points, but westwards in the Alpine chain they rise in a more continuous belt in the central portion of these crests, and show numerous mineralogical varieties, including protogine, mica-schist, and many other schists, as well as limestone and serpentine. But perhaps their most intelligible sections are those which they present in Bavaria and Bohemia between the valley of the Danube and the headwaters of the Elbe. They are there divided into two well-marked groups—(*a*) red gneiss, covered by (*b*) grey gneiss. According to Gümbel the former (called by him the Bojan gneiss) may be traced as a distinct formation associated with granite, but with very few other kinds of crystalline or schistose rocks, while the latter (termed the Hercynian gneiss) consists of gneiss with abundant interstratification of many other schistose rocks, graphitic limestone, and serpentine. The Hercynian gneiss is overlaid by mica-schist, above which comes a vast mass of argillaceous schists and shales. Gümbel some years ago found in the marbles associated with the younger gneiss what he considered to be an organism of the same genus as the *Eozoon* of Canada, to which reference will immediately be made. He named it *Eozoon Bavaricum.* More recently a similar substance was obtained in the Archæan series of Bohemia, and named by Fritsch *Eozoon Bohemicum.*

AMERICA.—In North America Archæan rocks cover a large part of the continent from the Arctic Circle southwards to the great lakes. They appear likewise, as in Europe, along the central parts of prominent mountain chains, as in the Rocky Mountain range and that of the Appalachians. They have been carefully studied in Canada, where the late Sir W. E. Logan, Director of the Geological Survey of the Dominion, estimated their depth at about 30,000 feet, but neither their top nor their base can there be found. He named them the Laurentian system from their abundant development along the shores of the St. Lawrence. They have been divided into two series—(1) a lower formation more than 20,000 feet thick, consisting chiefly of granitic, orthoclase gneiss, with bands of quartz-rock, schists, iron-ore, and limestone; and (2) an upper formation fully 10,000 feet thick, composed also, for the most part, of gneiss, but marked by the occurrence of bands of Labrador felspar, as well as schist, iron-ore, and limestone. The upper division has been stated to lie unconformably on the lower. Mr. Selwyn, however, has recently pointed out that this is almost certainly not the case, but that the limestone-bearing series rests conformably upon a massive granitoid gneiss, to which he would restrict the term Laurentian, classing the limestones in the next or Huronian system (*Nat. Hist. Soc. Montreal*, Feb., 1879).

In one of the Laurentian limestones of Canada, specimens have been found of a remarkable mixture of calcite and serpentine. These minerals are arranged in alternate layers, the calcite forming the main framework of the substance with the serpentine (sometimes loganite, pyroxene, etc.) disposed in thin, wavy, inconstant layers, as if filling up flattened up cavities in the calcareous mass. So different from any ordinary mineral segregation with which he was acquainted did this arrangement appear to Logan, that he was led to regard the substance as probably of organic origin. This opinion was adopted, and the structure of the supposed fossil was worked out in elaborate detail by Dr. Dawson of Montreal, who pronounced the organism to be the remains of a massive foraminifer which he called *Eozoon*, and which he believed must have grown in large thick sheets over the sea-bottom. This opinion was confirmed by Dr. W. B. Carpenter, who from a large suite of additional and better preserved specimens, described a system of internal canals having the characters of those in true foraminiferal structures. (See FORAMINIFERA.) Other observers, notably Professors King and Rowney of Galway and Möbius of Kiel, have opposed the organic nature of *Eozoon*, and have endeavored to show that the supposed canals and passages are merely infiltration veinings of serpentine in the calcite. In some cases, however, the "canal-system" is not filled with serpentine but with dolomite, which seems to show that the cavities must have existed before either dolomite or serpentine were introduced into the substance. Dr. Carpenter contends that the disposition of these passages in his decalcified specimens is very regular, and quite unlike any mineral infiltration with which he is acquainted.

The opinion of the organic nature of *Eozoon* has been supposed to receive support from the large quantity of graphite found throughout the Archæan rocks of Canada and the northern parts of the United States. This mineral occurs partly in veins, but chiefly disseminated in scales and laminæ in the limestones and as independent layers. Dr. Dawson estimates the aggregate amount of it in one band of limestone in the Ottawa district as not less than from 20 to 30 feet, and he thinks it is hardly an exaggeration to say that there is as much carbon in the Laurentian as in equivalent areas of the Carboniferous system. He compares some of the pure bands of graphite to beds of coal, and maintains that no other source for their origin can be imagined than the deoxidation of carbonic acid by living plants. In the largest of three beds of graphite at St. John he has found what he considers may be fibrous structure indicative of the existence of land-plants.

Still further evidence in favor of organized existence during Archæan time in the North American area has been adduced from the remarkably thick and abundant masses of iron ore associated with the Laurentian rocks of Canada and the United States. Dr. Sterry Hunt has called attention to these ores as proving the precipitation of iron by decomposing vegetation during the Laurentian period on a more gigantic scale than at any subsequent geological epoch.[1] Some of the beds of magnetic iron ranged up to

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[1] *Geology of Canada*, 1863, p. 573.

200 feet in thickness. Large masses also of hæmatite and titaniferous iron, as well as of iron sulphides, occur in the Canadian Archæan series. These great bands of iron ore run southward, and form an important feature in the economic geology of the Northern States of the Union.

Above the Laurentian rocks in the region of Lake Huron lies a vast mass of slates, conglomerates, limestones, and quartz-rocks, attaining a depth of from 10,000 to 20,000 feet. They are termed Huronian. No fossils have yet been found in them; but they must be much younger than the Laurentian rocks, on which they rest unconformably, and from which they have been in part at least derived.

II. PALÆOZOIC.

Under the general term of Primary or Palæozoic are now included all the older sedimentary formations containing organic remains, up to the top of what is termed the Permian system. These rocks consist mainly of sandy and muddy sediment with occasional intercalated zones of limestone. They everywhere bear witness to comparatively shallow water and the proximity of land. Their frequent alternations of sandstone, shale, conglomerate, and other detrital materials, their abundant, rippled, and sun-cracked surfaces marked often with burrows and trails of worms, as well as the prevalent character of their organic remains, show that they must have been deposited in areas of slow subsidence, bordering continental or insular masses of land. As regards the organisms of which they have preserved the casts, the Palæozoic rocks, as far as the present evidence goes, may be grouped into two divisions—an older and a newer:—the former distinguished more especially by the abundance of its graptolitic, trilobitic, and brachiopodous fauna, and by the absence of vertebrate remains; the latter by the number and variety of its fishes and amphibians, the disappearance and extinction of graptolites and trilobites, and the abundance of its cryptogamic terrestrial flora.

Cambrian.

This name was applied by Sedgwick to the rocks of North Wales (Cambria), where he first investigated them. Their base is there nowhere seen, so that, though they attain a great depth, some part of their total mass must be concealed from view. They pass up continuously into the base of the Silurian system. Considerable diversity of opinion has existed, and still continues, as to the line where the upper limit of the Cambrian system should be drawn. Murchison contended that this line should be placed below the strata where a trilobitic and brachiopodous fauna begins, and that these strata cannot be separated from the overlying Silurian system. He therefore included in the Cambrian only the barren grits and slates of the Longmynd, Harlech, and Llanberis. Sedgwick, on the other hand, insisted on carrying the line up to the base of the Upper Silurian rocks. He thus left these formations as alone constituting the Silurian system, and massed all the Lower Silurian in his Cambrian system. Murchison worked out the stratigraphical order of succession from above, and chiefly by help of organic remains. He advanced from where the superposition of the rocks is clear and undoubted, and for the first time in the history of geology ascertained that the "transition-rocks" of the older geologists could be arranged into zones by means of characteristic fossils as satisfactorily as the Secondary formations had been classified in a similar manner by William Smith. Year by year, as he found his Silurian types of life descend farther and farther into lower deposits, he pushed backward the limits of his Silurian system. In this he was supported by the general consent of geologists and palæontologists all over the world. Sedgwick, on the other hand, attacked the problem rather from the point of stratigraphy and geological structure. Though he had collected fossils from many of the rocks of which he had made out the true order of succession in North Wales, he allowed them to lie for years unexamined. Meanwhile Murchison had studied the prolongations of some of the same rocks into South Wales, and had obtained from them the abundant suite of organic remains which characterized his Lower Silurian formations. Similar fossils were found abundantly on the continent of Europe, and in America. Naturally the classification proposed by Murchison was adopted all over the world. As he included in his Silurian system the oldest rocks containing a distinctive fauna of trilobites and brachiopods, the earliest fossiliferous rocks were everywhere classed as Silurian, and the name Cambrian was discarded by geologists of other countries as indicative of a more ancient series of deposits not characterized by peculiar organic remains, and therefore not capable of being elsewhere satisfactorily recognized. Barrande, investigating the most ancient fossiliferous rocks of Bohemia, distinguished by the name of the "Primordial Zone" a group of strata underlying the Lower Silurian rocks, and containing a peculiar and characteristic suite of trilobites. He classed it, however, with the Silurian system, and Murchison adopted the term, grouping under it the lowest dark slates which in Wales and the border English counties contained some of the same early forms of life.

Investigations during the last twelve years, however, chiefly by the late Mr. Salter and Mr. Hicks, have brought to light a much more abundant fauna from the so-called primordial rocks of Wales than they were supposed to possess. These fossils were found to be in large measure distinct from those in the undoubted Lower Silurian rocks. Thus the question of the proper base of the Silurian system was re-opened, and the claims of the Cambrian system to a great upward extension were more forcibly urged than ever. But these claims could now be urged on palæontological evidence such as had never before been produced. Accordingly there has arisen a general desire among the geologists of Britain to revise the nomenclature of the older rocks. Though as yet a common accord of opinion has not been reached, there seems a strong probability that ultimately the boundary line between the Cambrian and Silurian systems will be drawn above the primordial zone along the base of the great Arenig group or Lower Llandeilo rocks of Murchison. All his Silurian strata of older date than these rocks will be classed as Cambrian.

According to this classification, the Cambrian system, as developed in North Wales and the border English counties, consists of purple, reddish-grey, and green slates, grits, sandstones, and conglomerates. Its true base is nowhere seen, yet even the visible mass of strata has been estimated to reach the enormous thickness of 25,000 feet. By far the larger part of this vast depth of rock is unfossiliferous. Indeed it is only in some bands of the upper 6000 feet, or thereabouts, that fossils occur plentifully. By fossil evidence the Cambrian system may be divided into Lower and Upper, and each of these sections may be further subdivided into two groups, as in the following table:—

Cambrian of Wales.	Upper.	4. Tremadoc slates.
		3. Lingula flags.
	Lower.	2. Menevian group.
		1. Harlech and Longmynd group.

1. *Harlech and Longmynd Group.*—This includes purple, red, and grey flags, sandstones, and slates, with conglomerates. These strata attain a great thickness, estimated at 4000 feet in South Wales, but more than 8000 in North Wales. They were formerly supposed to be nearly barren of organic remains; but in recent years, chiefly through the researches of Mr. Hicks at St. David's, they have yielded a tolerably abundant fauna, consisting of 30 species. Among these are 16 species of trilobite, (*Paradoxides*, *Plutonia*, *Microdiscus*, *Palæopyge*, *Agnostus*, *Conocoryphe*), four annelides (*Arenicolites*), a sponge (*Protospongia*), five brachiopods (*Discina*, *Lingulella*), two pteropods (*Theca*), etc. Many of the surfaces of the strata in some parts of this group are marked with ripples, sun-cracks, and rain-pittings as well as with trails of worms—indicative of shallow-water and shore-conditions of deposit. 14 of the 30 species, according to Mr. Etheridge, F. R. S., pass up into the Menevian group, and 7 continue into the Lingula flags.

2. *Menevian Group.*—This subdivision has been proposed for a series of sandstones and shales, with dark-blue slates and flags, dark-grey flags and grey grits, which are seen near St. David's (Menevia), where they attain a depth of about 600 feet. They pass down conformably into the Harlech group with which, as just stated, they are connected by 14 species in common. The Menevian beds have yielded upwards of 50 species of fossils, of which 24 are confined to the Menevian, while 18 pass up into the lower Lingula flags. Among these the trilobites are specially prominent. Some of them attained a great size, *Paradoxides Davidis* being nearly two feet long. But with these were mingled others of diminutive size. It is noteworthy also, as Mr. Hicks has pointed out, that while the trilobites had attained their maximum size at this early period, they are represented among the older Cambrian rocks by genera indicative of almost every stage of development, "from the little *Agnostus* with two rings in the thorax, and *Microdiscus* with four, to *Erinnys* with twenty-four," while blind genera occur together with those having the largest eyes.[1] Upwards of 30 species of

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[1] Hicks, *Quart. Journ. Geol. Soc.*, xxviii. 174.

trilobites have been obtained from the Menevian beds, the genera *Agnostus* (7 species), *Conocoryphe* (7 species), and *Paradoxides* being specially characteristic. Four species of sponges (*Protospongia*) and some annelide-tracks likewise occur. The mollusca are represented by 6 species of brachiopoda of the genera *Discina*, *Lingulella*, and *Obolella*; 5 pteropods (*Theca*) have been met with. The earliest entomostraca (*Entomis*) and the first cystidean (*Protocystites*) yet discovered occur in the Menevian fauna.

3. *Lingula flags.*—These strata, consisting of bluish and black slates and flags, with bands of grey flags and sandstones, attain in some parts of Wales a thickness of more than 5000 feet. They received their name from the discovery by Mr. E. Davis (1846) of vast numbers of a *Lingula* (*Lingulella Davisii*) in some of their layers. They rest conformably upon, and pass down into, the Menevian beds below them, and likewise graduate into the Tremadoc group above. They are distinguished by a characteristic suite (78 species) of organic remains. The trilobites include the genera *Agnostus*, *Anapolenus*, *Conocoryphe*, *Dikelocephalus*, *Erinnys*, *Olenus*, and *Paradoxides*. The earliest phyllopods (*Hymenocaris*) and heteropods (*Bellerophon*) occur in these beds. The brachiopods include species of *Lingulella* (*L. Davisii*), *Discina*, *Obolella*, and *Orthis*. The pteropods are represented by three species of *Theca*. Several annelides (*Cruziana*) and polyzoa (*Fenestella*) likewise occur.

According to a careful census by Mr. Etheridge, the Lingula flags may be grouped into three zones, each characterized by a peculiar assemblage of organic remains. The lower division contains 37 species, of which 9 are peculiar to it. The middle zone has yielded 5 species, 2 of which (*Conocoryphe bucephala* and *Lingulella Davisii*) pass down into the lower division, 1 (*Kutorgia cingulata*) into the upper, and 2 (*Lingula squamosa* and *Bellerophon Cambrensis*) are peculiar. The upper zone has yielded 40 species. Of these 9 pass up into the Tremadoc beds, while 2 (*Lingulella lepis* and *L. Davisii*) continue on into the Arenig group.

4. *Tremadoc Slates.*—This name was given by Sedgwick to a group of dark grey slates, about 1000 feet thick, found near Tremadoc in Carnarvonshire, and traceable thence to Dolgelly. Their importance as a geological formation was not recognized until the discovery of a remarkably abundant and varied fauna in them. They contain the earliest crinoids, star-fishes, lamellibranchs, and cephalopods yet found. The trilobites embrace 14 genera, among which, besides some, as *Agnostus*, *Conocoryphe*, and *Olenus*, found in the Lingula flags, we meet for the first time with *Angelina*, *Asaphus*, *Cheirurus*, *Neseuretus*, *Niobe*, *Ogygia*, *Psilocephalus*, etc. The same genera, and in some cases species, of brachiopods appear which occur in the Lingula flags, *Orthis Carausii* and *Lingulella Davisii* being common forms. Mr. Hicks has described 12 species of lamellibranchs from the Tremadoc beds of Ramsay Island and St. David's, belonging to the genera *Ctenodonta*, *Palæarca*, *Glyptarca*, *Davidia*, and *Modiolopsis*. The cephalopods are represented by *Orthoceras sericeum* and *Cyrtoceras præcox*; the pteropods by *Theca Davidii*, *T. operculata*, and *Conularia Homfrayi*; the echinoderms by a beautiful star-fish (*Palasterina ramseyensis*) and by a crinoid (*Dendrocrinus Cambrensis*).[1]

Careful analysis of the fossils yielded by the Tremadoc beds suggests a division of this formation into two zones. According to a census by Mr. Etheridge, the Lower Tremadoc rocks have yielded in all 56 species, of which 9 pass down into the Lingula flags and 10 ascend into the Upper Tremadoc zone, 31 being peculiar. The Upper Tremadoc beds contain, as at present ascertained, 33 species, of which 9 are peculiar, and 13 or possibly 15 pass up into the Arenig group. It is at the top of the Upper Tremadoc strata that the line between the Cambrian and Silurian systems is here drawn. According to Professor Ramsay, there is evidence of a physical break at the top of the Tremadoc beds of Wales, so that on a large scale the next succeeding or Arenig strata repose unconformably upon everything older than themselves. Mr. Etheridge also shows that the palæontological break is nearly complete, only about 7 per cent. of the fossils of the one series passing over into the other. Out of 184 known Arenig species, not more than 13 are common to the Tremadoc beds underneath. Besides these important facts the character of the Arenig fauna strongly distinguishes it from that of the formations below, and further supports the line of division here adopted between the Cambrian and Silurian systems.

In the north-west of Scotland a mass of reddish-brown and chocolate-colored sandstone and conglomerate (at least 8000 feet thick in the Loch Torridon district) lies unconformably upon the fundamental gneiss in nearly horizontal or gently inclined beds. It rises into picturesque groups of mountains which stand out as striking monuments of denudation, seeing that the truncated ends of their component flat strata can be traced even from a distance forming parallel bars along the slopes and precipices. The denudation must have been considerable even in early Silurian times, for the sandstones are unconformably overlaid by quartz-rocks and limestones containing Lower Silurian fossils. No trace of organic remains of any kind has been found in the red sandstones themselves. They were at one time regarded as Old Red Sandstone, though Macculloch, and afterwards Hay Cunningham, pointed out that they underlie parts of the schistose rocks of the northern Highlands. The discovery by Mr. C. W. Peach of Lower Silurian shells in the overlying limestones showed that the massive red sandstones of western Ross and Sutherland could not be paralleled with those of the eastern tracts of those counties, but must be of older date than part of the Llandeilo rocks of the Lower Silurian period. Sir R. Murchison classed them as Cambrian—an identification which has much support in the lithological resemblance between these rocks of the north-west Highlands and much of the Lower Cambrian system of Wales.

In the south-east of Ireland masses of purplish, red, and green shales, slates, grits, quartz-rocks, and schists occupy a considerable area and attain a depth of 14,000 feet without revealing their base, while their top is covered by unconformable formations (Lower Silurian and Lower Carboniferous). They have yielded *Oldhamia*, described originally as a sertularian zoophyte, but now regarded by many palæontologists as an alga; also numerous burrows and trails of annelides (*Histioderma Hibernicum*, *Arenicolites didymus*, *A. sparsus*, *Haughtonia pœcila*). No Upper Cambrian forms have been met with in these Irish rocks, which are therefore placed with the Lower Cambrian, the unconformability at their top being regarded as equivalent to the interval required for the deposition of the intervening formations up to the time of the Llandeilo rocks, as in the north-west of Scotland. Some portions of the Irish Cambrian series have been intensely metamorphosed. Thus on the Howth coast they appear as schists and quartz-rocks; in Wexford they pass into gneiss and granite. In West Galway Mr. Kinahan has described a vast mass of schists, quartz-rocks, and limestones (8000 feet and upwards) passing up into schistose, hornblendic, and unaltered rocks containing Llandeilo fossils, and he agrees with Griffith and King in regarding these as probably Cambrian. He suggests that they are Upper Cambrian, which would imply that Upper Cambrian rocks pass conformably into the Llandeilo formation without the occurrence of the thick Arenig rocks of Wales. In a difficult country, however, broken by faults and greatly metamorphosed, an unconformability might easily escape detection.

CONTINENTAL EUROPE.—According to the classification adopted by M. Barrande, the older Palæozoic rocks of Europe suggest an early division of the area of this continent into two regions or provinces,—a northern province, embracing the British Islands, and extending through North Germany into Scandinavia, on the one hand, and into Russia on the other, and a central European province, including Bohemia, France, Spain, Portugal, and Sardinia.

Bohemia.—The classic researches of M. Barrande have given to the oldest fossiliferous rocks of Bohemia an extraordinary interest. He has made known the existence there of a remarkable suite of organic remains representative of those which characterize the Cambrian rocks of Britain. At the base of the geological formations of that region lie the Archæan gneisses already described. These are overlaid by vast masses of schists, conglomerates, quartzites, slates, and igneous rocks, which have been more or less metamorphosed, and are singularly barren of organic remains, though some of them have yielded traces of annelides. They pass up into certain grey and green fissile shales, in which the earliest well-marked fossils occur. The organic contents of this zone (Étage C) form what M. Barrande terms his primordial fauna, which contains 40 or more species, of which 27 are trilobites, belonging to the characteristic Cambrian genera—*Paradoxides* (12), *Agnostus* (5), *Conocoryphe* (4), *Ellipsocephalus* (2), *Hydrocephalus* (2), *Arionellus* (1), *Sao* (1). Not a single species of any one of these genera, save *Agnostus* (of which 4 species appear in the second fauna), has been found by M. Barrande higher than his primordial zone. Among other organisms in this primordial fauna, the brachiopods are represented by 2 species (*Orthis* and *Orbicula*), the pteropods by 5 (*Theca*), and the echinoderms by 5 cystideans.

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[1] Hicks, *Quart. Journ. Geol. Soc.*, xxix. 39.

Scandinavia.—In Norway the vast masses of Archæan gneiss (Tellemark) are overlaid by schists, red sandstones, and conglomerates. These are termed the Sparagmite formation, and have hitherto proved barren of fossils. They are covered, however, by beds containing *Dictyonema Norvegicum*, which may represent the primordial zone of Barrande. In Sweden the sparagmite formation has been more productive of organic remains. It is there represented by a sandy zone not more than 50 or 60 feet thick—a poor equivalent for the great mass of strata in the Cambrian system of Wales. It was originally termed the *Regio Fucoidarum* by Angelin, from the fucoids alone found in it. In more recent years, however, its list of organic remains has been considerably increased; 12 species of plants, chiefly fucoids, but including some (*Eophyton*) of higher grade, 9 species of annelides, 4 brachiopods, a pteropod, a bryozoan, a coral, a crinoid, and a sponge have been obtained. Above the strata containing these organisms comes a zone which has yielded 77 species of primordial trilobites, including the genera *Agnostus* (19 species), *Conocoryphe* (13), *Olenus* (21), *Paradoxides* (9).

North America.—Rocks corresponding in position and in the general character of their organic contents with the Cambrian formations of Britain have been recognized in different parts of the United States and Canada. They appear in Newfoundland, whence, ranging by Nova Scotia and New Brunswick, they enter Canada, the northern parts of New York, Vermont, and eastern Massachusetts. They rise again along the Appalachian ridge, in Wisconsin, Minnesota, Missouri, Arkansas, Texas, and Georgia. Westwards from the great valley of the Mississippi, where they have been found in many places, they reappear from under the Secondary and younger Palæozoic rocks of the Rocky Mountains. They have been divided by American geologists into two formations—(1) Acadian, a mass (2000 feet) of grey and dark shales and some sandstones; and (2) Potsdam (or Georgian), which attains in Newfoundland a depth of 5600 feet, but thins away westward and southward till in the valley of the St. Lawrence, where it was studied by Logan and his associates of the Geological Survey of Canada, it is only from 300 to 600 feet thick.

Among the organic remains of the North American Cambrian rocks fucoid casts appear in many of the sandstones, but no traces of higher vegetation. The Acadian formation has yielded primordial trilobites of the genera *Paradoxides, Conocoryphe, Agnostus*, and some others; brachiopods of the genera *Lingulella, Discina, Obolella*, and *Orthis;* and several kinds of annelide-tracks. The Potsdam rocks contain a few sponges, the earliest forms of graptolite, some brachiopods, including, besides the genera in the Acadian beds, *Obolus, Camarella*, and *Orthisina;* some pteropods (*Hyolites* or *Theca*); two species of *Orthoceras;* annelide tracks; trilobites of the genera *Conocoryphe, Agnostus, Dikelocephalus, Olenellus, Ptychaspis, Chariocephalus, Aglaspis*, and *Illænurus.*

M. Barrande has called attention to the remarkable uniformity of character in the organic remains of his primordial zone over the continents of Europe and America. He published in 1871 the subjoined table, to show how close is the parallelism between the proportions in which the different classes of the animal kingdom are represented.[1]

Countries.	Crustaceans.				Mollusks.				Inferior Classes.			
	Trilobites.	Other Crustacea.	Ostracods.	Annelides.	Pteropods.	Heteropods.	Gasteropods.	Brachiopods.	Bryozoans.	Cystideans.	Sponges.	Total by countries.
1. Bohemia	27	.	.	.	5	.	.	2	1	5	.	40
2. Spain	9	.	1	.	.	.	2	6	.	1	.	19
3. Scandinavia {*Regiones* A and B}	77	.	5	.	2	.	.	8	4	.	.	96
4. England {Menevian Harlech, part}	33	1	4	4	7	.	.	6	.	1	2	58
5. Newfoundland	2	.	.	.	.	.	.	.	.	.	.	2
6. New Brunswick	18	.	.	.	.	.	.	6	.	1	.	25
7. New York	5	.	.	.	.	.	.	.	.	.	.	5
8. Braintree (Massachusetts)	1	.	.	.	.	.	.	.	.	.	.	1
	172	1	10	4	14	.	2	28	5	8	2=	246

Silurian.

The important system of rocks next to be described was first investigated by the late Sir R. Murchison in Wales and the bordering counties of England. He found it to be characteristically developed over the tract once inhabited by the Silures, an ancient British tribe, and he thence chose the name of Silurian as a convenient designation. It there passes down conformably into the Tremadoc slates at the top of the Cambrian series, and is covered conformably by the base of the Old Red Sandstone.

Great Britain.—In the typical area where Murchison's discoveries were first made he found the Silurian rocks divisible into two great and well-marked series, which he termed Lower and Upper. This classification has been found to hold good over a large part of the world. The subjoined table shows the present arrangement and nomenclature of the various subdivisions of the Silurian system.

		Feet.
B. Upper Silurian.	7. Ludlow group	1,950
	6. Wenlock group	1,600
	5. Upper Llandovery group	1,500
A. Lower Silurian.	4. Lower Llandovery group	1,000
	3. Bala and Caradoc group	6,000
	2. Llandeilo group	2,500
	1. Arenig or Stiper Stone group	4,000
	Approximate average thickness =	18,550

A. *Lower Silurian.*

1. *Arenig or Stiper Stone Group.*—These rocks consist of dark slates, shales, flags, and bands of sandstone. They are abundantly developed in the Arenig mountain, where, as originally described by Sedgwick, they contain masses of associated porphyry. Throughout that district they have been deposited at a time when streams of lava and showers of volcanic ashes were thrown out in great quantity from submarine vents. They contain an abundant suite of organic remains (184 species), of which only 13 species are common to the Tremadoc beds below. Trilobites occur of the genera *Æglina, Agnostus, Ampyx, Barrandea, Calymene, Cheirurus, Illænopsis, Illænus, Ogygia, Phacops*, and *Trinucleus.* Three species of pteropods (*Conularia, Theca*), 18 species of brachiopods (*Lingula, Lingulella, Obolella, Discina, Siphonotreta, Orthis*), 8 lamellibranchs, 3 gasteropods, and 5 cephalopods have been found; but the most abundant organisms are the graptolites, of which the Arenig rocks of St. David's, in Pembrokeshire, have yielded 48 species, which belong to 20 genera, including *Didymograptus, Tetragraptus, Diplograptus, Dendrograptus*, and *Callograptus.*[2] Altogether 78 species of Hydrozoa have been obtained from the British Arenig rocks, but none from any older strata. This sudden and great development of these organisms gives a distinctive aspect to the Arenig rocks. It continues in the overlying Llandeilo group, so that the graptolites form in Britain a convenient character by which to mark off the Cambrian from the Lower Silurian fauna.

2. *Llandeilo Flag Group.*—Dark argillaceous flagstones, sandstones, and shales, some parts often calcareous. These beds were first described by Murchison as occurring at Llandeilo, in Carmarthenshire. They reappear on the coast of Pembrokeshire, and at Builth, in Radnorshire. Up to the present time they have yielded 227 species of fossils. Of these 13 are common to the Arenig below, 82 to the Caradoc or Bala above, while 145 are peculiar. The hydrozoa are still the most abundant forms, 94 species being here met with, no fewer than 81 of these being confined to Llandeilo rocks, and only 9 passing down into the Arenig group. Of crustacea 44 species have been obtained. These include the characteristic trilobites—*Ampyx nudus, Asaphus tyrannus, Barrandea Cordai, Calymene duplicata, C. Cambrensis, Cheirurus Sedgwickii, Ogygia Buchii, Trinucleus concentricus, T. Lloydii.* The brachiopods number 37 species, including the genera *Orthis, Leptæna, Strophomena, Lingula, Siphonotreta.* The lamellibranchs are represented by 6 species, the gasteropods by 10 (*Murchisonia, Cyclonema, Loxonema*), the heteropods by 7 (*Bellerophon*), the pteropods

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[1] *Trilobites*, Prague. 1871, p. 196. Since the publication of this table the progress of research has increased the number of species from some localities; but the general facies of the primordial fauna has not been materially affected thereby.

[2] Hicks, *Quart. Journ. Geol. Soc.* xxxi. 167; Hopkinson and Lapworth, *ibid.*, p. 635.

by 2 (*Conularia, Theca*), the cephalopods by 8 (*Orthoceras, Cyrtoceras*).

A remarkable feature in the history of the Llandeilo rocks in Britain was the outbreak of volcanic action abundantly in North Wales and in Cumberland. Vast piles of lava and ashes were thrown out, which even to this day remain in mass sufficient to form groups of important hills, as Cader Idris, Aran Mowddwy, the Arenigs, and the Moelwyns in Wales, and Helvellyn and Scaw Fell in Westmoreland and Cumberland.

3. *Caradoc or Bala Group.*—Under this name are placed the thick yellowish and grey sandstones of Caer Caradoc in Shropshire, and the grey and dark slates, grits, and sandstones round Bala in Merionethshire. In the Shropshire area some of the rocks are so shelly as to become strongly calcareous. In the Bala district the strata contain two limestones separated by a sandy and slaty group of rocks 1400 feet thick. The lower or Bala limestone (25 feet thick) has been traced as a variable band over a large area in North Wales. It is usually identified with the Coniston limestone of the Westmoreland region. The upper or Hirnant limestone (10 feet) is more local. Bands of volcanic tuff and large beds of various felsitic lavas occur among the Bala beds, and prove the contemporaneous ejection of volcanic products. These attain a thickness of several thousand feet in the Snowdon region.

A large suite of fossils has been obtained from this formation:—the sponges represented by *Sphærospongia* and other genera; the graptolites by *Diplograptus pristis, Graptolithus priodon,* and *G. Sedgwickii,* etc.; the corals by species of *Heliolites, Favosites, Monticulipora, Halysites, Petraia;* the echinoderms by encrinites of the genera *Cyathocrinus* and *Glyptocrinus,* by cystideans of the genera *Echinosphærites* and *Sphæronites,* and by star-fishes of the genera *Palæaster* and *Stenaster;* the annelides by *Serpulites, Tentaculites,* and numerous burrows and tracks; the trilobites by many species of the genera *Phacops, Cheirurus, Cybele, Lichas, Aciduspis, Calymene, Remopleurides, Asaphus, Illænus, Ampyx,* and *Trinucleus;* the polyzoa by *Fenestella, Glauconome,* and *Ptilodictya;* the brachiopods by *Atrypa, Rhynchonella, Leptæna, Orthis* (many species), *Strophomena, Discina,* and *Lingula;* the lamellibranchs by *Modiolopsis, Mytilus, Palæarca, Pterinea, Orthonota,* and *Ctenodonta;* the gasteropods by *Murchisonia, Pleurotomaria, Raphistoma, Cyclonema, Euomphalus, Maclurea, Holopea;* the pteropods by *Conularia, Theca,* and *Ecculiomphalus;* the heteropods by various species of *Bellerophon;* and the cephalopods by many species of *Orthoceras,* with forms of *Cyrtoceras* and *Lituites.*

4. *Lower Llandovery Group.*—In North Wales the Bala beds about 5 miles S. E. of Bala Lake begin to be covered with grey grits, which gradually expand southwards until they attain a thickness of 1000 feet in South Wales. These overlying rocks are well displayed near the town of Llandovery, where they contain some conglomerate bands, and where Mr. Aveline detected an unconformability between them and the Bala group below them, so that the subterranean movements had already begun, which in Wales marked the close of the Lower Silurian period. Elsewhere they seem to graduate downwards conformably into that group. They cover a considerable breadth of country in Cardigan and Carmarthenshire, owing to the numerous undulations into which they have been thrown. Their chief interest lies in the transition which they present between the fauna of the Lower and Upper Silurian formations. They have yielded in all about 128 species of fossils, whereof 11 are peculiar, 93 are common to the Bala group below, and 83 pass up into Upper Llandovery rocks above. Some of the peculiar fossils are *Nidulites favus, Meristella crassa, M. angustifrons,* and *Murchisonia angulata.* Among the forms which come up from the Bala group and disappear here are the corals *Heliolites interstinctus, Petraia subduplicata,* and *Favosites aspera;* the trilobites *Lichas laxatus* and *Illænus Bowmanni;* the brachiopods *Orthis Actoniæ* and *O. insularis;* the gasteropods *Murchisonia gyrogonia* and *Cyclonema crebristria;* and the cephalopod *Orthoceras tenuicinctum.* But many of the Lower Silurian forms continue on into the Upper Llandovery beds. From the abundance of the peculiar brachiopods termed *Pentamerus* in the Lower, but still more in the Upper Llandovery rocks, these strata were formerly grouped together under the name of "Pentamerus beds." Though the same species are found in both divisions, *Pentamerus oblongus* is chiefly characteristic of the upper group and comparatively infrequent in the lower, while *Stricklandinia* (*Pentamerus*) *lens* abounds in the lower but appears more sparingly in the upper.

The lower Silurian rocks, typically developed in Wales, extend over nearly the whole of Britain, though largely buried under more recent formations. They rise into the hilly tracts of Westmoreland and Cumberland, where they consist of the following subdivisions in descending order:—

(Lower Llandovery not represented.)		
Coniston Limestone and Shale.........	=	Bala beds.
Volcanic series: tuffs and lavas without any intermixture of ordinary sedimentary strata except at the base, 12,000 ft...............	=	Part of Bala, whole of Llandeilo, and perhaps part of Arenig formation.
Skiddaw Slates, 10,000 or 12,000 ft., base not seen.........	=	Arenig, with perhaps Tremadoc and Lingula flags.

Apart from the massive intercalation of volcanic rocks these strata present considerable lithological and palæontological differences from the typical subdivisions in Wales. The Skiddaw slates are black or dark-grey argillaceous, and in some beds sandy rocks, often much cleaved, though seldom yielding workable slates, sometimes soft and black like Carboniferous shale. As a rule they are singularly unfossiliferous, but in some of their less cleaved and altered portions they have yielded about 40 species of graptolites (chiefly of the genera *Didymograptus, Diplograptus, Dichograptus, Tetragraptus, Phyllograptus* and *Climacograptus*), *Lingula brevis,* traces of annelides, a few trilobites (*Æglina, Agnostus, Asaphus,* etc.), some phyllopods (*Caryocaris*), and remains of plants (*Buthotrephis,* etc.). In many places the slates have been metamorphosed, passing into chiastolite-slate, mica-schist, andalusite-schist, etc., with protrusions of granite, syenite, and other crystalline rocks. Towards the close of the long period represented by the Skiddaw slates, volcanic action manifested itself, first by intermittent showers of ashes and streams of lava which were interstratified with the ordinary marine sediment, and then by a more powerful and continuous series of explosions, whereby a huge volcanic mountain or group of cones was piled up above the sea-level. The length of time occupied by this volcanic episode in Cumbrian geology may be inferred from the fact that all the Llandeilo and nearly all the Bala beds are absent here. The volcanic island slowly sank into a sea where Bala organisms flourished. Among these we find such familiar Bala species as *Favosites fibrosa, Heliolites interstinctus, Cybele verrucosa, Leptæna sericea, Orthis Actoniæ, O. biforata, O. caligramma, O. elegantula, O. porcata,* and *Strophomena rhomboidalis.* These organisms and their associates gathered on the submerged flanks of the sinking volcano into a bed of limestone—the Coniston limestone—which can still be traced for many miles through the Westmoreland hills, as the Bala limestone which it represents can be followed through the volcanic tracts of North Wales. The Coniston limestone is covered by certain flags and grits which from their organic remains are referred to the Upper Silurian series.

In the south of Scotland, according to the detailed researches of the Geological Survey, the Lower Silurian formations are represented by the subjoined groups of strata in descending order:—

Sandstones and conglomerates, Girvan valley...............................	=Llandovery.
Conglomerates, grits, shales, and lenticular bands of limestone, Peeblesshire, Dumfriesshire, S. W. Ayrshire, sometimes 2000 ft..	=Caradoc or Bala.
Carsphairn group, coarse pebbly grits and greywacke, 1200 ft.....	=Llandeilo (14,000 ft.).
Upper Black Shale, with graptolites, 550 ft.....................	
Lowther group, olive, grey, and blue shales, and sandstones, 4000 ft.......................................	
Dalveen group, greywacke and shale, with band of fine conglomerate, 3500 ft....................	
Queensberry group, massive greywackes and grits, with occasional conglomerate bands and some shales, 4500 ft......................	
Lower or Moffat Black Shale group, 200–400 ft............................	
Ardwell group, brown flags, greywackes, and shales, sometimes purplish and red; base not seen..	

As a whole these strata are singularly barren of organic remains. Most of the fossils which the Llandeilo groups contain lie in the bands of dark anthracitic shale which have been traced across nearly the whole breadth of the country. These shales are crowded with graptolites of recognizable Llandeilo forms, *Climacograptus teretiusculus*, *Diplograptus pristis*, and *Graptolithus sagittarius* being particularly abundant. Crustacea are exceedingly rare, but two phyllopods, *Discinocaris Browniana* and *Peltocharis aptychoides*, occur; while from Dumfriesshire two obscure trilobites are referred doubtfully to *Encrinurus* and *Phacops*. The vast thickness of sandy, gritty, and shaly unfossiliferous strata is the distinguishing feature of the Lower Silurian series in the south of Scotland. The Caradoc or Bala group lies unconformably upon the upper parts of the Llandeilo rocks. It contains in the eastern districts some calcareous conglomerates which here and there swell out into local masses of limestone. In the south-west of Ayrshire the limestones attain considerable dimensions. In these calcareous bands numerous Caradoc species have been found, among them *Cheirurus gelasinosus*, *Encrinurus punctatus*, with species of *Illænus* and *Asaphus*, *Orthis calligramma*, *O. confinis*, *Leptæna sericea*, *Maclurea*, and such corals as *Heliolites*, *Favosites*, *Omphyma*, and *Strephodes*. In the south-west of Ayrshire certain shales and sandstones full of Caradoc fossils are overlaid with sandstones, shales, and conglomerates containing *Pentamerus oblongus*, *Atrypa hemispherica*, *Meristella angustifrons*, *Lichas laxatus*, *Petraia elongata*, *Nidulites favus*, and numerous other fossils which indicate the horizon of the Llandovery rocks.

The Highlands of Scotland consist mainly of crystalline rocks—gneiss, mica-schist, chlorite-schist, clay-slate, quartz-rock, schistose flagstone, and many others, often much invaded by granite and other intrusive masses. It was at one time supposed that these rocks all belonged to the so-called primary or primitive series, older than any of the fossiliferous systems. But the discovery by Mr. C. W. Peach, already referred to, that recognizable fossils occur in the limestone of Durness in Sutherlandshire, led Murchison to infer that the whole of the overlying gneissose and schistose masses are really metamorphosed Lower Silurian rocks—a generalization which has been completely confirmed by subsequent investigation. At the base of this great series of rocks masses of white quartz-rock are found lying with a marked unconformability upon the red sandstones described in a previous page. These quartzose beds are merely hardened and somewhat metamorphosed sandstones; they still show their original false-bedding, and the casts of sea-weeds and worm-burrows. They contain a band of limestone which in Assynt swells out to a thickness of 1000 feet or more, and can be traced almost continuously from the Kyles of Skye to the north coast of Sutherlandshire. Over these strata, in perfect conformable sequence, and with a complete lithological gradation, come quartzose flagstones dipping like the rocks below at gentle angles to the south-east. They become more schistose and crumpled as they are traced upwards, until, after a thickness of several thousand feet has been passed over, they begin to undulate in steep folds and pass into the ordinary schistose rocks which cover so much of the Highlands. The gradation from the comparatively unaltered lower quartz-rocks and limestones on the west to the intensely crumpled crystalline upper schists and flagstones on the east can be followed step by step in numerous fine natural sections from the north of Sutherland to the Kyles of Skye. The proof is thus complete that a vast mass of schists and other crystalline rocks overlies fossiliferous limestones in the Scottish Highlands. It therefore becomes of the utmost importance to determine the geological horizon of the fossils in the limestones. This was done by the late Mr. Salter, who declared his conviction that they were unequivocally Lower Silurian, and bore a most remarkable resemblance to a group of fossils from the Lower Silurian rocks of North America. Five of the species he regarded as identical with known American forms (*Orthoceras arcuoliratum*, Hall; *Orthis striatula*, Emmons; *Ophileta compacta*, Salt.; *Murchisonia gracilis*, Hall; *M. bellicincta*, Hall), 4 as representative, 3 doubtful, and 1 new genus, found also in Canada. "That this truly North American assemblage," he remarks, "should be found in the extreme north of Scotland on the same parallel as the Canadian,—that species of *Maclurea* and *Raphistoma*, resembling those of the St. Lawrence basin, and *Orthocerata*, bearing large siphuncles like those of North America, Scandinavia, and Russia, should occur in Scotland and yet be scarcely known further south, is at least suggestive of a geographical distribution—perhaps even of climatal conditions—not very unlike that of more modern times."[1] From this palæontological decision it follows that the overlying schistose series of the Scottish Highlands is a mass of metamorphosed Silurian strata. Examined in detail they show very unequal and sporadic metamorphism. Some portions are scarcely more changed than the ordinary greywackes and shales of unaltered districts. False-bedding, pebble-beds, and other common features of sedimentation occur abundantly throughout the whole vast series of schists. Here and there the metamorphism has become extreme, the rocks passing into coarsely crystalline schists full of garnets, with bands of hornblende-rock, actinolite-schist, and other metamorphic products, and passing even into granitic gneiss and true granite. No more convincing proof could be obtained that vast masses of schist do not necessarily belong to an azoic period of the earth's history, but may have been produced by the alteration of previously existing sediments.

It is not necessary to believe that the sediments so altered were in all cases mere ordinary marine sand and mud. The white quartz-rocks were no doubt at one time pure white siliceous sand, the rounded grains of which can still be readily detected in them. The quartzose flagstones were stratified sand with thin partings of clay or mud. The clay slates were evidently thick accumulations of mud. But the rocks containing a marked percentage of magnesia, such as chlorite-slate, actinolite-schist, hornblende-rock, etc., may have resulted from the alteration of volcanic sediments and submarine lavas. The evidence from Cumberland and Wales proves how voluminous and long continued were the volcanic eruptions of the Lower Silurian period in Britain. The abundant diffusion of volcanic detritus over the present sea-bottom is now well known. The "Challenger" researches have also shown us that, besides the glauconite previously known to be deposited from sea-water in the chambers of foraminifera and other dead organisms on the ocean-bottom, true magnesian silicates are now in the process of elimination from sea-water in some of the abysses of the ocean. It is quite possible therefore that some of the rocks of the metamorphic series rich in magnesian silicates may have arisen from the alteration of volcanic tuffs or submarine lavas, and that others may owe their distinctive composition to original chemical precipitation, as ably contended by Sterry Hunt, though their present crystalline structure must be regarded as a part of the general metamorphism by which the whole of the Lower Silurian rocks of the Highlands have been affected.

In the south-east of Ireland, grey, greenish, and purple grits, and grey and dark shales, lie unconformably upon the Cambrian rocks, and contain a few fossils of Llandeilo age. They present interstratified beds of tuff and felsitic lavas indicating contemporaneous volcanic action. In the north-east of the island a broad belt of Lower Silurian rocks runs from the coast of Down into the heart of Roscommon and Longford. This belt is evidently a prolongation of that in the southern uplands of Scotland. It is marked by the occurrence of similar dark anthracitic shales crowded with graptolites. The richest fossiliferous localities among the Irish Lower Silurian rocks are found at the Chair of Kildare, Portrane near Dublin, Pomeroy in Tyrone, and Lisbellan in Fermanagh, where small protrusions of the older rocks rise as oases among the surrounding later formations. Portlock brought the northern and western localities to light, and Murchison pointed out that, while a number of the trilobites (*Trinucleus*, *Phacops*, *Calymene*, and *Illænus*), as well as the simple plaited *Orthidæ*, *Leptænæ*, and *Strophomenæ*, some spiral shells, and many *Orthocerata*, are specifically identical with those from the typical Caradoc and Bala beds of Shropshire and Wales, yet they are associated with peculiar forms, first discovered in Ireland, and very rare elsewhere in the British Islands. Among these distinctive fossils he cites the trilobites, *Remopleurides*, *Harpes*, *Amphion*, and *Bronteus*, with the smooth forms of *Asaphus* (*Isotelus*), which, though abundant in Ireland and America, seldom occur in Wales or England, and never on the Continent.[2]

In the north and west of Ireland a large area of surface is occupied by crystalline rocks—gneiss, schists, quartz-rocks, limestone, granite, etc.—which are manifestly a continuation of those of the Highlands of Scotland. They run south-westward parallel with the belt of unaltered Lower Silurian rocks from which, in some places, as in county Tyrone, they are only a few miles distant. The district of Pomeroy, so rich in Silurian fossils, promises to afford the greatest light on the interesting but difficult problem of the metamorphism of the Lower Silurian rocks of the Scottish Highlands and the north-west of Ireland. It will be seen from the evidence furnished by the sections in West Mayo (p. 299) that the metamorphism must have taken place prior to the deposition of the Upper Silurian formations of the west of Ireland.

B. *Upper Silurian.*

The formations which in the British Islands are classed as Upper Silurian occur in two very distinct types. So great indeed is the contrast between these types that it is only by a comparison of organic remains that the whole can be grouped together as the deposits of one great geological period. In the original region described by Murchison, and from which his type of the system was taken, the strata are comparatively flat, soft, unaltered, consisting mainly of somewhat incoherent sandy mud with occasional bands of limestone. But as these rocks are followed into North Wales, they are found to swell out into a vast series of grits and shales so like portions of the hard altered Lower Silurian rocks that, save for the evidence of fossils, they would naturally be grouped as part of that more ancient series. In Westmoreland and Cumberland, and still further north in the border counties of Scotland, also in the south-west of Ireland, it is the North Welsh type which prevails, so that in Britain the general lithological characters and minute palæontological subdivisions ascertained in the typical Silurian district are almost confined to that limited region, while over the rest of the British area for thousands of square miles the hard sandy and shaly type of North Wales is prevalent.

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[1] *Quart. Jour. Geol. Soc.*, xx. 381.

[2] *Siluria*, p. 174.

Taking first the Silurian tract of the south-west of England, and the east and south of Wales, we find a decided unconformability separating the Lower from the Upper Silurian formations. In some places the latter are found passing across the edges of the former, group after group, till they come to lie directly upon the Cambrian rocks. Indeed, in one district between the Longmynd and Wenlock edge, the base of the Upper Silurian rocks is found within a few miles to pass from the Caradoc group across to the Lower Cambrian rocks. It is evident, therefore, that in the Welsh regions very great disturbance and extensive denudation preceded the commencement of the deposition of the Upper Silurian rocks. As Professor Ramsay has pointed out, the area of Wales, previously covered by a wide though shallow sea, was ridged up into a series of islands, round the margin of which the conglomerates at the base of the Upper Silurian series began to be laid down. This took place during a time of submergence, for these conglomeratic and sandy strata are found creeping up the slopes and even capping some of the heights, as at Bogmine, where they reach a height of 1150 feet above the sea.[1] The subsidence probably continued during the whole of the interval occupied by the deposition of the Upper Silurian strata, which thus were piled to a depth of from 3000 to 5000 feet over the disturbed and denuded platform of Lower Silurian rocks.

Arranged in tabular form, the subdivisions of the Upper Silurian rocks of Wales and the adjoining counties of England are in descending order as follows:—

	Base of Old Red Sandstone.	
3. Ludlow Group	Tilestones. Upper Ludlow Rock. Aymestry Limestone. Lower Ludlow Rock.	
2. Wenlock group	Wenlock or Dudley Limestone............ Wenlock Shale.......... Woolhope or Barr Limestone and Shale	= Denbighshire Grits of North Wales.
1. Upper Llandovery group..	Tarannon Shale. May Hill Sandstones.	
	Lower Llandovery Rocks.	

1. *Upper Llandovery Group.*—(*a.*) *May Hill Sandstones.*—The position of these rocks as the true base of the Upper Silurian formations was first shown in 1853 by Sedgwick, who named them the May Hill Sandstones from the locality in Gloucestershire where they are so well displayed. Appearing on the coast of Pembrokeshire at Marloes Bay, they range across South Wales until they are overlapped by the Old Red Sandstone. They emerge again in Carmarthenshire, and trend north-eastward as a narrow strip at the base of the Upper Silurian series, from a few feet to 1000 feet or more in thickness, as far as the Longmynd, where as a marked conglomerate wrapping round that ancient Cambrian ridge they disappear. In the course of this long tract they pass successively and unconformably over Lower Llandovery, Caradoc, Llandeilo, and Cambrian rocks. They consist of yellow and brown ferruginous sandstones, often full of shells, which are apt to weather out and leave casts. Their lower parts are commonly conglomeratic, the pebbles being largely derived from older parts of the Silurian formations. Here and there, where the organic remains become extraordinarily abundant, the strata pass into a kind of sandy limestone, known as the "Pentamerus limestone," from the numbers of this brachiopod contained in it. The species of fossils found in the May Hill Sandstones number about 230.

Among these are some traces of fucoids; sponges (*Cliona, Ischadites*); the widely diffused *Graptolithus priodon;* a number of corals (*Petraia, Heliolites, Favosites, Halysites, Syringopora,* etc.); a few crinoids; some annelides, particularly the *Tentaculites anglicus,* which is abundant; a number of trilobites, of which *Phacops, Stokesii, P. Weaveri, Encrinurus punctatus,* and *Calymene Blumenbachii* are common; numerous brachiopods, as *Atrypa hemispherica, A. reticularis, Pentamerus oblongus, Stricklandinia lirata* (*S. lens* also occurs), *Leptæna transversalis, Orthis calligramma, O. eleyantula, O. reversa, Strophomena compressa, S. pecten,* and *Lingula parallela;* lamellibranchs of the mytiloid genera *Orthonota, Mytilus,* and *Modiolopsis,* with forms of *Pterinea, Ctenodonta,* and *Lyrodesma;* gasteropods, particularly the genera *Murchisonia, Pleurotomaria, Cyclonema, Holopella;* and cephalopods, chiefly *Orthocerata,* with some forms of *Actinoceras* and *Phragmoceras,* and the old species *Lituites cornu-arietis.*

(*b.*) *Tarannon Shale.*—Above the Upper Llandovery beds comes a very persistent zone of fine, smooth, light grey or blue slates, which has been traced down the whole length of Wales from the mouth of the Conway into Carmarthenshire. These rocks, termed the "paste-rock" by Sedgwick, have an extreme thickness of 1000 to 1500 feet. Barren in organic remains, their chief interest lies in the fact that the persistence of so thick a band of rock between what were supposed to be continuous and conformable formations should have been unrecognized until it was proved by the detailed mapping of the Geological Survey.

2. *Wenlock Group.*—(*a.*) *Woolhope Limestone.*—In the original typical Upper Silurian tract of Shropshire and the adjacent counties, the Upper Llandovery rocks are overlaid by a local group of grey shales containing nodular limestone which here and there swells out into beds having an aggregate thickness of 30 or 40 feet. These strata are well displayed in the picturesque valley of Woolhope in Herefordshire, which lies upon a worn quaquaversal dome of Upper Silurian strata rising in the midst of the surrounding Old Red Sandstone. They are seen likewise to the north-west at Presteign, Nash Scar, and Old Radnor in Radnorshire, and to the east and south in the Malvern Hills (where they include a great thickness of shale below the limestone), and May Hill in Gloucestershire. These strata have yielded many characteristically Upper Silurian fossils, among which may be mentioned *Bumastus Barriensis, Homalonotus delphinocephalus, Phacops caudatus, Atrypa reticularis, Orthis calligramma, Strophomena imbrex, Rhynchonella borealis, R. Wilsoni, Euomphalus sculptus, Orthoceras annulatum.*

It is a characteristic of the older Palæozoic limestones to occur in a very lenticular form, swelling in some places to a great thickness and rapidly dying out, to reappear again perhaps some miles away with increased proportions. This local character is well exhibited by the Woolhope limestone. Where it dies out, the shales underneath and intercalated with it join on continuously to the overlying Wenlock shale, and no line for the Woolhope group can then be satisfactorily drawn. The same discontinuity is strikingly traceable in the Wenlock limestone to be immediately referred to.

(*b.*) *Wenlock Shale.*—This is a group of grey and black fine shales, traceable from the banks of the Severn near Coalbrook Dale across Radnorshire to near Carmarthen—a distance of about 90 miles. The same strata reappear in the protrusions of Upper Silurian rock which rise out of the Old Red Sandstone plains of Gloucestershire, Herefordshire, and Monmouthshire. In the Malvern Hills they were estimated by Professor Phillips to reach a thickness of 640 feet, but towards the north they thicken out to 1000 or even 1400 feet. On the whole the fossils are identical with those of the overlying limestone. The corals, however, so abundant in that rock are here comparatively rare. The brachiopods (of the genera *Leptæna, Orthis, Strophomena, Atrypa,* and *Rhynchonella*) are generally of small size—*Orthis biloba, O. hybrida,* and the large flat *O. rustica,* being characteristic. Of the higher mollusca thin-shelled forms of *Orthoceras* are specially abundant. Among the trilobites, *Encrinurus punctatus, E. variolaris, Calymene Blumenbachii, C. tuberculosa, Phacops caudatus,* and *P. longicaudatus* are common. The *Graptolithus priodon,* so frequent among the Bala beds of the Lower Silurian series, also occurs in the Wenlock shale. *Graptolithus Flemingii* is here a characteristic species.

(*c.*) *Wenlock Limestone* is a thick-bedded, sometimes flaggy, usually more or less concretionary limestone, grey or pale pink, often highly crystalline, occurring in some places as a single massive bed, in others as two or more strata separated by grey shales, the whole forming a thickness of rock ranging from 100 to 300 feet. As its name denotes, this stratum is typically developed along Wenlock Edge in Shropshire, where it runs as a prominent ridge for fully 20 miles, also between Aymestry and Ludlow. It likewise appears at the detached areas of Upper Silurian strata above referred to, being specially well seen near Dudley (whence it is often spoken of as the Dudley limestone), Woolhope, Malvern, May Hill, and Usk in Monmouthshire.

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[1] *Physical Geology of Britain,* p. 91.

A distinguishing characteristic of the Wenlock limestone is the abundance and variety of its corals, of which 53 species have been described. The rock seems indeed to have been formed in part by massive sheets and bunches of coral. Among characteristic species are *Halysites catenularia*, *Heliolites interstinctus*, *H. tubulatus*, *Alveolites Labechei*, *Favosites aspera*, *F. fibrosa*, *F. Gothlandica*, *Cœnites juniperinus*, *Syringopora fascicularis*, and *Omphyma turbinatum*. The crinoids are also specially abundant, and are often beautifully preserved: *Periechocrinus moniliformis* is one of the most frequent species; others are *Crotalocrinus rugosus*, *Cyathocrinus goniodactylus*, and *Marsupiocrinus cælatus*; with several cystideans, as *Pseudocrinites quadrifasciatus*. The crustaceans include numerous trilobites, among which we miss some of the persistent Lower Silurian genera, such as *Asaphus*, *Ogygia*, and *Trinucleus*, none of which ascend into the Wenlock group. The most abundant trilobite is the long-lived *Calymene Blumenbachii*, which ranges from the Llandeilo flags up to near the top of the Upper Silurian formations. It occurs abundantly at Dudley, where it received the name of the "Dudley Locust." Other common forms are *Encrinurus punctatus*, *E. variolaris*, *Phacops caudatus*, *P. Downingiæ*, *P. Stokesii*, *Bumastus Barriensis*, *Homalonotus delphinocephalus*, and *Cheirurus bimucronatus*. The brachiopods continue to be abundant; among typical species may be noted *Atrypa reticularis*, *Meristella tumida*, *Spirifer elevatus*, *S. plicatellus*, *Rhynchonella borealis* (very common), *R. cuneata*, *R. Wilsoni*, *Orthis elegantula*, *O. rustica*, *Strophomena rhomboidalis*, and *Pentamerus galeatus*. The lamellibranchs are not well represented; but several species of *Pterinea* are abundant, with *Grammysia cingulata*, and some species of *Modiolopsis* and *Ctenodonta*. The gasteropods are most characteristically marked by 8 or 9 species of *Euomphalus*, 3 or more of *Murchisonia*, with species of *Pleurotomaria*, *Acroculia*, and *Cyclonema*. The cephalopods are confined to few genera, *Lituites*, *Actinoceras*, *Cyrtoceras*, *Orthoceras*, and *Phragmoceras*; of these the orthoceratites are by far the most abundant both in species and individuals. *Orthoceras annulatum* is the most common form. The pteropods appear in the beautiful and very abundant *Conularia Sowerbyi*, and the heteropods in the common and characteristic *Bellerophon Wenlockensis*.

3. *Ludlow Group.*—This series of strata consists essentially of shales, with occasionally a calcareous band in the middle. It graduates downward into the Wenlock group, so that when the Wenlock limestone disappears the Wenlock and Ludlow shales form one continuous argillaceous formation. It is in this united form that the two groups stretch to the south-west through Brecon and Carmarthen. The Ludlow rocks are typically seen between Ludlow and Aymestry. They appear likewise at the detached Silurian areas from Dudley to the mouth of the Severn. They were grouped by Murchison into three zones.

(*a.*) *Lower Ludlow Rock.*—This is a group of soft dark-grey to pale greenish-brown or olive sandy shales, often with calcareous concretions. Much of the rock, however, presents so little fissile structure as to get the name of mudstone, weathering out into concretions which fall to angular fragments as the rock crumbles down. It becomes more sandy and flaggy towards the top. From the softness of the shales this zone of rock has been extensively denuded, and the Wenlock limestone rises up boldly from under it.

An abundant suite of fossils has been yielded by these shales. No fewer than 18 species of star-fishes, belonging to 6 genera, have been described (*Protaster*, like the brittle-stars of the British seas, *Palæocoma*, *Palasterina*). A few graptolites occur, particularly the persistent *Graptolithus priodon* (common), *G. colonus*, and *G. Flemingii*. A few of the Wenlock corals survive in the Lower Ludlow rock, but the conditions of deposit were evidently unfavorable for their growth. The trilobites are less numerous than in older beds; they include the venerable *Calymene Blumenbachii*, *Phacops caudatus*, and its still longer-tailed variety *P. longicaudatus*; also *Acidaspis Brightii*, *Homalonotus delphinocephalus*, and *Cyphaspis megalops*. But other forms of crustacean life occur in some number. As the trilobites begin to wane numerous phyllopods appear, the genus *Ceratiocaris* being represented by 10 or more species. Large eurypterides now make their entrance upon geological history —*Eurypterus*, *Pterygotus*, and *Hemiaspis*. Though brachiopods are not scarce, hardly any seem to be peculiar to the Lower Ludlow rock, the *Lingula lata*, which Murchison suggested might be peculiar, having been obtained from what is supposed to be representative of this group of strata in Westmoreland. *Rhynchonella Wilsoni*, *Spirifer exporrectus*, *Strophomena euglypha*, *Atrypa reticularis*, and *Chonetes minima* are not infrequent. Among the more frequently recurring species of lamellibranchs the following may be named—*Cardiola interrupta*, *C. striata*, *Orthonota rigida*, *O. semisulcata*, and a number of species of *Pterinea*. The orthoceratites are numerous, as *Orthoceras Ludense*, *O. subundulatum*, also species of *Phragmoceras* and *Lituites*. The numbers of these straight and curved cephalopods form one of the distinguishing features of the zone. At one locality, near Leintwardine in Shropshire, which has been prolific in Lower Ludlow fossils, particularly in star-fishes and eurypterid crustaceans, a fragment of the fish *Pteraspis* was discovered in 1859. This is the earliest trace of vertebrate life yet detected. It is interesting to note that the *Pteraspis* does not stand low in the scale of organization, but has affinities with our modern sturgeon.

(*b.*) *Aymestry Limestone* is a dark grey somewhat earthy concretionary limestone in beds from 1 to 5 feet thick. Where at its thickest it forms a conspicuous feature, rising above the soft and denuded Lower Ludlow shales, and, owing to the easily removable nature of some fuller's earth on which it lies, it has here and there been dislocated by large landslips. It is still more inconstant than the Wenlock limestone. Though well developed at Aymestry it soon dies away into bands of calcareous nodules, which finally disappear, and the lower and upper divisions of the Ludlow group then come together. The most characteristic fossil is the *Pentamerus Knightii*; other common forms are *Rhynchonella Wilsoni*, *Lingula Lewisii*, *Strophomena euglypha*, *Bellerophon dilatatus*, *Pterinea Sowerbyi*, with many of the same shells, corals, and trilobites found in the Wenlock limestone. Indeed, as Murchison has pointed out, except in the less number of species and the occurrence of some of the shells more characteristic of the Upper Ludlow zone, there is not much palæontological distinction between the two limestones.[1]

(*c.*) *Upper Ludlow Rock.*—In the original Silurian district described by Murchison, the Aymestry limestone is covered by a calcareous shelly band full of *Rhynchonella navicula*, sometimes 30 or 40 feet thick. This layer is succeeded by grey sandy shale or mudstone, often weathering into concretions, as in the Lower Ludlow zone, and assuming externally the same rusty-brown or greyish olive-green hue. Its harder beds are quarried for building stone; but the general character of the deposit, like that of the argillaceous portions of the Upper Silurian formations as a whole in the typical district of Siluria, is soft, incoherent, and crumbling, easily decomposing once more into the original mud, and presenting in this respect a contrast to the hard fissile and often slaty shales of the Lower Silurian series. Many of the sandstone beds are crowded with ripple-marks, rill-marks, and annelid-trails, indicative of the shallow littoral waters in which they were deposited. One of the uppermost sandstones is termed the "Fucoid Bed," from the number of its cylindrical sea-weed-like stems. It likewise contains numerous inverted pyramidal bodies, which are believed to be casts of the cavities made in the muddy sand by the rotatory movement of crinoids rooted and half-buried in the micaceous mud.[2] At the top of the Upper Ludlow rock near the town of Ludlow, a brown layer occurs from a quarter of an inch to 3 or 4 inches in thickness, full of fragments of fish, *Pterygotus*, and shells. This layer, termed the "Ludlow Bone-bed," is the oldest from which any considerable number of vertebrate remains has been obtained. In spite of its insignificant thickness it has been detected at numerous localities from Ludlow as far as Pyrton passage, at the mouth of the Severn—a distance of 45 miles from north to south, and from Kington to Ledbury and Malvern—a distance of nearly 30 miles from west to east; so that it probably covers an area (now largely buried under Old Red Sandstone) not less than 1000 square miles in extent, yet it appears never to exceed and usually to fall short of a thickness of 1 foot. Fish remains, however, are not confined to this horizon. They have been detected in strata above the original bone-bed at Ludlow, together with some minute globular bodies believed to be the sporangia of a lycopod. These, with some other plant remains from the same district, are the earliest traces of land vegetation yet found. The higher parts of the Ludlow rock consist of fine yellow sandstone and harder grits known as the Downton sandstone. Originally the whole of these flaggy upper parts of the Ludlow group were called "Tilestones" by

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[1] *Siluria*, p. 130.

[2] *Siluria*, p. 133.

Murchison, and being often red in color were included by him as the base of the Old Red Sandstone, into which they gradually and conformably ascend. Undoubtedly they show the gradual change of physical conditions which took place at the close of the Silurian period in the west of England, and brought in the deposits of the Old Red Sandstone. But as their organic contents are still unequivocally those of the Ludlow group, they are now classed as the uppermost zone of the Silurian system.

A considerable suite of organic remains has been obtained from the Upper Ludlow rock, which on the whole are the same as those in the zones underneath. Vegetable remains, some of which seem to be fucoids, but most of which are probably terrestrial and lycopodiaceous, abound in the Downton sandstone and passage-beds into the Old Red Sandstone. Corals, as might be supposed from the muddy character of the deposit, seldom occur, though Murchison mentions that the encrusting form *Alveolites fibrosus* may not infrequently be found enveloping shells, *Cyclonema corallii* and *Murchisonia corallii* being, as their names imply, its favorite habitats. Some annelides (*Serpulites longispinus, Cornulites serpularius, Tentaculites tenuis*, and *Trachyderma coriacea*) are not uncommon. The crustacea are represented chiefly by small ostracods (*Beyrichia Klœdeni, Leperditia marginata, Entomis tuberosa*) and by species of *Ceratiocaris, Dictyocaris, Eurypterus, Hemiaspis, Pterygotus*, and *Stylonurus*; the trilobites having still further waned, though *Homalonotus Knightii, Encrinurus punctatus, Phacops Downingiæ*, and a few others still occur, and even the persistent *Calymene Blumenbachii* may occasionally be found. Of the brachiopods the most abundant forms are *Rhynchonella nucula, Chonetes striatella, Discina rugata*, and *Lingula cornea*. The most characteristic lamellibranchs are *Orthonota amygdalina, Goniophora cymbæformis, Pterinea lineata, P. retroflexa*; some of the commonest gasteropods are *Murchisonia corallii, Platyschisma helicites*, and *Holopella obsoleta*. The orthoceratites are specifically identical with those of the Lower Ludlow rock, and are sometimes of large size, *Orthoceras bullatum* being specially abundant. The fish remains consist of bones, teeth, shagreen-like scales, plates, and fin-spines. They include some plagiostomous (placoid) forms (*Thelodus*, shagreen-scales, *Sphagodus*, skin, *Onchus*, spines) and some ostracosteans (*Cephalaspis, Auchenaspis*, and *Pteraspis*).

In the typical Silurian region of Shropshire and the adjacent counties, nothing can be more decided than the lithological evidence for the gradual disappearance of the Silurian sea, with its crowds of graptolites, trilobites, and brachiopods, and for the gradual introduction of those geographical conditions which brought about the deposit of the Old Red Sandstone. The fine grey and olive-colored muds, with their occasional zones of limestone, are succeeded by bright red clays, sandstones, cornstones, and conglomerates. The evidence from fossils is equally explicit. Up to the top of the Ludlow rocks the abundant Silurian fauna continues in hardly diminished numbers. But as soon as the red strata begin the organic remains rapidly die out, until at last only the fish and the large eurypterid crustaceans continue to occur.

Turning now from the interesting and extremely important though limited area in which the original type of the Upper Silurian rocks is developed, we observe that whether we pass northwards or south-westwards the soft mudstones and thick limestones give way to hard slates, grits, and flagstones, among which it is scarcely possible sometimes even to discriminate what represents the Wenlock from what may be the equivalent of the Ludlow group. It is in Denbighshire and the adjacent counties that this change becomes most marked. The Tarannon shale above described passes into that region of North Wales, where it forms the base of the Upper Silurian formations. It is covered by a series of grits or sandstones which in some places are at least 3000 feet thick. These are covered by and pass laterally into hard shales, which are believed to represent parts of the true Wenlock group, perhaps even some portion of the Ludlow rocks. It is evident, however, that in spite of the wide extent over which these Silurian rocks of North Wales are spread, and the great thickness which they attain, they do not present an adequate stratigraphical equivalent for the complete succession in the original Silurian district. Instead of passing up conformably into the base of the Old Red Sandstone, as at Ludlow, they are covered by that formation unconformably. In fact they have been upturned, crumpled, faulted, and cleaved before the deposition of those portions of the Old Red Sandstone which lie upon them. These great physical changes took place in Denbighshire when, so far as the evidence goes, there was entire quiescence in the Shropshire district; yet the distance between the two areas was not more than about 60 miles. These subterranean movements were doubtless the precursors of those more widely extended upheavals which converted the floor of the Silurian sea into a series of isolated basins, in which the Old Red Sandstone was laid down.

In Westmoreland and Cumberland a vast mass of hard slates, grits, and flags was identified by Sedgwick as of Upper Silurian age. These form the varied ranges of hills in the southern part of the lake district from near Shap to Duddon mouth. The following are the local subdivisions with the conjectural equivalents in Siluria.[1]

Hay Fell and Kirkby Moor Flags	Flaggy beds, with lamellibranchs abundant	=(?)Tilestones.
	Massive greenish and grey sandstones, with bands of fossils, *Holopella* abundant.	= Upper Ludlow.
Bannisdale Slates	Calcareous beds, with *Rhynchonella navicula* abundant.	= Aymestry Limestone.
	Sandstone and shale, with star-fish	= Lower Ludlow.
	Dark blue flags and grits of great thickness	= Upper Wenlock.
Coniston Grits	Flags and greywacke (*Orthoceras subundulatum, O. angulatum, Graptolithus Flemingii, G. colonus, Ceratiocaris Murchisoni*), upwards of 4000 feet	= Lower Wenlock.
Coniston Flags	Dark grey coarse flags (*Cardiola interrupta, Orthoceras subundulatum*), 1000 feet	
Coniston Limestone (Lower Silurian)		= Caradoc or Bala.

In the northern part of the Lake district a great anticlinal fold takes place. The Skiddaw slates arch over and are succeeded by the base of the volcanic series above described. But before more than a small portion of that series has appeared the whole Silurian area is overlapped unconformably by the Carboniferous Limestone series. It is necessary to cross the broad plains of Cumberland and the south of Dumfriesshire before Silurian rocks are again met with. In this intervening tract a synclinal fold must lie, for along the southern base of the uplands of the south of Scotland a belt of Upper Silurian rocks, dipping on the whole to the south-east, can be traced from the heart of the Cheviot Hills to the headlands of Wigtownshire. These rocks must reach a thickness of several thousand feet, but their top is nowhere seen. They repose on some of the older parts of the Llandeilo series, with so close a coincidence of dip and strike that no decided unconformability has yet been traced between them. They consist essentially of shales, with a considerable proportion of greywacke bands towards the base. At different horizons they contain lenticular bands of a calcareous pebbly grit. But their most characteristic feature, and one which at once distinguishes them locally from the adjoining Lower Silurian rocks, is the occurrence of a nearly black, highly fissile shale, composed of layers in most cases as thin as ordinary writing paper and usually crowded with graptolites. These peculiar bands occur throughout the whole series of rocks from bottom to top. They are sometimes so thin that 20 or 30 seams or ribs, each finely fissile, may be seen intercalated within the space of an inch of the ordinary shale or greywacke. Occasionally they form zones 80 to 100 feet thick, consisting entirely of finely leaved graptolitic shales. As a whole these Upper Silurian strata resemble lithologically the corresponding series in Westmoreland, though here and there they assume the character of mudstones not unlike those of Shropshire. The abundant fossils in them are simple graptolites (*Graptolithus Sedgwickii, G. Becki, G. Flemingii, G. colonus, G. Griestonensis, Retiolites Geinitzianus*, etc.). Orthoceratites come next in point of numbers (*Orthoceras annulatum, O. tenuicinctum*, etc.). In some of the shales crustacean fragments are numerous. They include large pieces of the carapace of *Dictyocaris*, with remains of *Pterygotus* and *Ceratiocaris*. The pebbly grits contain *Petraia* and crinoid stems. In the south of Kirkcudbright certain limestones and conglomerates intercalated among these shales have yielded a more varied fauna, having on the whole a decidedly Wenlock character. It includes *Favosites*, *Catenipora*, *Beyrichia tuberculata*, *Phacops caudatus*, *Meristella*, *Leptæna sericea*, *Atrypa reticularis*, *Strophomena imbrex*, *Murchisonia*, *Orthoceras tenuicinctum*, etc.

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[1] The arrangement and thicknesses here given are those in the Kendal district as mapped by Mr. Aveline and Mr. Hughes in the course of the Geological Survey (*Sheet 98*, S. E., *Explanation*, pp. 6–13, 1872).

It is impossible in the south of Scotland to separate the Upper Silurian rocks into Wenlock and Ludlow groups. On the whole these rocks seem to be representative mainly of the older half of the Upper Silurian formations. They are covered unconformably by Lower Old Red Sandstone and later formations. In the counties of Edinburgh and Lanark, however, the base of the Lower Old Red Sandstone is found to graduate downward into a thick series of brown, olive, and grey shales, sandstones, and grits, containing undoubted Ludlow fossils. It is deserving of remark also that the peculiar lithological type so characteristic of the strata in the original Silurian area reappears in the centre of Scotland, many of the concretionary brown shales and olive-colored mudstones being undistinguishable from those in the typical sections at Ludlow. Some of these beds are crowded with fossils. Among the most characteristic are *Leptæna transversalis*, *Orthonota amygdalina*, *Platyschisma helicites*, *Beyrichia Klœdeni*, *Orthoceras Maclareni*, with many crustaceans of the genera *Ceratiocaris*, *Eurypterus*, *Pterygotus*, *Slimonia*, and *Stylonurus*. In the Pentland Hills these strata are estimated to attain a thickness of 3500 to 4000 feet, but their base is nowhere reached; in Lanarkshire they are at least as thick. Their lower portions may represent some of the higher parts of the Wenlock group.

Ireland furnishes some interesting evidence regarding the geographical changes in the west of Europe between the close of the Lower Silurian and the beginning of the Upper Silurian period. It has already been pointed out that the metamorphosed Lower Silurian rocks of the Scottish Highlands are prolonged into the north of Ireland, whence they range south-westwards to Galway Bay. In the picturesque tract between Loch Mask and the mouth of Killary harbor these metamorphosed rocks are unconformably overlaid by masses of sandstones, conglomerates, and shales more than 7000 feet thick, and containing Llandovery and Wenlock fossils with a mixture of Caradoc forms. In the midst of the greatly metamorphosed Lower Silurian platform, portions are to be found still little altered and full of fossils. The overlying Upper Silurian strata have not been metamorphosed, but contain pebbles of the altered rocks on the upturned edges of which they lie. It is evident therefore, as Mr. Hull has remarked, that the metamorphism must have occurred between the close of the Lower and the commencement of the Upper Silurian period.[1] In connection with this question it should be remarked that abundant volcanic activity accompanied the deposit of these Upper Silurian rocks in the west of Ireland, successive sheets of lava (eurite) and beds of tuff forming conspicuous bands among the stratified rocks, and reaching a collective thickness of 800 feet and upwards. Between Brandon Head and Dingle Bay a thick mass of strata on the coast must, from the comparatively few fossils obtained from it, be held to represent Upper Silurian formations.

CONTINENTAL EUROPE.—The broad hollow which, running from the mouth of the English Channel across the plains of northern Germany into the heart of Russia, divides the high grounds of the north and north-west of Europe from those of the centre and south, separates the European Silurian area into two distinct tracts. In the northern of these we find the Lower and Upper Silurian formations attaining an enormous development in Britain, but rapidly diminishing in thickness towards the north-east, until in the south of Scandinavia and the Gulf of Finland they reach only about $\frac{1}{25}$th of that depth. In these tracts, too, they have on the whole escaped so well from the dislocations, crumplings, and metamorphisms so conspicuous to the south-west, that to this day they remain over wide areas nearly as horizontal and soft as at first. In the southern tract Silurian rocks appear only here and there from amidst later formations, and almost everywhere present proofs of intense subterranean movement.

In the south of Scandinavia (Christiania, Mjösen See, Malmö, Gothland) the Lower and Upper Silurian rocks attain a united thickness of not more than about 1200 feet, yet are said to contain representatives of all the leading subdivisions of the British series. The following table exhibits the Silurian succession in the south of Norway and Sweden, with the supposed English equivalents:—

Sandy beds, with *Pterinea retroflexa*, *Rhynchonella nucula*, *Orthonota retusa*, *Beyrichia tuberculata*. S. Gothland...	= Upper Ludlow.
Upper Malmö limestone	= Lower Ludlow.
Upper Graptolite marls with *Graptolithus priodon* (*Ludense*) abundant	
Lower Malmö or upper Orthoceratite limestone, with large *Orthocerata* having central siphuncles	
Encrinital schists with orthoceratites and *Gomphoceras pyriforme*	= Wenlock.
Coral limestone (*Omphyma turbinatum* and other Wenlock corals)	
Pentamerus limestone, *Pentamerus oblongus*, *P. galeatus*, *Stricklandinia lens*, *Leptæna transversalis*, *Encrinurus punctatus*, etc	= Llandovery.
Lower argillaceous schists	
Calcareous sandstones (containing a mixture of Llandovery forms, as *Meristella angustifrons*, and many large smooth *Pentameri*	= Caradoc.
Calcareous and argillaceous flagstones, *Orthis calligramma*, *O. testudinaria*, *O. pecten*, *Leptæna sericea*, *Conularia quadrisulcata*, *Asaphus expansus*, *Trinucleus concentricus*, etc	
Orthoceratite limestone and lower Encrinital schists	
Upper Graptolite schists, with *Diplograptus pristis*, *D. folium*, *D. teretiusculus*, and forms of *Asaphus*, *Ogygia*, *Trinucleus*, etc	= Llandeilo.
Lower Orthoceratite limestone, with *Orthoceras duplex*, *O. annulatum*, *Lituites cornu-arietis*, *Orthis calligramma*, *O. elegantula*, *Bellerophon bilobatus*, etc...	
Lower Graptolite schists (with numerous graptolites)	= Arenig in part.
Alum schists, 150 feet (= Regiones A and B of Angelin), containing the fossils enumerated on p. 293.	= Cambrian.
Quartzite (Fucoids)	

Though the general resemblance of the succession of fossils in Scandinavia and in Britain is singularly close, there are, as might have been anticipated, differences in the range of species, some forms having appeared earlier or having survived later in the one region than in the other. Thus the *Pentamerus oblongus* ascends in Scandinavia into rocks full of Wenlock corals, but does not occur in the Wenlock group of Britain. On the other hand, among Scandinavian strata containing such characteristically Lower Silurian genera of trilobites as *Asaphus*, *Trinucleus*, and *Ogygia*, there occur organisms which in Britain are typically Upper Silurian, such as *Orthoceras dimidiatum* and *O. distans*, two fossils of the Ludlow rocks. This is a point of considerable importance in its bearing upon the value of palæontological evidence in correlating the formations of different countries. It shows that the order of succession found to hold good in one region cannot be rigidly applied to others, and that in such cases it is not from individual species so much as from the general facies of the fossils that we must draw geological parallels. The first appearance and duration of a species have doubtless greatly varied in different regions.

In Russia Silurian rocks must occupy the whole vast breadth of territory between the Baltic and the flanks of the Ural Mountains, beyond which they spread eastwards into Asia. Throughout most of this extensive area they lie in horizontal undisturbed beds, covered over and concealed from view by later formations. Along the flanks of the Urals they have been upheaved and placed on end or at a high angle against the central portions of that chain, and have been partially metamorphosed into chlorite-schist, mica-schist, quartz-rock, and other crystalline masses. But along the southern margin of the Gulf of Finland they appear at the surface as soft clays, sands, and unaltered strata, which, so far as their lithological characters go, might be supposed to be of late Tertiary date, so little have they been changed during the enormous lapse of ages since Lower Palæozoic time. The great plains between the Ural chain on the east and the rising grounds of Germany on the south-west have thus from a remote geological antiquity been exempted from the terrestrial corrugations which have affected so much of the rest of Europe. They have been alternately, but gently, depressed as a sea-floor, and elevated into steppes or planes. The following subdivisions have been established by F. Schmidt among the Silurian rocks of north-west Russia:[1]—

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[1] *Physical Geology of Ireland*, p. 22; Kinahan's *Geology of Ireland*, chap. iii.; *Geological Survey of Ireland, Explanation of Sheets* (76, 77, 83, and 84).

I. *Upper Silurian*—	
Sandy variable limestone, with marly layers passing into sandstone (*Beyrichia tuberculata*, *Grammysia cingulata*, *Chonetes striatella*, and numerous fish remains, *Onchus*, etc.)................	= Tilestones.
Upper Oesel group, yellow marly and sometimes dolomitic strata (*Rhynchonella Wilsoni*, *Chonetes striatella*, *Platyschisma helicites*, *Eurypterus remipes*, and fish remains, etc.).....................	= Ludlow.
Lower Oesel group, dolomite, with marl and limestone below (*Propora tubulata*, *Halysites distans*, *Beyrichia Klödeni*, *Encrinurus punctatus*, *Proëtus concinnus*, *Meristella tumida*, *Spirifer crispus*, *Leptæna transversalis*, *Euomphalus funatus*, *Orthoceras annulatum*, etc.)..	= Wenlock.
II. *Middle Silurian*—	
Pentamerus band, with *P. ehstonus* (*oblongus*), *Alveolites Labechei*, *Bellerophon dilatatus*, *Bronteus signatus* (*laticauda*)..	= Llandovery.
Compact limestone and dolomite with siliceous nodules (*Heliolites interstinctus*, *Ptilodictya scalpellum*, *Strophomena pecten*, *Orthis hybrida*, *Pentamerus linguifer*, *Leperditia marginata*)	
Pentamerus band, limestone, and dolomite, with *Pentamerus borealis*, etc....	
III. *Lower Silurian*—	
(*c*) Borkholm limestones and marls (*Halysites labyrinthica*, *Heliolites megastoma*, *Syringophyllum organum*, *Lichas margaritifer*, *Pleurorhynchus dipterus*, *Orthoceras calamiteum*, etc.).....	= Caradoc.
(*b*) Lyckholm, yellow or grey compact limestone and marls (*Orthis flabellulum*, *O. Actoniæ*, *O. insularis*, etc.)....	
(*a*) Wesenberg limestone and marl (*Orthis testudinaria*, *Encrinurus multisegmentatus*, *Lichas Eichwaldi*, etc.)......	
(*c*) Limestone usually somewhat bituminous, with partings of reddish yellow and brown very bituminous marl (*Beyrichia complicata*, *Asaphus acuminatus*, *Orthis Calligramma*, *Leptæna sericea*, etc.)....................................	= Llandeilo.
(*b*) Orthoceratite limestone and marl bands 15 to 40 feet thick (*Monticulipora petropolitana*, *Echinosphærites aurantium*, *Asaphus expansus*, *Orthis calligramma*, *Orthoceras vaginatum*, etc.)..	
(*a*) Limestone, full of glauconite grains especially towards the bottom (*Orthis calligramma*, *O. extensa*, abundant fragments of *Illænus* and *Asaphus*, etc.)......	
(*d*) Glauconite sand (6 feet) with numerous Foraminifera in the glauconite grains (*Panderella*, *Cymbulia*, *Tiedemannia*, etc.) and the "Conodonts" of Pander......................	= Arenig.
(*c*) Alum-slate (10 feet), highly carbonaceous, with pyrite-nodules and abundant graptolites (*Dictyonema Hisingeri*, *Obolus*, etc.)......................	
(*b*) Ungulite sandstone (120 feet), yellow to white, with (in the upper part) abundant shells of *Obolus Apollinis* ("Ungulites" of Pander).................	
(*a*) Blue clay with sandstone bands, sparingly fossiliferous; bored at Revel to a depth of 800 feet without its bottom being reached.........................	

In the centre and south of Europe by far the most important Silurian area is the basin of Bohemia, so admirably worked out by M. Barrande in his great work already cited (p. 286), wherein the formations are grouped as in the subjoined table:—

Upper Silurian.	3d Fauna.	Étage H	Shales with coaly layers and beds of quartzite (*Phacops fecundus*, *Tentaculites elegans*) with species of *Leptæna*, *Orthoceras*, *Lituites*, *Goniatitis*, etc....	850 ft.
		" G	Argillaceous limestones with chert, shales, and calcareous nodules............ .... Numerous trilobites of the genera *Dalmanites*, *Bronteus*, *Phacops*, *Proëtus Harpes*, and *Calymene*; *Atrypa reticularis*, *Pentamerus linguifer*.	1000 "
		" F	Pale and dark limestone with chert. *Harpes*, *Lichas*, *Phacops*, *Atrypa reticularis*, *Pentamerus galeatus*, *Favosites Gothlandica*, *F. fibrosa*, *Tentaculites*.	
		" E	Shales with calcareous nodules, and shales resting on sheets of igneous rock (300 ft.).... A very rich Upper Silurian fauna, abundant cephalopods, trilobites, etc.; *Halysites catenularius*, graptolites many species.	450–900 "
Lower Silurian.	2d Fauna.	" D	Yellow, gray, and black shales, with quartzite and conglomerate at base...... .... Abundant trilobites of genera *Trinucleus*, *Ogygia*, *Asaphus*, *Illænus*, *Remopleurides*, etc.	3000 "
Cambrian.	Primordial Fauna.	" C	Shales or "schists," sometimes with porphyries and conglomerates............... .... *Paradoxides*, *Ellipsocephalus*, *Agnostus*, and other genera of trilobites referred to above, (*ante*, p. 292).	900 1200 "
Azoic.		" B " A	Schists wholly unfossiliferous resting on bottom gneiss.	

The lower two *étages* (A, B) correspond probably to some of the older parts of the British Cambrian series, and perhaps in part to still older rocks. Étage C, or the Primordial Zone, is the equivalent of the Upper Cambrian rocks of Wales, possibly also partly of the Arenig series. Étage D, subdivided into five groups (*d*1, *d*2, *d*3, *d*4, and *d*5), appears to be, on the whole, representative of the Lower Silurian formations of the British area, though it is impossible to make the minor subdivisions in the two countries agree. The remaining four formations answer to the English and Welsh Upper Silurian series,—the highest zone of all (H) indicating by its organic remains the approach of the Devonian series.

Small though the area of the Silurian basin of Bohemia is (for it measures only 100 miles in extreme length by 44 miles in its greatest breadth), it has proved extraordinarily rich in organic remains. M. Barrande has named and described above 2000 species from that basin alone, the greater number being peculiar to it. Some aspects of its organic facies are truly remarkable. One of these is the extraordinary variety and abundance of its straight and curved cephalopods. M. Barrande has determined 18 genera and 2 sub-genera, comprising in all no fewer than 1127 distinct species. The genus *Orthoceras* alone contains 554 species, and *Cyrtoceras* has 330.[2] The trilobites likewise appear in great numbers, the same indefatigable explorer having detected as many as 42 distinct genera, comprising 350 species. Of these the most prolific genus is *Bronteus*, which includes 46 species entirely confined to the 3d fauna or Upper Silurian; *Acidaspis* has 40 species, of which 6 occur in the 2d and 34 in the 3d fauna. *Proëtus* also numbers 40 species, which all belong to the 3d fauna, save 2 found in the 2d. Other less prolific but still abundant genera are *Dalmanites*, *Phacops*, and *Illænus*. The 2d fauna, or Lower Silurian rocks, contain in all 32 genera and 127 species of trilobites, while the 3d fauna, or Upper Silurian formations, contain 17 genera and 205 species, so that generic types are more abundant in the earlier and specific varieties in the later rocks.[3]

In Germany Silurian rocks appear in a few detached areas, but present a great contrast to those of Bohemia in their comparatively unfossiliferous character, and the absence of any one continuous succession of the whole Silurian system. They occur in the Thuringer Wald, where a series of fucoidal-schists (perhaps Cambrian) passes up into slates, greywackes, etc., with *Lingula*, *Discina*, *Calymene*, numerous graptolites, and other fossils. These strata (from 1600 to 2000 feet thick) may represent the Lower Silurian formations. They are covered by some graptolitic alum-slates, shales, flinty slates, and limestones

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[1] *Untersuchungen über die Silurische Formation von Estland, Nord-Livland, and Oesel*, Dorpat, 1858.

[2] *Syst. Silur.*, vol. ii., suppt., p. 266, 1877.

[3] Barraude, *Syst. Silur.*, vol. i. suppt., "Trilobites," 1871.

(*Favosites Gothlandica*, etc.), which no doubt represent the Upper Silurian, and pass into the base of the Devonian formations. Among the Harz mountains certain greywackes and shales containing land-plants (lycopods, etc.), trilobites (*Dalmanites*, etc.), graptolites, etc., are regarded as of intermediate age between true Upper Silurian and Lower Devonian rocks. In the north-west of France an impoverished series of sandstones and slates represents the succession of formations up to the top of the Silurian or base of the Devonian system, and contains a suite of trilobites which indicate more analogy with the Silurian fauna of Bohemia and of Spain than with that of the British Islands. In the western half of the Spanish peninsula Silurian rocks are found flanking the older schists and crystalline masses, and spreading over a vast area of the table-land. They appear to belong chiefly if not wholly to the lower division of the system, and they include representatives of Barrande's primordial zone, containing 19 species of organisms, of which 9 are primordial trilobites.

North America.—In the United States and Canada the Silurian formations spread continuously over a vast territory, from the mouth of the St. Lawrence south-westwards into Alabama and westwards by the great lakes. They almost encircle and certainly underlie all the later Palæozoic deposits of the great interior basin. The rocks are most typically developed in the state of New York, where they have been arranged as in the subjoined table.

B. Upper Silurian.

IV. Oriskany Formation.	Oriskany sandstone (*Spirifer arenosus*).	Ludlow.
III. Lower Helderberg Formation.	(4) Upper Pentamerus limestone (*Pentamerus pseudogaleatus*)	
	(3) Delthyris limestone (*Meristella lævis*)	
	(2) Lower Pentamerus limestone (*Pentamerus galeatus*)	
	(1) Water-lime (*Tentaculites*, *Eurypterus*, and *Pterygotus*)	
II. Salina Formation.	Onondago salt group, nearly barren of fossils	
I. Niagara Formation.	(3) Niagara shale and limestone (*Halysites*, *Favosites*, *Calymene Blumenbachii*, *Homalonotus delphinocephalus*, *Leptæna transversalis*, etc.	Wenlock.
	(2) Clinton group (*Pentamerus oblongus*, *Atrypa reticularis*, etc.)	Upper Llandovery.
	(1) Medina group with Oneida conglomerate (*Modiolopsis orthonota*)	

A. Lower Silurian.

II. Trenton Formation.	(3) Cincinnati (Hudson River) group (*Syringopora*, *Halysites*, *Diplograptus pristis*, *Pterine demissa*, *Leptæna sericea*).		
	(2) Utica group—Utica shale.		
	(1) Trenton group.	Trenton limestone. Black River limestone. Birdseye limestone.	*Graptolithus Amplexicaulis*, *Trinucleus concentricus*, *Orthis testudinaria*, *Murchisonia*, *Conularia*, *Orthoceras*, *Cyrtoceras*, etc.
I. Canadian Formation.	(3) Chazy group—Chazy limestone (*Maclurea magna*, *M. Logani*, *Orthoceras*, *Illænus*, *Asaphus*).		
	(2) Quebec group (upwards of 100 species of trilobites of genera *Agnostus*, *Ampyx*, *Amphion*, *Conocoryphe*, *Dikelocephalus*, *Illænus*, *Asaphus*, etc., more than 50 species of graptolites).		
	(1) Calciferous group (graptolites, *Lingulella acuminata*, *Leptæna*, *Conocardium*, *Ophileta compacta*, *Orthoceras primigenium*, 14 species of trilobites of the genera *Amphion*, *Bathyurus*, *Asaphus*, *Conocoryphe*).		
	Potsdam formation, representing Cambrian (see *ante*, p. 293).		

The most recent researches of Mr. Selwyn and his colleagues of the Geological Survey of Canada have shown that in the so-called Quebec group have been included a number of formations of very different stratigraphical positions. He recognizes in it three distinct groups :—(1) at the base a group of crystalline schists; (2) a group of sandstones and slates with abundant volcanic rocks, probably Cambrian; and (3) Lower Silurian slates, shales, limestones, quartzites, sandstones, and conglomerates. He objects to the introduction of new names to denote systems of rocks, and thinks that Laurentian, Huronian, Cambrian, and Silurian meet all present requirements.

DEVONIAN AND OLD RED SANDSTONE.

In Wales and the adjoining counties of England, where so full a development of the Silurian system was originally discovered and worked out by Murchison, the abundant marine fauna comes to an abrupt close when the red rocks set in at the top of the Ludlow group. From that horizon upwards in the geological series we have to pass through some 10,000 feet or more of barren red sandstones and marls, until we again encounter a copious marine fauna in the Carboniferous Limestone. It is evident that between the disappearance of the Silurian and the arrival of the Carboniferous fauna very great geographical changes must have occurred over the area of Wales and the west of England. The sea must have been excluded from the area, or at least must have been rendered unfit for the existence and development of marine life over the area in question. From the striking contrast between the general facies of life in the Silurian and that in the Carboniferous system it is manifest that the interval between them must have been of long duration.

The geological records of this vast interval are still only very partially unravelled and interpreted. At present the general belief among geologists is that, while in the west and north-west of Europe the Silurian sea-bed was upraised into land in such a way as to enclose large inland basins, in the centre and south-west the geographical changes did not suffice to exclude the sea, which continued to cover more or less completely that region. In the isolated basins of the north-west a peculiar type of deposits termed the Old Red Sandstone is believed to have accumulated, while in the shallow seas to the south and east a series of marine sediments and limestones was formed to which the name of Devonian has been given. It is thus supposed that the Old Red Sandstone and the Devonian represent different geographical areas, with different phases of sedimentation and of life, during the long lapse of time between the Silurian and Carboniferous periods.

That the Old Red Sandstone does really represent this prolonged interval can be demonstrated by innumerable sections in Britain, where its lowest strata are found graduating downward into the top of the Ludlow group and its highest beds are seen to pass up into the base of the Carboniferous system. But the evidence is not everywhere so clear in regard to the true position of the Devonian rocks. That these rocks lie between Silurian and Carboniferous formations is indeed sufficiently clear. But it is a curious fact that where the Lower Devonian beds are best developed the Upper Silurian formations are scarcely to be recognized, or if they occur, they can hardly be separated from the so-called Devonian rocks. It is therefore quite possible that the lower portions of what has been termed the Devonian series may in certain regions to some extent represent what are elsewhere recognized as undoubted Ludlow or even perhaps Wenlock rocks. We cannot suppose that the rich Silurian fauna died out abruptly at the close of the Ludlow epoch. We should be prepared for the discovery of younger Silurian rocks than the latest of those in Britain, such as M. Barrande has shown to exist in his Étage H. The rocks termed Lower Devonian may partly represent some of these later phases of Silurian life, if they do not also mark peculiar geographical conditions of a still older period in Upper Silurian time. On the other hand, the upper parts of the Devonian system might in several respects be claimed as fairly belonging to the Carboniferous system above.

The late Mr. Jukes proposed a solution of the Devonian problem, the effect of which would be to turn the whole of the Devonian rocks into Lower Carboniferous, and to place them above the Old Red Sandstone, which would thus become the sole representative in Europe of the interval between Silurian and Carboniferous time.[1] In the following descriptions an account will first be given of the Devonian type and then of the Old Red Sandstone.

A. Devonian.

This name was first applied by Sedgwick and Murchison to the rocks of North and South Devon and Cornwall, whence a suite of fossils was obtained which Lonsdale pronounced to be intermediate in character between Silurian and Carboniferous. The relations of these strata to Silurian rocks cannot be determined from any section. They pass upward into Carboniferous strata. They have been arranged into three divisions, as in the subjoined table.

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[1] See his papers in *Journ. Roy. Geol. Soc. Ireland* (1865), i. pt. 1, new ser., and *Quart. Journ. Geol. Soc.*, xxii. (1866), and his pamphlet on *Additional Notes on Rocks of North Devon*, etc., 1867.

Upper.	Pilton and Pickwell-Down Group.—Grey slate with courses of impure limestone (Pilton) passing down into yellow, brown, and red sandstones (Baggy Point, Marwood), and a series of hard grey and red sandstones and micaceous flagstones at the base (Pickwell-Down, Dulverton, Morte Bay).
Middle.	Ilfracombe Group. — Grey unfossiliferous slates (Morte Hoe, Woolacombe, and Lee Bay) passing down into calcareous fossiliferous slates and limestones (Ilfracombe, Combe Martin, Torquay, Plymouth) resting on hard green, grey, and red grits, sandstones, and conglomerates (Hangman Hill).
Lower.	Lynton Group.—Soft slates with thin limestone and sandstone bands (Lynton) resting on lowest schists and red and grey micaceous sandstones (Lynton, Lynmouth, Foreland, etc.).

The total fauna of the British Devonian rocks numbers about 400 species. The middle group is the chief repository of fossils.

Lower.—Among the lower gritty slates and limestone bands of North Devon there are found, according to the detailed census compiled by Mr. Etheridge, 18 species of fossils, comprising *Favosites cervicornis*, *Fenestella antiqua*, *Orthis arenata*, *Spirifer canaliferus*, *S. lævicostus*, *etc.* Of these organisms 7 species are also found among the Devonian rocks of the Rhine, Belgium, or France. Mr. Etheridge remarks that it is singular that the British Lower Devonian rocks should only have yielded 1 gasteropod (*Pleurotomaria aspera*), 4 lamellibranchs, 1 cephalopod (*Orthoceras gracile*), and 1 nucleobranch (*Bellerophon bisulcatus*). They have furnished only 10 brachiopods. Traces of fish remains have been obtained among them in the form of bones and coprolitic debris. So far as observation has gone not a single Silurian species has been certainly detected in the Devonian rocks of Britain, with, according to Mr. Etheridge, the sole exception of the long-lived and universally diffused *Atrypa reticularis*, which occurs in the Ilfracombe group. There can be no doubt, however, from the meagre list of fossils from the Lower Devonian rocks of Devon and Cornwall, that either the conditions for the existence or those for the fossilization of the early Devonian fauna must have been singularly unfavorable in the south-west of England. It would be exceedingly rash to argue as to the extinction of the Silurian fauna from the unsatisfactory evidence of these rocks.

Middle.—As above remarked, this is the great storehouse of Devonian fossils in the south-west of England. In this fauna, as tabulated by Mr. Etheridge, there are 8 amorphozoans, including 5 species of *Stromatopora*; 23 genera and 50 species of cœlenterates, among which the corals *Acervularia*, *Alveolites*, *Cyathophyllum*, *Favosites*, *Pleurodictyum*, and *Petraia* are conspicuous; 4 genera and 8 species of crinoids (*Hexacrinus*, *Cyathocrinus*, etc.); 1 annelide (*Tentaculites annulatus*); 5 genera and 13 species of crustaceans, which are all trilobites (*Phacops granulatus*, *P. latifrons*, *P. punctatus*, *Bronteus flabellifer*, *Cheirurus articulatus*, *Harpes macrocephalus*, etc.); and 12 species of polyzoans. The brachiopods are abundant; 68 species have been yielded by the rocks of South Devon, including *Athyris concentrica*, *A. lachryma*, *Atrypa reticularis*, *A. desquamata*, *Camarophoria rhomboidea*, *Cyrtina Lemarlii*, *Orthis striatula*, *Rhynchonella acuminata*, *R. pugnus*, *Pentamerus brevirostris*, *Spirifer disjunctus*, *Stringocephalus Burtini*, *Uncites gryphus*, etc. The lamellibranchs are poorly represented, 11 genera only occurring, and many of them represented by only 1 species. The gasteropods are likewise present in but small numbers and variety; 12 genera and 36 species have been enumerated. Of these species, 4 (*Acroculia vetusta*, *Euomphalus lævis*, *Macrocheilus imbricatus*, and *Murchisonia spinosa*) survived into the Carboniferous period. The cephalopods are represented by 5 genera, the most abundant specifically being *Cyrtoceras* and *Orthoceras*; *Goniatites*, *Clymenia*, and *Nautilus* also occur. Of the total list of fossils a large proportion is found in the Middle Devonian rocks of the continent of Europe. Very few species agree with those of the Silurian or with those of the Carboniferous system.

Upper.—From the calcareous portions of the Petherwin and Pilton beds of Cornwall and Devon a considerable number of fossils has been obtained. Among the more characteristic of these we find 11 species of the coiled cephalopod *Clymenia* (*C. undulata*, *C. lævigata*, *C. striata*), the trilobites *Phacops granulatus* and *P. latifrons*, the small ostracod *Cypridina serrato-striata*, the brachiopods *Spirifer disjunctus* or *Verneuilii*, *Strophomena rhomboidalis*, *Chonetes Hardrensis*, *Productus subaculeatus*, and the lamellibranch *Cucullæa Hardingii*. The Marwood and Baggy Point beds have also yielded traces of land plants, such as *Knorria dichotoma* and *Adiantites Hibernicus*, the latter fern being common in some parts of the Upper Old Red Sandstone of Ireland.

The higher red and yellow sandy portions of the Upper Devonian rocks shade up insensibly at Barnstaple in North Devon into strata which by their fossils are placed at the base of the Carboniferous Limestone series. But in no other series save the south-western district of Britain can such a passage be observed. In all other places the Carboniferous system, where its true base can be seen, passes down into the red sandy and marly strata of the Upper Old Red Sandstone without marine fossils.

CONTINENTAL EUROPE.—Devonian rocks occupy a large area in the centre of Europe, extending from the Ardennes through the south of Belgium across Rhenish Prussia to Darmstadt. They are best known from the picturesque gorges which have been cut through them by the Rhine below Bingen and by the Moselle below Treves. They have been arranged into the following groups in the Eifel region, where their true geological position was first indicated by Sedgwick and Murchison.

- III. *Upper Devonian*—
  - (*c*) Cypridina shales (*Cypridina serrato-striata*).
  - (*b*) Goniatite shales (*Goniatites retrorsus*, *G. primordialis*, *Orthoceras subflexuosum*, *Cardiola retrostriata*, etc.).
  - (*a*) Nodular crumbling limestone (Kramenzelkalk), dolomitic marl, and shaly limestone (*Spirifer disjunctus* or *Verneuilli*, *Atrypa reticularis*, *Rhynchonella cuboides*, *Productus subaculeatus*, etc.).
- II. *Middle Devonian*—
  - (*b*) Stringocephalus group, consisting of the great Eifel limestone with underlying crinoidal beds (*Stringocephalus Burtini*, *Spirifer undatus*, *Productus subaculeatus*, *Pentamerus galeatus*, *Atrypa reticularis*, *Calceola sandalina*, and many corals and crinoids).
  - (*a*) Calceola group,—marly limestones full of *Calceola sandalina*, *Spirifer concentricus*, *Camarophoria microrhyncha*, etc., resting upon impure shaly ferruginous limestone and greywacke, marked by an abundance of *Spirifer cultrijugatus*, *Rhynchonella Orbignyana*, *Atrypa reticularis*, *Phacops latifrons*, etc.
- I. *Lower Devonian*—
  - (*c*) Upper greywacke and shale (Vichter-Schichten), with a mixture of Lower and Middle Devonian fossils.
  - (*b*) Ahr group,—greywacke-shales with *Chonetes sarcinulata*, *C. dilatata*, *Rhynchonella Livonica*, *Spirifer paradoxus*, *S. speciosus*, many species of *Pterinea*, *Pleurotomaria*, and *Murchisonia*.
  - (*a*) Coblentz group, greywacke and clay-slate (*Leptæna laticosta*, *Chonetes sarcinulata*, *Rhynchonella Livonica*, *Pleurodictyum problematicum*, etc.).

This threefold subdivision, with a central mass of calcareous strata, is traceable westwards through Belgium (where the Calcaire de Givet represents the Stringocephalus limestone of the Eifel) and eastwards into the Harz. The rocks reappear with local petrographical modifications, but with a remarkable persistence of general palæontological characters, in Eastern Thuringia, Franconia, Saxony, Silesia, the north of Moravia, and East Galicia. Devonian rocks have been detected among the crumpled rocks of the Styrian Alps by means of the evidence of abundant corals, clymenias, gasteropods, lamellibranchs, and other organic remains. Perhaps in other tracts of the Alps, as well as in the Carpathian range, similar shales, limestones and dolomites, though as yet unfossiliferous, but containing ores of silver, lead, mercury, zinc, cobalt, and other metals, may be referable to the Devonian system.

In the centre of Europe, therefore, the Devonian rocks consist of a vast thickness of dark-grey sandy and shaly rocks, with occasional seams of limestone, and in particular with one thick central calcareous zone. These rocks are characterized in the lower zones by numerous broad-winged spirifers and by peculiar trilobites (*Phacops*, *Homalonotus*, etc.), which, though generically like those of the Silurian system, are specifically distinct. The central calcareous zone abounds in corals and crinoids as well as in numerous brachiopods. In the highest bands a profusion of coiled cephalopods (*Clymenia*) occurs in some of the limestones, while the shales are crowded with a small but characteristic ostracod crustacean (*Cypridina*). Here and there traces of fishes have been found, more especially in the Eifel, but seldom in such a state of preservation as to warrant their being assigned to any definite place in the zoological scale. More recently, however, E. Beyrich has described from Gerolstein in the Eifel an undoubted species of *Pterichthys*, which, as it cannot be certainly identified with any known form, he names *P. Rhenanus*. A *Coccosteus* has been described by F. A. Roemer from the Harz, and more recently one has been cited from Bicken near Herborn by V. Koenen; but as Beyrich points out, there may be some doubt as to whether the latter is not a *Pterichthys*.[1] A *Ctenacanthus*, seemingly undistinguishable from the *C. Bohemicus* of Barrande's Étage G, has also been obtained from the lower Devonian "Nereitenschichten" of Thuringia.[2] The characteristic *Holoptychius nobilissimus* has recently been detected in the Psammite de Condroz, which in Belgium forms a characteristic sandy portion of the Upper Devonian rocks. These are interesting facts, as helping to link the Devonian and Old Red Sandstone types together. But they are as yet too few and unsupported to warrant any large deduction as to the correlations between these types.

It is in the north-east of Europe that the Devonian and Old Red Sandstone appear to be united into one system, where the limestones and marine organisms of the one are interstratified with the fish-bearing sandstones and shales of the other. In Russia, as was shown in the great work *Russia and the Ural Mountains* by Murchison, De Verneuil, and Keyserling, rocks intermediate between the Upper Silurian and Carboniferous Limestone formations cover an extent of surface larger than the British Islands. This wide development arises not from the thickness but from the undisturbed horizontal character of the strata. Like the Silurian formations above described, they remain to this day nearly as flat and unaltered as they were originally laid down. Judged by mere vertical depth, they present but a meagre representative of the massive Devonian greywacke and limestone of Germany, or of the Old Red Sandstone of Britain. Yet vast though the area is over which they form the surface rock, it is probably only a small portion of their total extent; for they are found turned up from under the newer formations along the flank of the Ural chain. It would thus seem that they spread continuously across the whole breadth of Russia in Europe. Though almost everywhere undisturbed, they afford evidence of some terrestrial oscillation between the time of their formation and that of the Silurian rocks on which they rest, for they are found gradually to overlap Upper and Lower Silurian formations.

The chief interest of the Russian rocks of this age lies in the fact, first signalized by Murchison and his associates, that they unite within themselves the characters of the Devonian and the Old Red Sandstone types. In some districts they consist largely of limestones, in others of red sandstones and marls. In the former they present mollusks and other marine organisms of known Devonian species; in the latter they afford remains of fishes, some of which are specifically identical with those of the Old Red Sandstone of Scotland. The distribution of these two palæontological types in Russia is traced by Murchison to the lithological characters of the rocks, and consequent original diversities of physical conditions, rather than to differences of age. Indeed cases occur where in the same band of rock Devonian shells and Old Red Sandstone fishes lie commingled. In the belt of the formation which extends southwards from Archangel and the White Sea, the strata consist of sands and marls, and contain only fish remains. Traced through the Baltic provinces, they are found to pass into red and green marls, clays, thin limestones, and sandstones, with beds of gypsum. In some of the calcareous bands such fossils occur as *Orthis striatula*, *Spiriferina prisca*, *Leptæna productoides*, *Spirifer calcaratus*, *Spirorbis omphaloides*, and *Orthoceras subfusiforme*. In the higher beds *Holoptychius* and other well-known fishes of the Old Red Sandstone occur. Followed still further to the south, as far as the watershed between Orel and Woronesch, the Devonian rocks lose their red color and sandy character, and become thin-bedded yellow limestones, and dolomites with soft green and blue marls. Traces of salt deposits are indicated by occasional saline springs. It is evident that the geographical conditions of the Russian area during the Devonian period must have closely resembled those of the Rhine basin and central England during the Triassic period.

The Russian Devonian rocks have beeen classified as follows:—

Upper ...	Red and white sandstone and green marls,—numerous fish remains, particularly *Holoptychius nobilissimus*, *Glyptosteus favosus*, *Diplopterus macrocephalus*.
Middle...	Limestones, clays, marls, dolomite, and gypsum,—numerous characteristic Devonian shells and crinoids, also *Holoptychius nobilissimus*.
Lower ...	In some districts red and green limestones with red marls and Middle Devonian fossils; in others (North Livonia) sandstones and clays, with numerous fish remains of the genera *Osteolepis*, *Dipterus*, *Diplopterus*, *Asterolepis*, and others found also in the Caithness flags of Scotland.

There is an unquestionable passage of the uppermost Devonian rocks of Russia into the base of the Carboniferous system. The Devonian rocks of North America are noticed at the end of the next section.

B. *Old Red Sandstone.*

Under this name is comprised a vast and still imperfectly described series of red sandstones, shales, and conglomerates, intermediate in age between the Ludlow rocks of the Upper Silurian formations and the base of the Carboniferous system in Britain. These rocks were termed "Old" to distinguish them from a somewhat similar series overlying the Coal-measures, to which the name New Red Sandstone was applied. When the term Devonian was adopted, it speedily supplanted that of Old Red Sandstone, inasmuch as it was founded on a type of marine strata of wide geographical extent, whereas the latter term described what appeared to be merely a British and local development. For the reasons already given, however, it is desirable to retain the title Old Red Sandstone as descriptive of a remarkable suite of formations to which there is nothing analogous in typical Devonian rocks. It is in Great Britain that the Old Red Sandstone of Europe is almost entirely developed. This interesting series of deposits must from the first have been deposited in separate areas or basins, the sites of some of which can still be traced. Their diversities of sediment and discrepance of organic contents point to the want of any direct communication between them. It was maintained may years ago by Mr. Godwin Austen, and has been more recently enforced by Professor Ramsay, that these basins were lakes or inland seas. The character of the strata, the absence of unequivocally marine fossils, the presence of land-plants and of numerous ganoid fishes which have their modern representatives in rivers and lakes, suggest and support this opinion, which has been generally adopted by geologists. The red arenaceous and marly beds which, with their fish remains and land-plants, occupy a depth of many thousand feet between the top of the Upper Silurian and the base of the Lower Carboniferous formations, are regarded as the deposits of a series of lakes or inland seas formed by the uprise of portions of the Silurian sea-floor. The length of time during which these lacustrine basins must have existed is shown, not only by the thickness of the deposits formed in them, but by the complete change which took place in the marine fauna between the close of the Silurian and the commencement of the Carboniferous period. The prolific fauna of the Wenlock and Ludlow rocks was extirpated over the British area by the physical changes which produced the lake-basins of the Old Red Sandstone. When a marine population—crinoids, corals, and shells—once more overspreads the area it is found to be completely different. So thorough a change must have demanded a long interval of time.

Murchison, who strongly advocated the opinion that the Old Red Sandstone and Devonian rocks represented different geographical conditions of the same period, and who had with satisfaction seen the adoption of the Devonian classification by Continental geologists, endeavored to trace in the Old Red Sandstone of Britain a threefold division like that which had been accepted for the Devonian system. He accordingly arranged the formations as in the subjoined table.

Old Red Sandstone as classified by Murchison.	Upper.	Yellow and red sandstones and conglomerates (*Pterichthys major*, *Holoptychius nobilissimus*, *etc.*) = Dura Den beds.
	Middle.	Grey and blue calcareous and bituminous flagstones, limestones, and red sandstones, and conglomerates (*Dipterus*, *Osteolepis*, *Asterolepis*, *Acanthodes*, *Pterichthys*, *etc.*) = Caithness flags.
	Lower.	Red and purple sandstones, grey flagstones, and coarse conglomerates (*Cephalaspis*, *Pteraspis*, *Pterygotus*) = Arbroath flags.

It is important to observe that in no district can these three subdivisions be found together, and that the so-called "middle" formation occurs only in one region—the north of Scotland. The classification, therefore, does not rest upon any actually ascertained stratigraphical sequence, but on an inference from the organic remains. The value of this inference will be estimated a little further on. All that can be affirmed from stratigraphical evidence in any Old Red Sandstone district in Britain is that a great physical and palæontological break can generally be traced in the Old

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[1] *Zeitschrift der Deutsch. Geol. Gesell.*, xxix. 751.

[2] *Op. cit.*, 423.

Red Sandstone, dividing it into two completely distinct series—a Lower, which graduates downward into the Upper Silurian, and an Upper, which passes upward into the base of the Carboniferous system.

As a whole, the Old Red Sandstone, where its strata are really red, is like other masses of red deposits, singularly barren of organic remains. The physical conditions under which the precipitation of iron oxide took place were evidently unfavorable for the development of animal life in the same waters. Professor Ramsay has connected the occurrence of such red formations with the existence of salt lakes, from the bitter waters of which not only iron-oxide but often rock-salt, magnesian limestone, and gypsum were thrown down. He points also to the presence of land-plants, footprints of amphibia, and other indications of terrestrial surfaces, while truly marine organisms are either found in a stunted condition or are absent altogether. Where the strata of the Old Red Sandstone, losing their red color and ferruginous character, assume grey or yellow tints and pass into a calcareous or argillaceous condition, they not infrequently become fossiliferous. At the same time it is not unworthy of remark that some of the red conglomerates, which might be supposed little likely to contain organic remains, are occasionally found to be full of detached scales, plates, and bones of fishes.

Along the border of the Silurian region from Shropshire into South Wales the uppermost parts of the Silurian system graduate into a mass of red strata not less than 10,000 feet thick, which in turn pass up conformably into the base of the Carboniferous system. This vast accumulation of red rocks, termed the Old Red Sandstone, consists in its lower portions of red and green shales and flagstones, with some white sandstones and thin cornstones; in the central and chief division, of red and green spotted sandy marls and clays, with red sandstones and cornstones; in the higher parts of grey, red, chocolate-colored, and yellow sandstones, with bands of conglomerate. No unconformability has yet been detected in any part of this series of rocks, though, from the observations of De la Beche, it may be suspected that the higher strata which graduate upward into the Carboniferous formations are separated from the underlying portions of the Old Red Sandstone by a distinct discordance.

Although, as a whole, barren of organic remains, these red rocks have here and there, more particularly in the calcareous zones, yielded fragments of fishes and crustaceans. In their lower and central portions remains of the ganoids *Cephalaspis*, *Didymaspis*, *Scaphaspis*, *Pteraspis*, and *Cyathaspis* have been found, together with crustaceans of the genera *Stylonurus*, *Pterygotus*, and *Prearcturus*, and obscure traces of plants. The upper yellow and red sandstones contain none of the cephalaspid fishes, which are there replaced by *Pterichthys* and *Holoptychius*, associated with distinct impressions of land-plants. In some of the higher parts of the Old Red Sandstone of South Wales and Shropshire, *Serpula* and *Conularia* occur; but these are exceptional cases, and point to the advent of the Carboniferous marine fauna, which doubtless existed outside the British area before it spread over the Old Red Sandstone basins.

It is in Scotland that the Old Red Sandstone shows the most complete and varied development, alike in physical structure and inorganic contents. Throughout that country the system is found everywhere to present a division into two well-marked groups of strata, separated from each other by a strong unconformability and a complete break in the succession of organic remains. It occurs in distinct areas which appear to mark the site of separate basins of deposit. One of these occupies the central valley between the base of the Highland mountains and the uplands of the southern counties. On the north-east it is cut off by the present coast-line from Stonehaven to the mouth of the Tay. On the south-west it ranges by the island of Arran across St. George's Channel into Ireland, where it runs almost to the western sea-board, flanked on the north, as in Scotland, by hills of crystalline rocks and on the south chiefly by a Lower Silurian belt. Another distinct and still larger basin lies on the north side of the Highlands, but only a portion of it comes within the present area of Scotland. It skirts the slopes of the mountains along the Moray Firth and the east of Ross and Sutherland, and stretches through Caithness and the Orkney Islands as far as the south of the Shetland group. It may possibly have been at one time continued as far as the Sognefjord and Dalsfjord in Norway, where red conglomerates like those of the north of Scotland occur. There is even reason to infer that it may have ranged eastwards into Russia, for some of its most characteristic organisms are found also among the red sandstones of that country. A third minor area of deposit lay on the south side of the southern uplands over the east of Berwickshire and the north of Northumberland, including the area of the Cheviot Hills. A fourth occupied a basin on the flanks of the south-west Highlands, which is now partly marked by the terraced hills of Lorne. There is sufficient diversity of lithological and palæontological characters to show that these several areas were distinct basins, separated both from each other and from the sea.

In the central basin of Scotland between the Highlands and the southern uplands, the twofold division of the Old Red Sandstone is typically seen. The lower series of deposits attains a maximum depth of upwards of 20,000 feet. In Lanarkshire it is found to pass down conformably into the Upper Silurian rocks; elsewhere its base is concealed by later formations, or by the unconformabilty with which different horizons rest upon the older rocks. It is covered unconformably by every formation younger than itself. It consists of reddish-brown or chocolate-colored, grey, and yellow sandstones, red shales, grey flagstones, coarse conglomerates, and occasional bands of limestone and cornstone. The grey flagstones and thin grey and olive shales and "calmstones" are almost confined to Forfarshire in the north-east part of the basin, and are known as the Arbroath flags. One of the most marked lithological features in this central Scottish basin is the prodigious masses of interbedded volcanic rocks. These, consisting of porphyrite-lavas, felsites, and tuffs, attain a thickness of more than 6000 feet, and form important chains of hills, as in the Pentland, Ochil, and Sidlaw ranges. They lie several thousand feet above the base of the system, and are regularly interstratified here and there with bands of the ordinary sedimentary strata. They point to the outburst of numerous volcanic vents along the lake or inland sea in which the Lower Old Red Sandstone of central Scotland was laid down; and their disposition shows that these vents ranged themselves in lines or linear groups parallel with the general trend of the great central valley. The fact that the igneous rocks are succeeded by thousands of feet of sandstones, shales, and conglomerates, without any intercalation of lava or tuff, proves that the volcanic episode in the history of the lake came to a close long before the lake itself disappeared.

As a rule the deposits of this lake are singularly unfossiliferous, though some portions of them, particularly in the Forfarshire flagstone group, have proved rich in fish remains. In Lanarkshire about 5000 feet above the base of the system a thin band of shale occurs, containing a graptolite, *Spirorbis Lewisii*, and *Orthoceras dimidiatum*,—undoubtedly Upper Silurian forms. This interesting fact serves to indicate that, though geographical changes had elevated the Upper Silurian sea-floor partly into land and partly into isolated inland water-basins, the sea outside still contained an Upper Silurian fauna, which was ready on any favorable opportunity to re-enter the tracts from which it had been excluded. The interval of its reappearance seems to have been very brief, however, for the band of shale containing these Upper Silurian marine organisms is only a few inches thick, and the fossils have not been detected on any other horizon. With these exceptions, the fauna of the formation consists entirely of fishes and crustaceans. Nine or more species of crustaceans have been obtained, chiefly eurypterids, but including one or two phyllopods. The large pterygotus (*P. Anglicus*) is especially characteristic, and must have attained a great size, for some of the individuals indicate a length of 6 feet with a breadth of $1\frac{1}{2}$ feet. There occur also a smaller species (*P. minor*), two *Eurypteri*, three species of *Stylonurus*, and abundant clusters of crustacean egg-packets termed *Parkia decipiens*. Seventeen species of fishes have been obtained, chiefly from the Arbroath flags. They belong to the suborders *Acanthodidæ* and *Ostracostei*. One of the most abundant forms is the little *Acanthodes Mitchelli*. Another common fish is *Diplacanthus gracilis*. There occur also *Climatius scutiger*, *C. reticulatus*, and *C. uncinatus*, *Parexus incurvus*, *Euthacanthus* (four species), *Cephalaspis Lyellii*, and *Pteraspis Mitchelli*. Some of the sandstones and shales are crowded with indistinctly preserved vegetation, occasionally in sufficient quantity to form thin laminæ of coal. In Forfarshire the surfaces of the shaly flagstones are now and then covered with linear grass-like plants like the sedgy vegetation of a lake or marsh. In Perthshire certain layers occur chiefly made up of compressed stems of *Psilophyton.* The adjoining land was doubtless clothed with a flora in large measure lycopodiaceous.

The Old Red Sandstone of the northern basin is typically developed in Caithness, where it consists chiefly of the well-known dark-grey bituminous and calcareous flagstones of commerce. It rests unconformably upon the metamorphosed Lower Silurian schists, and must have been deposited on the very uneven bottom of a sinking basin, seeing that occasionally even some of the higher platforms are found resting against the schists and granites. The lower zones consist of red sandstones and conglomerates which graduate upward into the flagstones. Other red sandstones, however, supervene in the higher parts of the system. The total depth of the series in Caithness has been estimated at upwards of 16,000 feet.

Murchison was the first to attempt the correlation of the Caithness flagstones with the Old Red Sandstone of the rest of Britain. Founding upon the absence from these northern rocks of the characteristic cephalaspidean fishes of the admitted Lower Old Red Sandstone of the south of Scotland and of Wales and Shropshire, upon the presence of numerous genera of fishes not known to occur in the true Lower Old Red Sandstone, and upon the discovery of a *Pterygotus* in the basement red sandy group of strata, he concluded that the massive flagstone series of Caithness could not be classed with the Lower Old Red Sandstone, but must be of younger date. He supposed the red sandstones, conglomerates, and shales at the base, with their *Pterygotus,* to represent the true Lower Old Red Sandstone, while the great flagstone series with its distinctive fishes was made into a middle division answering in some of its ichthyolitic contents to the Middle Devonian rocks of the Continent. This view has been accepted everywhere by geologists. Recently, however, it has been called in question by Professor Geikie, who gives reasons for maintaining the Caithness flagstones to be Lower Old Red Sandstone, and for denying the existence of any middle division. He shows that the discrepance in organic contents between the Caithness and the Arbroath flags is by no means so strong as Murchison supposed, but that several species are common to both. In particular, he finds that the characteristically Lower Old Red Sandstone and Upper Silurian crustacean genus *Pterygotus* occurs, not merely in the basement zone of the Caithness flags, but also high up in the series. The genera *Acanthodes* and *Diplacanthus* are abundant both in Caithness and in Forfarshire. *Parexus incurvus* occurs in the northern as well as the southern basin. It is contended that the palæontological distinctions are not greater than the striking lithological differences between the strata of the two regions would account for, or than the contrast between the ichthyic faunas of contiguous water-basins at the present time.

Somewhere about 60 species of fishes have been obtained from the Old Red Sandstone of the north of Scotland. Among these the genera *Acanthodes, Asterolepis, Cheiracanthus, Cheirolepis, Coccosteus, Diplacanthus, Diplopterus, Dipterus, Glyptolepis, Osteolepis,* and *Pterichthys* are specially characteristic. Some of the shales are crowded with the little ostracod crustacean *Estheria membranacea.* Land-plants abound, especially in the higher groups of the flagstones, where forms of *Psilophyton, Lepidodendron, Stigmaria, Sigillaria, Calamite,* and *Cyclopteris,* as well as other genera, occur. In the Shetland Islands traces of abundant contemporaneous volcanic rocks have been observed, which, with the exception of two trifling examples in the region of the Moray Firth, are the only known instances of volcanic action in the Lower Old Red Sandstone of the north of Scotland. In the other two Scottish basins, those of the Cheviot Hills and of Lorne, volcanic action continued long vigorous, and produced thick piles of lava like those of the central basin above referred to.

The Upper Old Red Sandstone consists in Scotland of red sandstones, clays or marls, conglomerates, and breccias, the sandstones sometimes becoming yellow or even white. These strata, wherever their stratigraphical relations can be distinctly traced, lie unconformably upon the lower division of the system and pass up conformably into the Carboniferous rocks above. If they are studied from the side of the underlying formation, they seem naturally to form part of the Old Red Sandstone, since they agree with it in general lithological character and also in containing some distinctively Old Red Sandstone genera of fishes, such as *Pterichthys* and *Holoptychius.* But, approached from the upper or Carboniferous direction, they appear rather to form the natural sandy base of that system into which they insensibly graduate. On the whole, they are remarkably barren of organic remains, though in one locality—Dura Den in Fife—they have yielded a number of genera and species of fishes, crowded profusely through the pale sandstone as if the individuals had been suddenly killed and rapidly covered over with sediment. Among the characteristic organisms of the Scottish Upper Old Red Sandstone are *Pterichthys major, Holoptychius nobilissimus, H. Andersoni, Glyptopomus, Glyptolæmus,* and *Phaneropleuron.*

An interesting fact deserves mention here as a corollary to what has been stated above regarding the survival for some time of an Upper Silurian fauna outside the area of the British Old Red Sandstone lakes. In the Upper Old Red Sandstone of the basin of the Firth of Clyde, *Pterichthys major* and *Holoptychius* occur at the Heads of Ayr, while a band of marine limestone lying in the heart of the red sandstone series in Arran is crowded with ordinary Carboniferous Limestone shells, such as *Productus giganteus, P. semireticulatus, P. punctatus, Chonetes Hardrensis, Spirifer lineatus,* etc. None of these fossils has been detected in the great series of red sandstones overlying the limestone. They do not reappear till the limestones at the base of the Carboniferous series; yet the organisms must have been living during all that long interval outside of the Upper Old Red Sandstone area. Not only so, but they must have been in existence long before the formation of the thick Arran limestone, though it was only during the comparatively brief interval represented by that limestone that geographical changes permitted them to enter the Old Red Sandstone basin and settle for a while on its floor. Thus we see that while, on the one hand, the older parts of the Lower Old Red Sandstone were coeval with an Upper Silurian fauna which, having disappeared from the area of Britain, survived outside of that area, on the other hand, the higher parts of the Upper Old Red Sandstone were contemporaneous with a Carboniferous Limestone fauna which, having appeared beyond the British area, was ready to spread over it as soon as the conditions became favorable for the invasion. It is, of course, obvious that such an abundant and varied fauna as that of the Carboniferous Limestone cannot have come suddenly into existence at the period marked by the base of that formation. It must have had a long previous existence outside the present area of the deposits. But it is seldom that we obtain such clear evidence of the fact as in these instances from the Scottish Old Red Sandstone.

In the north of Scotland, on the lowlands bordering the Moray Firth, and again in the Island of Hoy, one of the Orkney group, yellow and red sandstones, sometimes containing characteristic Upper Old Red Sandstone fishes, are found lying unconformably upon the Caithness flags. In these northern tracts the same relation is thus traceable as in the central counties between the two divisions of the system.

Turning southward across the border districts, we trace the red sandstones and conglomerates of the Upper Old Red Sandstone lying unconformably on Silurian rocks and Lower Old Red Sandstone. Some of the brecciated conglomerates have much resemblance to glacial detritus, and it has been suggested that they have been connected with contemporaneous ice-action. Such are the breccias of the Lammermuir Hills, and those which show themselves here and there from under the overlying mass of Carboniferous strata which flanks the Silurian hills of Cumberland and Westmoreland. Red conglomerates and sandstones appear interruptedly at the base of the Carboniferous rocks even as far as Flintshire and Anglesea. They are commonly classed as Old Red Sandstone, but merely from their position and lithological character. No organic remains have been found in them. They may therefore, in part at least, be taken as the basement beds of the Carboniferous system.

In Devonshire, at Barnstaple, Pilton, Marwood, and Baggy Point, certain sandstones, shales, and limestones (already referred to in the account of the Devonian rocks) graduate upward into the base of the Carboniferous system, and appear to represent the Upper Old Red Sandstone of the rest of Britain. They contain land plants and also many marine fossils, some of which are common Carboniferous forms. They thus indicate a transition into the geographical conditions of the Carboniferous period, as is still more clearly illustrated by the corresponding strata in Scotland.

North America.—The Devonian system, as developed in the Northern States and eastern Canada, and Nova Scotia, presents much geological interest in the union which it contains of the same two distinct petrographical and biological types found in Europe. If we trace the range of these rocks along the Alleghany chain through Pennsylvania into New York, we find them to contain a characteristic suite of marine organisms comparable with those of the Devonian system of Europe. But on the eastern side of the great range of Silurian hills in the north-eastern States, we encounter in New Brunswick and Nova Scotia a succession of red and yellow sandstones, limestones, and shales nearly devoid of marine organisms, yet full of land-plants, and with occasional traces of fish remains.

The marine or Devonian type has been grouped in the following subdivisions by the geologists of New York:—

Upper Devonian.	Catskill Red Sandstone.
	Chemung group.
	Portage group.
	Genesee group.
	Hamilton group.
	Marcellus group.
Lower Devonian.	Corniferous or Upper Helderberg group.
	Schoharie Grit.
	Cauda-galli Grit.

In the Lower Devonian series traces of terrestrial plants (*Psilophyton, Caulopteris*, etc.) have been detected even as far west as Ohio. Corals (cyatho-phylloid forms with *Favosites, Syringopora*, etc.) abound, especially in the Corniferous Limestone, which is perhaps the most remarkable mass of coral-rock in the American Palæozoic series. Among the brachiopods are species of *Pentamerus, Stricklandinia, Rhynchonella*, and others, with the characteristic European form *Spirifer cultrijugatus*, and the world-wide *Atrypa reticularis*. The trilobites include the genera *Dalmanites, Proëtus*, and *Phacops*. The earliest known traces of American fishes occur in the Corniferous group. They consist of ichthyodorulites, and teeth of cestraciont and hybodont placoids, and plates, bones, and teeth of some peculiar ganoids (*Macropetalichthys, Onychodus*).

In the Hamilton formation (embracing the Marcellus shale, the Hamilton beds, and the Genesee shale) remains of land-plants occur, but much less abundantly than among the rocks of New Brunswick. Brachiopods are especially abundant among the sandy beds in the centre of the formation. They comprise, as in Europe, many broad-winged spirifers (*S. mucronatus*, etc.), with species of *Productus, Chonetes, Athyris*, etc. The earliest American goniatites have been noticed in these beds. Newberry has described a gigantic fish (*Dinichthys*) from the Black Shale of Ohio.

The Portage and Chemung groups have yielded land-plants and fucoids, also some crinoids, numerous broad-winged spirifers, with *Aviculæ*, and a few other lamellibranchs. These strata consist in the New York region of shales and laminated sandstones, which attain a maximum thickness there of upwards of 2000 feet, but die out entirely towards the interior. They are covered by a mass of red sandstones and conglomerates—the Catskill group, which is 2000 or 3000 feet deep in the Catskill Mountains, and thickens along the Appalachian region to 5000 or 6000 feet. Those red arenaceous rocks bear a striking similarity in their lithological and biological characters to the Upper Old Red Sandstone of Europe. As a whole they are unfossiliferous, but they have yielded some ferns like those of the Upper Old Red Sandstone of Ireland and Scotland (*Cyclopteris*), and some characteristic genera of fish, as *Holoptychius* and *Bothriolepis*.

Turning now to the eastern side of the ancient Laurentian and Silurian ridge, which, stretching southwards from Canada, separated in later Palæozoic time the great interior basin from the Atlantic slopes, we find the Devonian rocks of New York, Pennsylvania, and the interior represented in New Brunswick and Nova Scotia by a totally different series of deposits. The contrast strikingly recalls that presented by the Old Red Sandstone of the north of Scotland and the Devonian rocks of north Germany. On the south side of the St. Lawrence the coast of Gaspé shows rocks of the Quebec group unconformably overlaid by grey limestones with green and red shales, attaining, according to Logan, a total thickness of about 2000 feet,[1] and replete in some bands with Upper Silurian fossils. They are conformably followed by a vast arenaceous series of deposits termed the Gaspé Sandstones, to which the careful measurements of Logan and his colleagues of the Canadian Geological Survey assign a depth of 7036 feet. This formation consists of grey and drab-colored sandstones, with occasional grey shales and bands of massive conglomerate. Similar rocks reappear along the southern coast of New Brunswick, where they attain a depth of 9500 feet, and again on the opposite side of the Bay of Fundy. The researches chiefly of Dr. J. W. Dawson have shown that these strata contain an abundant terrestrial flora—the oldest of which any relics have yet been recovered, for the few Upper Silurian land-plants at present known hardly deserve to be reckoned as a known flora. In his recent census he enumerates no fewer than 118 species of land-plants. They are almost all acrogens, the lycopods and ferns being largely predominant. Among the distinctive forms the following may be mentioned—*Psilophyton, Arthrostigma, Leptophleum, and Prototaxites*. Forty-nine ferns are given, including the genera *Cyclopteris, Neuropteris, Sphenopteris*, and some tree-ferns (*Psaronius, Caulopteris*). Lepidodendroid and sigillaroid plants abound, as well as calamites. Higher forms of vegetation are represented by a few conifers (*Dadoxylon, Ormoxylon, Prototaxites*, etc.). From a locality on Lake Erie, Dr. Dawson describes a fragment of dicotyledonous wood, not unlike that of some modern trees—the most ancient fragment of an angiospermous exogen yet discovered. So abundant are these vegetable remains that in some layers they actually form thin seams of coal.

The interest of these remains of the most venerable American forests is heightened by the discovery of the fact that they were not without the hum of insect life. The most ancient known relics of insect forms have been recovered from the Devonian strata of New Brunswick. They are all neuropterous wings, and have been referred by Mr. Scudder, of Boston, to four species combining a remarkable union of characters now found in distinct orders of insects. In one fragment he observed a structure which he could only compare to the stridulating organ of some male *Orthoptera*. Another wing indicates the existence of a gigantic *Ephemera*, with a spread of wing extending to 5 inches. In the shallow pools of the period some small crustaceans lived, the remains of which have been partially preserved. Among these is a minute, shrimp-like *Eurypterus*, and a more highly organized form named *Amphipeltis*. That the sea had at least occasional access to the inland basins into which this abundant terrestrial vegetation was washed is proved by the occurrence of marine organisms, such as a small annelid (*Spirorbis*) adhering to the leaves of the plants, and (in Gaspé and Nova Scotia) by the occasional appearance of brachiopods, especially *Lingula, Spirifer*, and *Chonetes*.[2]

CARBONIFEROUS.

This great system of rocks has received its name from the seams of coal which form one of its distinguishing features both in Europe and in North America. In Europe it is most completely developed in the British Islands. Elsewhere on that continent it occurs in patches, either lying in hollows of older rocks, or exposed by the removal of overlying formations.

Great Britain.—The area within which the Carboniferous rocks of Britain occur is sufficiently extensive to contain more than one type of the system, and thus to cast much light on the varied geographical conditions under which these rocks were accumulated. In prosecuting the study of this part of British geology, it is soon discovered, and it is essential to bear in mind, that, during the Carboniferous period, the land whence the chief supplies of sediment were derived rose mainly to the north and north-west, as it seems to have done from very early geological time. While therefore the centre and south of England lay under clear water of moderate depth, the north of the country and the south of Scotland were covered by shallow water, which was continually receiving sand and mud from the adjacent northern land. Hence vertical sections of the Carboniferous formations of Britain differ greatly according to the districts in which they are taken. The subjoined table may be regarded as expressing the typical subdivisions which can be recognized, with modifications, in all parts of the country.

Coal-measures..	Red and grey sandstones, clays, and sometimes breccias, with occasional seams and streaks of coal and spirorbis limestone (*Cythere inflata, Spirorbis carbonarius*).
	Middle or chief coal-bearing series of yellow sandstones, clays, and shales, with numerous workable coals (*Anthracosia, Anthracomya, Beyrichia, Estheria, Spirorbis*, etc.).
	Gannister beds, flagstones, scales, and thin coals, with hard siliceous (gannister) pavements (*Orthoceras, Goniatites, Posidonia, Aviculopecten, Lingula*, etc.).
Millstone Grit..	Grits, flagstones, and shales, with thin seams of coal.

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[1] *Geology of Canada*, p. 393.

[2] Dawson's *Acadian Geology*, chaps. xxi. and xxii.

Carboniferous Limestone series	Yoredale group of shales and grits passing down into dark shales and limestones (*Goniatites, Aviculopecten, Posidonomya, Lingula, Discina*, etc.). Thick limestone in south and centre of England and Ireland, passing northwards into sandstones, shales, and coals (abundant corals, polyzoans, brachiopods, lamellibranchs, etc.). Lower Limestone Shale of south and centre of England (marine fossils like those of overlying limestone), passing northward into the Calciferous Sandstone group of Scotland (marine, estuarine, and terrestrial organisms).

In the article COAL (vol. vi. p. 47) an account has been given of the principal coal-fields of the world; likewise a diagram (p. 47) representing the chief subdivisions of the Carboniferous system in Britain, as the rocks are traced from north to south.

Base of the System.—In the south-west of England, and in South Wales, the Carboniferous system passes down conformably into the Old Red Sandstone. The passage beds consist of yellow, green, and reddish sandstones, of green, grey, red, blue, and variegated marls and shales, sometimes full of terrestrial plants. They are well exposed on the Pembrokeshire coasts, marine fossils being there found even among the argillaceous beds at the top of the Red Sandstone series. They occur with a thickness of about 500 feet in the gorge of the Avon near Bristol, but show less than half that depth about the Forest of Dean. At their base there lies a bone-bed containing abundant palatal teeth. Not far above this horizon plant-bearing strata are found. Hence these rocks bring before us a mingling of terrestrial and marine conditions. In Yorkshire, near Lowther Castle, Brough, and in Ravenstonedale, alternations of red sandstones, shales, and clays, containing *Stigmaria* and other plants, occur in the lower part of the Carboniferous Limestone. Along the eastern edge of the Silurian hills of the Lake district the Old Red Sandstone appears here and there, and passes up through a succession of red and grey sandstones, and green and red shales and marls, with plants, into the base of the Carboniferous Limestone.

It is in Scotland, however, that this peculiar type of the basement Carboniferous rocks is best seen. In that country the lowest subdivision of the Carboniferous system, known as the Calciferous Sandstones, consists of red, white, and yellow sandstones, blue, grey, green, and red marls or clays, blue and black shales, thin coals, seams of limestone and cement-stone, and abundant volcanic rocks. The red sandstones lie at the base, and pass down into the Upper Old Red Sandstone, in which, as has been already pointed out (*ante*, p. 305), true Upper Old Red Sandstone fishes are found, while there occur also bands of limestone full of true Carboniferous Limestone corals and brachiopods. Hence it is evident that the Carboniferous Limestone fauna had already appeared outside the British area before the close of the Old Red Sandstone period. It was when the peculiar geographical conditions which prevailed during that period finally ceased, and the sea began to spread over the ancient lakes and land of Britain, that the abundant Carboniferous fauna invaded the area. The Calciferous Sandstones of Scotland may therefore represent a portion of the Carboniferous Limestone of England.

Over the greater part of the south and centre of Scotland the lower red sandstones are surmounted by a series of contemporaneous volcanic rocks. Successive sheets of porphyrites and tuffs form long ranges of hills from Arran and Bute on the west to the mouth of the estuary of the Forth on the east, and from the Campsie Fells on the north to the heights of Liddesdale and the English border. These volcanic sheets sometimes reach a thickness of 1500 feet. That they belong to the Carboniferous system is shown by the occurrence of shales and sandstones (with Carboniferous plants) at their base. They show that the early part of the Carboniferous period in Scotland was marked by a prodigious volcanic activity, which, on its cessation, was followed by the prolonged subsidence required for the accumulation of the Carboniferous system. The rocks succeeding the volcanic zone are termed the cement-stone group. In Berwickshire and the west of Scotland they consist of thin-bedded white, yellow, and green sandstones, grey, green, blue, and red clays and shales, with thin bands of a pale argillaceous limestone or cement-stone. Seams of gypsum occasionally appear. These strata are, on the whole, singularly barren of organic remains. They seem to have been laid down with great slowness, and without disturbance, in enclosed basins, which were not well fitted for the support of animal life, though fragmentary plants serve to show that the adjoining slopes were covered with vegetation.

In the basin of the Firth of Forth, however, the group presents a different lithological aspect and is abundantly fossiliferous. It there usually consists of yellow, grey, and white sandstones, with blue and black shales, clay-ironstones, limestones, "cement-stones," and occasional seams of coal. The sandstones form excellent building stones, the city of Edinburgh having been built of them. Some of the shales are so bituminous as to yield, on distillation, from 30 to 40 gallons of crude petroleum to the ton of shale; they are consequently largely worked for the manufacture of mineral oils. The limestones are usually dull, yellow, and close grained, in seams seldom more than a few inches thick, and graduate by addition of carbonate of iron into cement-stone; but occasionally they swell out into thick lenticular masses like the well-known limestone of Burdie House, so long noted for its remarkable fossil fishes. This limestone appears to be mainly made up of the crowded cases of a small ostracod crustacean (*Leperditia Okeni*, var. *Scoto-Burdigalensis*). The coal-seams are few and commonly too thin to be workable, though one of them, known as the Houston coal, has been mined to some extent in Linlithgowshire. The fossils of the cement-stone group indicate an alternation of fresh or brackish water and marine conditions. They include numerous plants, of which the most abundant are *Sphenopteris affinis*, *Lepidodendron* (two or three species), *Lepidostrobus variabilis*, *Araucarioxylon*. Some of the shales near Edinburgh have afforded a few specimens of a true monocotyledon allied to the modern Pothos (*Pothocites Grantoni*). Ostracod crustaceans, chiefly the *Leperditia* above mentioned, crowd many of the shales. With these are usually associated abundant traces of the presence of fish, either in the form of coprolites or of scales, bones, plates, and teeth. The following are characteristic species: *Elonichthys striolatus*, *E. Robisoni*, *Rhadinichthys ornatissimus*, *Nematoptychius Greenockii*, *Eurynotus crenatus*, *Rhizodus Hibberti*, *Megalichthys* sp., *Gyracanthus tuberculatus*, *Ctenoptychius pectinatus*. At intervals throughout the group marine horizons occur, usually as shale bands marked by the presence of such distinctively Carboniferous Limestone species as *Spirorbis carbonarius*, *Discina nitida*, *Lingula squamiformis*, *Bellerophon decussatus*, and *Orthoceras cylindraceum*.

One of the most interesting features in the cement-stone group of the basin of the Firth of Forth is the prodigious number and variety of the associated volcanic masses, and the proofs which they exhibit that, at the time when that group of strata was accumulating, the region of shallow lagoons, islets, and coal-growths was dotted over with innumerable active volcanic vents. The eruptions continued into the time of the Carboniferous Limestone, but ceased before the deposition of the Millstone Grit. The lavas are chiefly varieties of basalt-rocks, sometimes coarsely crystalline and even granitoid in texture, and graduating through intermediate stages to true close-grained compact basalts, which neither externally nor in microscopic structure differ from basalt of Tertiary date.

The basement group of the Carboniferous system in Ireland is evidently a prolongation of the Scottish cement-stone group. In the south of this island, however, a very distinct and peculiar development of the Lower Carboniferous rocks is to be remarked. Between the top of the Old Red Sandstone and the base of the Carboniferous Limestone there occurs in the county of Cork an enormous mass (fully 5000 feet) of black and dark-grey shales, impure limestones, and grey and green grits and true cleaved slates. To these rocks the name of Carboniferous Slate was given by Griffith. They contain numerous Carboniferous Limestone species of brachiopods, echinoderms, etc., as well as traces of land-plants in the grit bands. Great though their thickness is in Cork, they rapidly change their lithological character, and diminish in mass as they are traced away from that district. In the almost incredibly short space of 15 miles, the whole of the 5000 feet of Carboniferous Slate of Bantry Bay have disappeared, and at Kenmare the Old Red Sandstone is followed immediately and conformably by the Limestone with its underlying shale. Mr. Jukes held that the Carboniferous Slate is the equivalent of part of the Devonian rocks of Devon and Cornwall.

Carboniferous Limestone.—The Lower Limestone shale is overlaid conformably by a thick mass of limestone, one of the most distinctive members of the British Carboniferous system. On referring to a geological map of England it will be seen that from Northumberland southwards to the low plains in the centre of England there runs a ridge of high ground, formed by a great anticline, along which the Carboniferous Limestone appears at intervals from underneath higher members of the system. In this northern Carboniferous area, of which the axis is known as the Pennine Chain, the limestone attains its maximum development. In one portion of the district it reaches a depth of 4000 feet, and yet its actual base is nowhere seen. This Pennine region appears to have been the area of maximum depression during the early part of the Carboniferous period in Britain. Traced towards the south-west, the limestone diminishes to sometimes not more than 500 feet in South Wales. Northwards, losing its character as a massive calcareous formation, it is split up by intercalations of sandstone, shale, coal, etc., until actual limestone becomes a very subordinate member of the series in central Scotland.

In the Carboniferous areas of the south-west of England and South Wales, the limits of the Carboniferous Limestone are well defined by the Limestone Shale below, and by the Farewell Rock or Millstone Grit above. In the Pennine area, however, the massive limestone is succeeded by a series of shales, limestones, and sandstones, known as the Yoredale group. These cover a large area and attain a great thickness. In North Staffordshire they are 2300 feet, which, added to the 4000 feet of limestone below, gives a depth of 6300 feet for the whole Carboniferous Limestone series of that region. In Lancashire the Yoredale rocks attain still more stupendous dimensions, Mr. Hull having found them to be no less than 4500 feet thick. Both the lower or main (Scaur) limestone and the Yoredale group pass northwards into sandstones and shales, with coal-seams, and diminish in thickness. It is not impossible, as already suggested, that the cement-stone group of the Calciferous Sandstones of Scotland may represent, not only the thin Lower Limestone shale, but also some of the older parts of the English Carboniferous Limestone.

Where typically developed, the Carboniferous Limestone is a massive, well-bedded limestone, chiefly light bluish-grey in color, varying from a compact homogeneous to a distinctly crystalline texture, and rising into ranges of hills, whence its original name, "Mountain Limestone." It contains occasional scattered irregular nodules and nodular beds of dark chert. It is abundantly fossiliferous. The fossils commonly stand out on weathered surfaces of the rock, but microscopic investigation shows that even those portions of the mass which appear most structureless consist of the crowded remains of marine organisms. The limestone may be regarded as derived entirely from the organic debris of a sea-floor. Diversities of color and lithological character occur, whereby the bedding of the thick calcareous mass can be distinctly seen. Here and there a more marked crystalline structure has been superinduced; but the most distinct examples of metamorphic change are those where the rock has been converted into what is termed "dun-stone." This alteration is frequent in the mining districts of Yorkshire and the neighboring counties. It consists in the dolomitization of the rock along either the lines of bedding or the joints. Thus changed, it becomes a yellowish or brown crystalline dolomite, which runs vertically through the mass of the limestone along some definite joint, in courses of 20 or 30 fathoms in width. Such a metamorphism must have been effected by water percolating along the line of the joint, and affecting the rock for some distance on either side. In Derbyshire sheets of contemporaneous lava, locally termed "toadstone," are interpolated in the Carboniferous Limestone.

The fauna of the Carboniferous Limestone of England is abundant and characteristic. Numerous foraminifers occur, *Saccamina Carteri* being often very characteristic. The corals are numerous, embracing upwards of 30 genera and about 100 species. These include both simple cup corals, as *Zaphrentis*, *Clisiophyllum*, and compound forms, like *Alveolites* and *Phillipsastræa*. Crinoids are individually in enormous numbers, many beds of limestone appearing to consist of little else than their fragmentary stems and cups; *Actinocrinus*, *Platycrinus*, *Poteriocrinus*, *Cyathocrinus* are common genera. Three species of sea-urchins are known. Of the trilobites, so characteristic of the older Palæozoic rocks, the last lingering forms are here found in three small genera—*Brachymetopus*, *Phillipsia* and *Griffithides*. Polyzoa abound, some portions of the limestone being almost entirely composed of them, the genera *Fenestella*, *Sulcoretepora*, *Vincularia*, *Polypora*, *Diastopora*, and *Glauconome* being frequent. The brachiopods comprise 18 genera and 160 species, some of the most common forms being *Productus*, *Spirifer*, *Rhynchonella*, *Athyris*, *Chonetes*, *Orthis*, *Lingula*, and *Discina*. But the higher mollusks now begin to preponderate over the brachiopods. The lamellibranchs number 49 genera and 334 species, including forms of *Aviculopecten*, *Leda*, *Nucula*, *Sanguinolites*, *Leptodomus*, *Schizodus*, *Edmondia*, *Modiola*, and *Conocardium*. The gasteropods amount to 206 species belonging to 29 genera, among which *Euomphalus*, *Natica*, *Pleurotomaria*, *Macrocheilus*, and *Lexonema* are frequent. The genus *Bellerophon* is represented by 23 species, among which *B. Urei* and *B decussatus* are frequent. The cephalopods number 148 species belonging among other genera to *Orthoceras*, *Nautilus*, *Discites*, and *Goniatites*. About 100 genera of fishes, chiefly from teeth and spines, have been described, as *Psammodus*, *Cochliodus*, *Cladodus*, *Petalodus*, *Rhizodus*, *Ctenoptychius*, etc. Some of these were no doubt placoids which lived solely in the sea, but many, if not all of the ganoids, probably migrated between salt and fresh water; at least their remains are found in Scotland in strata full of land-plants, cyprids, and other indications of estuarine or fluviatile conditions.

The Carboniferous Limestone series of Scotland presents a striking contrast to that of the typical formation in England. It consists mainly of sandstones, shales, fire-clays, and coal-seams, with a few comparatively thin seams of encrinal limestone. Its lower portions include the chief limestone bands. The thickest of these seams, known as the Hurlet or main limestone, is usually about 6 feet in thickness, but in the north of Ayrshire swells out to 100 feet, which is the most massive bed of limestone in any part of the Scottish Carboniferous system. It lies upon a seam of coal, and is in some places associated with pyritous shales, which have been largely worked as a source of alum. This superposition of a bed of marine limestone on a seam of coal is of frequent occurrence in the Carboniferous Limestone series of Scotland. Above the group of Lower Limestones comes a thick mass of strata containing many valuable coal-seams and ironstones. Some of these strata are full of terrestrial plants (*Lepidodendron*, *Sigillaria*, *Stigmaria*, *Sphenopteris*, *Alethopteris*); others, particularly the ironstones, contain marine shells, such as *Lingula*, *Discina*, *Leda*, *Myalina*, *Euomphalus*. Numerous remains of fishes have been obtained, more especially from some of the ironstones and coals (*Gyracanthus formosus* and other placoid fin-spines, *Megalichthys Hibberti*, *Rhizodus Hibberti*, with species of *Elonichthys*, *Acanthodes*, *Ctenoptychius*, etc.). Remains of labyrinthodonts have also been found in this group of strata, and have been detected even down in the Burdie House limestone. The highest division of the Carboniferous Limestone series consists of a group of sandstones and shales, with a few coal-seams, and three, sometimes more, bands of marine limestone. Although these limestones are each seldom more than 3 or 4 feet thick, they have a wonderful persistence throughout the coal-fields of central Scotland. As already mentioned, they can be traced over an area of at least 1000 square miles, and they probably extended originally over a considerably greater region. The Hurlet limestone with its underlying coal can also be followed across a similar extent of country. Hence it is evident that during certain epochs of the Carboniferous period a singular uniformity of conditions prevailed over a large region of deposit in the centre of Scotland.

The difference between the lithological characters of the Carboniferous Limestone series, in its typical development, as a great marine formation, and in its arenaceous and argillaceous prolongation into the north of England and Scotland, has long been a familiar example of the nature and application of the evidence furnished by strata as to former geographical conditions. It shows that the deeper and clearer water of the Carboniferous sea spread over the site of Yorkshire, Derbyshire, and Lancashire; that the land lay to the north; and that, while the whole area was undergoing subsidence, the maximum movement took place over the area of deeper water. It was from the northern land that the sand and mud were derived, but the sediment during the time of the Carboniferous Limestone seems to have sunk to the bottom before it could reach the great basin in which foraminifers, corals, crinoids, and mollusks were building up the great calcareous deposit. Yet the thin limestone bands, which run so persistently among the Lower Carboniferous rocks in Scotland, prove that there were occasional episodes during which the sediment ceased to arrive, and when the same species of shells, corals, and crinoids, spread northwards towards the land, forming for a time over the sea-bottom a continuous sheet of calcareous ooze like that of the deeper water further south. These intervals of limestone growth no doubt point to times of more rapid submergence, perhaps also to other geographical changes whereby the sediment was for a time prevented from spreading so far.

Viewed as a whole, therefore, the Carboniferous Limestone series of Northumberland and Scotland contains the records of a long-continued but intermittent process of subsidence. The numerous coal-seams with their underclays were undoubtedly surfaces of vegetation that grew in rank luxuriance on the wide marine mud-flats, and mark pauses in the subsidence. Perhaps we may infer the relative length of these pauses by the comparative thicknesses of the coal-seams. The overlying and intervening sandstones and shales indicate a renewal of the downward movement, and the gradual infilling of the depressed area with sediment, until the water once more shoaled, and the vegetation from adjacent swamps spread over the muddy flats as before. The occasional limestones serve to indicate the epochs of more prolonged or more rapid subsidence, when marine life was enabled to flourish over the site of the submerged forests. But that the sea, even though tenanted in these northern parts by a limestone-making fauna, was not so clear and well suited for the development of animal life during some of these submergences as it was further south, seems to be proved by the paucity and dwarfed forms of the fossils in the thin limestones, as well as by the admixture of clay in the stone.

In Ireland the Carboniferous Limestone swells out to a vast thickness, and covers a large part of the island. It attains a maximum in the west and south-west, where, according to Kinahan,[1] it consists in Limerick of the following subdivisions:—

		Feet.
Upper (Burren) Limestone ...	Bedded limestone..............................	240
	Cherty zone..	20
Upper (Calp) Limestone ...	Limestones and shales........................	1000
	Cherty zone..	40
Lower Limestone...........	*Fenestella* limestone..........................	1900
	Lower cherty zone..............................	20
	Lower shaly limestones........................	280
Lower Limestone Shale		100
		3600

The chert bands which form such marked horizons among these limestones are counterparts of others found abundantly in the Carboniferous Limestone of England and Scotland. They have been recently studied by Hull and Hardman, who have found them full of siliceous replacements of calcareous foraminifers, crinoids, etc., and who regard them as due to a chemical alteration on the floor of the Carboniferous sea. Portions of the limestone have a dolomitic character, and sometimes are oolitic. Great sheets of melaphyre, felstone, and tuff, representing volcanic eruptions of contemporaneous date, are interpolated in the Carboniferous Limestone of Limerick and other parts of Ireland. As the limestone is traced northwards it shows a similar change to that which takes place in the north of England, becoming more and more split up with sandstone, shale, and coal-seams, until, at Ballycastle, it presents exactly the characters of the coal-bearing part of the formation in Scotland.

Millstone Grit.—This name is given to a group of sandstones and grits, with shales and clays, which runs persistently through the centre of the Carboniferous system from South Wales into the middle of Scotland. In South Wales it has a depth of 400 to 1000 feet; in the Bristol coal-field, of about 1200 feet. Traced northwards it is found to be intercalated with shales, fire-clays, and thin coals, and, like the lower members of the Carboniferous system, to swell out to enormous dimensions in the Pennine region. In North Staffordshire, according to Mr. Hull, it attains a thickness of 4000 feet, which in Lancashire increases to 5500 feet. These massive accumulations of sediment were deposited on the north side of a barrier of Silurian and Cambrian rocks, which, during all the earlier part of the Carboniferous period, seems to have extended across central England, and which was not submerged until part of the Coal-measures had been laid down. North of this great area of deposit the Millstone Grit thins away to not more than 400 or 500 feet. It continues a comparatively insignificant formation in Scotland, attaining its greatest thickness in Lanarkshire and Stirlingshire, where it is known as the Moor Rock. In Ayrshire it does not exist, unless its place be represented by a few beds of sandstone at the base of the Coal-measures.

The Millstone Grit is generally barren of fossils. When they occur they are either plants like those in the coal-bearing strata above and below, or marine organisms of Carboniferous Limestone species. In Northumberland, indeed, it contains a band of limestone undistinguishable from some of those in the Yoredale group and Scaur limestone.

Coal-Measures.—This division of the Carboniferous system consists of numerous alternations of grey, white, yellow, sometimes reddish sandstone, dark-grey and black shales, clay-ironstones, fire-clays, and coal-seams. In South Wales it attains a maximum depth of about 12,000 feet; in the Bristol coal-field it is 5090 feet. But in these districts as in the rest of the Carboniferous areas of Britain, we cannot be sure that all the Coal-measures originally deposited now remain, for they are always unconformably covered by later formations. In some localities, indeed, the denudation must have been very great, for the next overlying system of deposits (Permian) is found resting even on the Carboniferous Limestone. In North Staffordshire the depth of the Coal-measures is about 5000 feet, which in South Lancashire increases to 8000. These great masses of strata diminish as we trace them eastwards and northwards. In Derbyshire they are about 2500 feet thick, in Northumberland and Durham about 2000 feet, and about the same thickness on the west side of the island in the Whitehaven coal-field. In Scotland they attain a maximum of about 2000 feet.

The Coal-measures are susceptible of local subdivisions indicative of different and variable conditions of deposit. The following tables show the more important of these:—

GLAMORGANSHIRE.

Upper series, more than 3400 feet..................	Sandstones, shales, etc., with 26 coal-seams.
Pennant Grit, 3246 feet	Hard thick-bedded sandstones, etc., 15 coal-seams.
Lower series, 450 to 850 feet........................	Shales, ironstones, and 34 coal-seams.
	Millstone Grit.

SOUTH LANCASHIRE.

Upper, 1680 to 2000 feet	Shales, *Spirorbis* limestone, ironstone, sandstone, and thin coal-seams.
Middle, 3000 to 4000...	A great series of strata, with numerous valuable coals.
Lower or Gannister, 1400 to 2000 feet...............	Flags, shales, and three or four thin coals, with floors of "gannister."
	Millstone Grit.

CENTRAL SCOTLAND.

150 feet and upwards...	Red sandstones and clays, with occasional thin coals and *Spirorbis* limestones.
Upwards of 2000 feet in Lanarkshire..............	Sandstones, shales, and fire-clays, with ironstones and coals.
	Moor-rock or Millstone Grit.

The numerous beds of compressed vegetation form the most remarkable feature of the Coal-measures. Each of them is usually underlaid by a seam of fire-clay, representing the soil on which the plants grew. Hence they mark successive terrestrial surfaces, which, after enduring for a longer or shorter period, were carried down beneath the water and covered over with sand and silt. There is no modern formation that affords a close parallel to that of the ancient coal-growths. The nearest analogy is furnished by the mangrove swamps alluded to already on p. 257. These masses of arborescent vegetation grow out into the sea as a belt or fringe on low shores, and form a matted soil which adds to the breadth of the land. Their roots spread in the salt water where marine organisms are abundant. The coal-growths no doubt also flourished in salt or at least brackish water; for such shells as *Aviculopecten*, *Anthracosia*, and *Goniatites* are found lying on the coal or in the shales attached to it.

The vegetation of the Carboniferous period must have been luxuriant and varied. Upwards of 500 species of plants have been obtained from the Carboniferous rocks of Britain, yet these must represent but a small portion of the original flora.

The most abundant forms were ferns and lycopods. Numerous reed-like plants likewise played a conspicuous part in the general vegetation of the low grounds, while apparently on the drier and more elevated tracts (for their remains are less frequently met with) large coniferous trees flourished. The ferns strikingly resemble many modern forms. Among the more frequent genera were *Sphenopteris*, *Pecopteris*, *Alethopteris*, *Neuropteris*, and *Cyclopteris*. The lycopodiaceous plants attained the size of forest trees. Among the more typical forms were many species of *Lepidodendron*, the stems and seed-cones of which are scattered through the Carboniferous strata. Some of the coal-seams are largely composed of the spores of these plants. *Sigillaria*, regarded by some as allied to the cycads, by others as more akin to the lycopods, is represented by numerous species. The roots known as *Stigmaria* abound in most fire-clays, showing how largely the coal consists of trees having roots of this kind. The *Equisetaceæ* show themselves in the form of numerous *Calamites* which, though resembling in general aspect our modern horse-tails, differed in many points of structure, and notably in their gigantic size. Coniferous trees occur chiefly in the form of stems and branches. They include the genera *Dadoxylon*, *Araucarioxylon*, and *Pinites*. Small nut-like fruits (*Trigonocarpum*) abound in some beds, and are now believed to be the fruits of yew-like conifers. The presence of monocotyledonous plants is proved by the *Pothocites* referred to above (p. 307).

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[1] *Geology of Ireland*, p. 72.

The animal remains of the Coal-measures are comparatively few. In certain bands, particularly of ironstone, numerous mollusca occur, and similar forms are to be occasionally met with in the shales.

Among the more frequent species are *Anthracomya modiolaris*, *Anthracosia ovalis*, *A. robusta*, *A. acuta*, *Anthracoptera Browniana*, *Aviculopecten papyraceus*, and *Goniatites Listeri*. But at the top of the Middle Coal-measures, near Manchester, a band of true marine shells occurs, including *Ctenodonta*, *Nautilus*, *Discites*, *Goniatites*, and *Orthoceras*. The little *Spirorbis carbonarius* abounds in some shales. The crustaceans are chiefly represented by *Beyrichia* and *Estheria*, but large eurypterid forms likewise occur. Fishes occur frequently, remains of the larger kinds usually appearing as scales, teeth, fin-spines, or bones, while the smaller ganoids are often preserved entire. Common species are *Megalichthys Hibberti* (?), *Rhizodus granulatus*, *Cœlacanthus lepturus*, *Palæoniscus Egertoni*, *Pleuracanthus gibbosus*. The British Carboniferous rocks have yielded 13 genera of labyrinthodonts (*Anthracosaurus*, *Loxomma*, *Ophiderpeton*, *Pholiderpeton*, *Pteroplax*, *Urocordylus*, etc.). These were probably fluviatile animals of predaceous habits, living on fish, crustacea, and other organisms of the fresh or salt waters of the coal lagoons. The larger forms are believed to have measured 7 or 8 feet in length: some of the smaller examples, though adult and perfect, do not exceed as many inches.[1] That the woods of the Carboniferous period were not devoid of insect life is known from the discovery of some beetles and neuroptera at Coalbrookdale.

Continental Europe.—As in Britain so on the Continent the Carboniferous system occupies many detached areas or basins—the result partly of original deposition, partly of denudation, and partly of the spread and overlap of more recent formations. There can be no doubt that the English Carboniferous Limestone once extended continuously eastward across the north of France, along the base of the Ardennes, through Belgium, and across the present valley of the Rhine into Westphalia. From the western headlands of Ireland this calcareous formation can thus be traced eastward for a distance of 750 English miles into the heart of Europe. It then begins to pass into a series of shales and sandstones, which no doubt represent the same proximity to shore as the similar strata in the north of England and Scotland. In Silesia, and still much further eastwards in central and southern Russia, representatives of the Carboniferous Limestone appear, but interstratified, as in Scotland, with coal-bearing strata. Traces of the same blending of marine and terrestrial conditions are found also in the north of Spain. But over central France, and eastwards through Bohemia and Moravia into the region of the Carpathians, the coal-measures rest directly upon the older formations, most commonly upon gneiss and other crystalline rocks. It would appear that these tracts had remained above water during the time of the Carboniferous Limestone, but were gradually depressed during that of the Coal-measures.

In the north of France and Belgium the British type of the Carboniferous system is well shown. At the base lies a group of green, grey, and reddish shales and yellow sandstones, precisely similar in lithological character to parts of the Calciferous Sandstones of Scotland. They are well seen in some recent railway cuttings to the north of Boulogne, and also in the valley of the Meuse above Namur, lying upon the Psammites de Condroz or Upper Devonian beds. They are succeeded by the Carboniferous Limestone, which is subdivided into eight formations, having an aggregate thickness of 800 metres, and each characterized by its own assemblage of fossils. The horizon of the Millstone Grit is marked by the occurrence of certain alum-schists. The Coal-measures of this area have been referred to in the article Coal.[2]

The Saarbruck coal-field furnishes a good example of that type of the Carboniferous system where the lower marine series is absent. It lies unconformably on Devonian rocks, and attains a thickness of more than 10,000 feet. It is divided into the following groups of strata:—

2. Upper series, consisting at the top of red sandstones, below which come shales, sandstones, etc., with a few coal-seams—*Anthracosia*, *Estheria*.
1. Lower series, consisting of an upper group of red conglomerates, sandstones, clays, resting upon the great coal-bearing division. Abundant plants, with labyrinthodonts and insect remains.

Geinitz, drawing attention to the distribution of plants in the Saxon Coal-measures, remarks that a certain order can be observed in their appearance. He divides the strata accordingly into three zones, each marked by a characteristic assemblage of plants, and he believes that the classification can be applied in other countries.

3. The Fern Zone, marked by the profusion of its ferns (*Sphenopteris*, *Hymenophyllites*, *Schizopteris*, *Odontopteris*, *Neuropteris*, *Cyclopteris*, *Alethopteris*, *Caulopteris*). This is underlaid by
2. The Sigillaria Zone, containing many species of *Sigillaria*, also *Lepidodendron*, *Calamites*, *Asterophyllites*, and a few ferns.
1. The Lycopod Zone, abounding in *Sagenaria Veltheimiana*, with *Sphenopteris distans*, *Calamites transitionis*, etc.

The lowest of these zones (1) is compared by Geinitz with the Culm, that is, the sandy, shaly, and coal-bearing representative of the Carboniferous Limestone. To the east of the Rhine valley, as already mentioned, the true Carboniferous Limestone loses its normal character and assumes that of the Culm—a series of shales, sandstones, greywackes, and conglomerates, in which the abundant fauna of the limestone is reduced to a few mollusks (*Productus antiquus*, *P. latissimus*, *P. semireticulatus*, *Posidonomya Becheri*, *Goniatites sphæricus*, *Orthoceras striatulum*, etc.). The *Posidonomya* particularly characterizes certain dark shales known as Posidonia schists. About 50 species of plants have been obtained from the Culm, typical species being *Calamites transitionis*, *Sagenaria Veltheimiana*, *Stigmaria ficoides*, *Sphenopteris distans*, *Cyclopteris tenuifolia*. This flora bears a strong resemblance to that of the Calciferous Sandstones of Scotland.

North America.—Rocks corresponding in geological position and the general aspect of their organic contents with the Carboniferous system of Europe are said to cover an area of more than 200,000 square miles in the United States and British North America. The following table shows the subdivisions which have been established among them:—

Carboniferous.	Coal-measures,—a series of sandstones, shales, ironstones, coals, etc., varying from 100 feet in the interior continental area to 4000 feet in Pennsylvania, and more than 8000 feet in Nova Scotia. The plant remains include forms of *Lepidodendron*, *Sigillaria*, *Stigmaria*, *Calamites*, ferns, and coniferous leaves and fruits. The animal forms embrace in the marine bands species of *Spirifer*, *Productus*, *Bellerophon*, *Nautilus*, etc. Among the shales and carbonaceous beds numerous traces of insect life have been obtained, comprising species related to the may-fly and cockroach. Spiders, scorpions, centipedes, limuloid crabs, and land snails like the modern *Pupa* have also been met with. The fish remains comprise teeth and ichthyodorulites of placoid genera, and a number of ganoids (*Eurylepis*, *Cœlacanthus*, *Megalichthys*, *Rhizodus*, etc.). Several labyrinthodonts occur, and true reptiles are represented by one saurian genus found in Nova Scotia, the *Eosaurus*.
	Millstone Grit,—a group of arenaceous and sometimes conglomeratic strata, with occasional coal-seams, only 25 feet thick in some parts of New York, but swelling out to 1500 feet in Pennsylvania.

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[1] Miall, *Brit. Assoc. Rep.* 1873, p. 246.

[2] [In the article Coal, vol. vi. p. 53, the coal basin of Hardinghen is said to be of Carboniferous Limestone age. This, which appeared to be the most probable view of a very obscure point, has been proved to be a mistake, as the strata are actually Coal-measures inverted in position, the same disturbance being characteristic of the south side of the basin of the Pas-de-Calais for a considerable distance. This is now so generally recognized that borings for coal in that basin through the Tertiary and Cretaceous formations are not necessarily stopped on reaching Devonian strata, as coal-seams have been discovered vertically below the older strata at considerable depths, *e. g.*, at Auchy au Bois. In another pit, at Courrières,

Sub-Carboniferous.

Chester group.—Limestones, shales, and sandstones, sometimes 600 feet.

St. Louis group.—Limestones with shale, in places 250 feet.

Keokuk group.—Limestone with chert layers and nodules.

Burlington group.—Limestone, in places with chert and hornstone, 25 to 200 feet.

Kinderhook group.—Sandstones, shales, and thin limestones, 100 to 200 feet, resting on the Devonian black shale.

The sub-Carboniferous groups are mainly marine limestones, but contain here and there remains of the characteristic Carboniferous land vegetation. Crinoids of many forms abound in the limestones. A remarkable polyzoon, *Archimedes*, occurs in some of the bands. The brachiopods are chiefly represented by species of *Spirifer* and *Productus*; the lamellibranchs by *Myalina, Schizodus, Aviculopecten, Nucula, Pinna*, and others; the cephalopods by *Orthoceras, Nautilus, Goniatites, Gyroceras*, etc. The European genus of trilobite, *Phillipsia*, occurs. Numerous teeth and fin-spines of selachian fishes give a further point of resemblance to the European Carboniferous Limestone. Some of the rippled rain-pitted beds contain amphibian foot-prints—the earliest American forms yet known.

Permian.

Britain.—In England the Coal-measures are unconformably overlaid by a series of red sandstones, conglomerates, breccias, and marls, which at one time were grouped in one great formation as the New Red Sandstone, in contradistinction to the *Old* Red Sandstone lying below the Carboniferous system. They were likewise known as the Poikilitic series, from their mottled or variegated colors. They are now divided into two systems or groups of formations, the lower half being included in the Palæozoic series under the name of Permian (after Perm, a Russian province where they are well displayed), and the upper half being relegated to the Secondary series, and termed Trias.

The Permian system in England consists of the following subdivisions:—

		W. of England.	E. of England.
3. Upper..	Red sandstones, clays, and gypsum...........	600 ft.	50–100 ft.
2. Middle..	Magnesian limestone... Marl slate.................	10–30 "	600 "
1. Lower...	Red and variegated sandstone.............. Reddish-brown and purple sandstones and marls, with calcareous conglomerates and breccias of volcanic rocks.........	3000 "	100–250 "

From the thicknesses here given, it is evident that the Permian rocks have a very different development on the two sides of England. On the east side, from the coast of Northumberland southwards to the plains of the Trent, they consist chiefly of a great central mass of limestone. But on the west side of the Pennine Chain, and extending southwards into the central counties, the calcareous zone disappears, and we have a great accumulation of red, arenaceous, and gravelly rocks.

Lower.—This subdivision attains its greatest development in the vale of the Eden, where it consists of brick-red sandstones, with some beds of calcareous conglomerate of breccia, locally known as "brockram," derived from the waste of the Carboniferous Limestone. These red rocks extend across the Solway into the valleys of the Nith and Annan, in the south of Scotland, where they lie unconformably on the Lower Silurian rocks. Their breccias consist of fragments of the adjacent Silurian greywackes and shales, but near Dumfries some calcareous breccias or "brockrams" occur. These brecciated masses have evidently accumulated in small lakes or narrow fjords. Much further south, in Staffordshire, and in the districts of the Clent and Abberley Hills, the brecciated conglomerates in the Permian series attain a thickness of 400 feet. They have been shown by Ramsay to consist in large measure of volcanic rocks, grits, slates, and limestones, which can be identified with rocks on the borders of Wales. Some of the stones are 3 feet in diameter and show distinct striation. The same writer has pointed out that these Permian drift-beds cannot be distinguished by any essential character from modern glacial drifts, and he has no doubt that they were ice-borne, and, consequently, that there was a glacial period during the accumulation of the Lower Permian deposits of the centre of England.

Like red rocks in general the Lower Permian beds are almost barren of organic remains. Such as occur are indicative chiefly of terrestrial surfaces. Plant remains occasionally appear, such as *Caulerpites* (supposed to be of marine growth), *Lepidodendron dilatatum, Calamites, Sternbergia*, and fragments of coniferous wood. The cranium of a labyrinthodont (*Dasyceps*) has been obtained from the Lower Permian rocks at Kenilworth. Footprints referred to members of the same extinct order have been observed abundantly on the surfaces of the sandstones of Dumfriesshire, and also in the vale of the Eden.

Middle.—This subdivision is the chief repository of fossils in the Permian system. Its strata are not red, but consist of a lower zone of hard brown shale with occasional thin limestone bands (Marl Slate) and an upper thick mass of dolomite (Magnesian Limestone). The latter is the chief feature in the Permian development of the east of England. It corresponds with the Zechstein of Germany, as the Marl Slate does with the Kupfer-schiefer. It is a very variable rock in its lithological characters, being sometimes dull, earthy, fine-grained, and fossiliferous, in other places quite crystalline, and composed of globular, reniform, botryoidal, or other irregular concretions of crystalline and frequently internally radiated dolomite. Though the Magnesian Limestone runs as a thick persistent zone down the east of England it is represented on the Lancashire and Cheshire side by bright red and variegated sandstone covered by a thin group of red marls, with numerous thin courses of limestone, containing *Schizodus, Bakevellia*, and other characteristic fossils of the Magnesian Limestone.

The Middle Permian division has yielded about 100 species belonging to 46 genera of fossils—a singularly poor fauna when contrasted with that of the Carboniferous system below. The brachiopods (9 genera, 21 species) include *Productus horridus, Camarophoria multiplicata, C. Schlotheimii, Strophalosia Goldfussi, Lingula Credneri*, and *Terebratula elongata*. The lamellibranchs number 16 genera and 31 species, among which *Schizodus Schlotheimii, Bakevellia tumida, B. antiqua, B. ceratophaga, Mytilus squamosus*, and *Arca striata* are characteristic. The univalves are represented by 11 genera and 26 species, including *Pleurotomaria* and *Turbo* as common genera. Fishes have been obtained chiefly in the marl slate to the number of 21 species belonging to 8 genera, of which *Palæoniscus* is the chief. These small ganoids are closely related to some which haunted the lagoons of the Carboniferous period.

Upper.—Murchison and Harkness have classed as Upper Permian certain red sandstones with thin partings of red shale, and an underlying band of red and green marls and gypsum. These rocks, seen at St. Bees, near Whitehaven, resting on a magnesian limestone, have not yet yielded any fossils.

Continental Europe.—The two types of the Permian system presented by the east and west sides of England reappear in different areas on the mainland of Europe. The eastern or Durham type is found in enormous masses of strata flanking the Harz Mountains, also in Thuringia, in Saxony, and in Bohemia. The western or Salopian type is found over many thousands of square miles in the north and east of Russia.

The German geologists, recognizing the remarkable twofold character of its rocks, have called this system "Dyas," and have proposed to retain the term Permian to express the more simple type, such as is found in Russia and western England. They group the members of their Dyas as follows:—

Zechstein Group.

Anhydrite, gypsum, rock-salt, marl, dolomite, fetid shale, and limestone. The amorphous gypsum is the chief member of this group; the limestone is sometimes full of bitumen.

Crystalline granular (*Rauchwacke*) and fine sandy (*Asche*) dolomite (6 to 65 feet).

Zechstein, an argillaceous thin-bedded compact limestone 15 to 30 (sometimes even 90) feet thick.

Kupfer-schiefer—a black bituminous shale not more than about 2 feet thick.

Zechstein, conglomerate, and calcareous sandstone.

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the fact that the measures on the upper levels are inverted in position has been recently proved by the sinkings traversing the same seams in reverse order, *i. e.*, in their normal position in the lower workings. These facts have an important bearing on the question of the probable extension of the Coal-measures in the south-east of England. The discovery (in 1878) of Devonian strata at the moderate depth of 1400 feet in the centre of London, at Messrs. Meux's brewery, is another interesting fact that bears out the views previously put forward by Mr. Godwin Austen. (H. B.)]

Rothliegende Group.	Upper.—Conglomerates (quartz-porphyry conglomerate) and sandstone, with associated melaphyres and tuffs.
	Middle.—Red-clays, shales, and fine shaly sandstones, with bands of quartz-conglomerate and earthy limestone. Melaphyre and porphyrite masses intercalated.
	Lower.—Shaly sandstones, shales (with bituminous bands), and conglomerates.

The name "Rothliegende" or "Rothtodtliegende" (red-layer or red-dead-layer) was given by the miners because their ores disappeared in the red rocks below the copper-bearing Kupferschiefer. The coarse conglomerates have been referred by Ramsay to a glacial origin, like those of the Abberley Hills. One of the most interesting features of the formation is the evidence of the contemporaneous outpouring of great sheets of quartz-porphyry, granite porphyry, porphyrite, and melaphyre, with abundant interstratifications of various tuffs, not infrequently enclosing organic remains. From the very nature of its component materials, the Rothliegende is comparatively barren of fossils; a few ferns, calamites, and remains of coniferous trees are found in it, particularly towards the base, where indeed they form, in the Mansfeld district, a coal-seam about 5 feet thick.

The plants, all of terrestrial growth, on the whole resemble generically the Carboniferous flora, but seem to be nearly all specifically distinct. They include forms of *Calamites* (*C. gigas*), *Asterophyllites*, and ferns of the genera *Sphenopteris*, *Alethopteris*, *Neuropteris*, *Odontopteris*, with well-preserved silicified stems of tree ferns (*Psaronius*, *Tubicaulis*). The conifer *Walchia* (*W. piniformis*) is specially characteristic. Fish remains occur sparingly (*Amblypterus*, *Palæoniscus*, *Acanthodes*), and traces of labyrinthodonts (*Archegosaurus Decheni*) have been met with.

The Zechstein group is characterized by a suite of fossils like those of the Middle Permian of England. The Kupfer-schiefer contains numerous fish (*Palæoniscus Frieslebeni*, *Platysomus gibbosus*, etc.) and remains of plants (coniferous leaves and fruits and sea-weeds). This deposit is believed to have been laid down in some enclosed sea-basin, the waters of which, probably from the rise of mineral springs connected with some of the volcanic foci of the time, were so charged with metallic salts in solution as to become unfit for the continued existence of animal life. The dead fish, plants, etc., by their decay, gave rise to reduction and precipitation of these salts as sulphides, which thereupon enclosed and replaced the organic forms, and permeated the mud at the bottom. This old sea-floor is now the widely extended band of copper-slate which has so long and so extensively been worked along the flanks of the Harz. After the formation of the Kupfer-schiefer the area must have been once more covered by clearer water, for the Zechstein contains a number of organisms of which *Productus horridus*, *Spirifer undulatus*, *Strophalosia Goldfussi*, *Schizodus obscurus*, and *Fenestella retiformis* are common. Renewed unfavorable conditions are indicated by the dolomite, gypsum, and rock-salt which succeed. Professor Ramsay, reasoning upon such phenomena as developed in England, has connected them with the abundant labyrinthodont footprints and other evidences of shores and land, as well as the small number and dwarfed forms of the shells in the Magnesian Limestone, and has speculated on the occurrence of a long continental period in Europe, during one epoch of which a number of salt inland seas existed wherein the Permian rocks were accumulated. He compares these deposits to what may be supposed to be forming now in parts of the Caspian Sea.

North America.—The Permian system is hardly represented at all in this part of the globe. In Kansas certain red and green clays, sandstones, limestones, conglomerates, and beds of gypsum lie conformably on the Carboniferous system, and contain a few genera and species of molluscs (*Bakevellia*, *Myalina*, etc.), which occur in the European Permian rocks.

III. SECONDARY OR MESOZOIC.

Triassic.

It has been already mentioned that the great mass of red rocks, which in England overlie the Carboniferous system, were formerly classed together as New Red Sandstone, but are now ranged in two systems. We have considered the lower of these under the name of Permian. The general facies of organic remains in that division is still decidedly Palæozoic. Its brachiopods and its plants connect it with the Carboniferous rocks below. Hence it is placed at the close of the long series of Palæozoic formations. When, however, we enter the upper division of the red rocks, though the general lithological characters remain very much as in the lower group, the fossils bring before us the advent of the great Mesozoic flora and fauna. This group therefore is put at the base of the Mesozoic or Secondary series. It is called Trias, because in Germany it consists of three well-marked subdivisions. But the old name, New Red Sandstone, is familiarly retained for it by many geologists in England. The term Trias, like Dyas, is unfortunately chosen, for it elevates a mere local character into an importance which it does not deserve. The threefold subdivision, though so distinct in Germany, disappears elsewhere.

Great Britain.—Triassic rocks occupy a large area of the low plains in the centre of England, ranging thence northwards along the flanks of the Carboniferous tracts to Lancaster Bay, and southwards by the head of the Bristol Channel to the south-east coast of Devonshire. They have been arranged in the following subdivisions:—

Rhætic......	Penarth beds.—Red, green, and grey marls, and "White Lias."
Upper Trias or Keuper.	New Red Marl.—Red and grey shales and marls, with beds of rock-salt and gypsum (*Estheria* and *Foraminifera*).
	Lower Keuper Sandstone.—Thinly laminated micaceous sandstones and marls (waterstones) passing downwards into white, brown, or reddish sandstones, with a base of calcareous conglomerate or breccia.
Middle..........	Wanting in England (Muschelkalk of Germany).
Lower Trias or Bunter.	Upper Mottled Sandstone.—Soft bright-red and variegated sandstones, without pebbles.
	Pebble beds.—Harder reddish-brown sandstones with quartzose pebbles, passing into conglomerate; with a base of calcareous breccia.
	Lower Mottled Sandstone.—Soft bright-red and variegated sandstone, without pebbles.

Like the Permian red rocks below, the sandstones and marls of the Triassic series are almost barren of organic remains. Hence the subdivisions in the foregoing table are based on mineral characters, and could not therefore be relied on as a guide in districts outside of the English area. Indeed, extraordinary differences in the development of the different members of the series occur, even within that area, as may be seen from the subjoined table, which shows the variations in thickness from north-west to south-east:—

		Lancashire and W. Cheshire.	Staffordshire.	Leicestershire and Warwickshire.
		Feet.	Feet.	Feet.
Keuper.	Red marl........................	3000	800	700
	Lower Keuper sandstone	450	200	150
Bunter.	Upper mottled sandstone.	500	50–200	absent
	Pebble beds......................	500–750	100–300	0–100
	Lower mottled sandstone.	200–500	0–100	absent

Hence we observe that, while towards the north-west the Triassic rocks attain a maximum depth of 5200 feet, they rapidly come down to a fifth or a sixth of that thickness as they pass towards the south-east. Recent borings in the south-eastern counties show that the Triassic rocks are there absent altogether. It is evident that the source of supply of the sediment lay towards the north. This is further borne out by the character of the pebble-beds. These are coarsest towards the north, and, besides local materials, contain abundant rolled pebbles of quartz which have evidently been derived from some previous conglomerate, probably from some of the Old Red Sandstone masses now removed or concealed. The Trias everywhere rests unconformably on the rocks underneath it, so that, although the general physical conditions as regards climate, geography, and sedimentation, which prevailed in the Permian period still continued, great terrestrial movements had, in the mean while, taken place, whereby the Permian sediments were upraised and exposed to denudation. Hence the Trias rests now on Permian, now on Carboniferous, and sometimes even on Cambrian rocks. Moreover, the upper parts of the Triassic series overlap the lower, so that the Keuper groups come to rest directly on Permian or Carboniferous rocks.

One of the most interesting features in the English Trias is the occurrence of beds of rock-salt which have long been profitably worked. The uppermost subdivision of the Keuper, consisting of red marls, has a wide distribution, for it can be traced from the coast of Lancashire to the Bristol Channel, and covers a larger area of surface in the central counties than the rest of the Trias and the whole of the Permian sandstones combined. Even as far south as the coast of Devonshire, it contains casts of the cubical spaces once occupied by crystals of common salt. But in Cheshire the salt occurs in two or more beds, of which the lower is sometimes upwards of 100 feet thick. It is a crystalline substance, usually tinged yellow or red from intermixture of clay and peroxide of iron, but is tolerably pure in the best part of the beds, where the proportion of chloride of sodium is as much as 98 per cent. Through the bright red marls with which the salt is interstratified there run bands of gypsum, somewhat irregular in their mode of occurrence, sometimes reaching a thickness of 40 feet and upwards. Thin seams of rock-salt likewise occur among the red marls. These facts point to the concentration and evaporation of salt lakes or inland seas.

The organic remains of the Trias are comparatively few, as the conditions for at least animal life must have been extremely unfavorable in the waters of the ancient Dead Sea wherein these red rocks were accumulated. The land possessed a vegetation which from the few fragments yet known, seems to have consisted in large measure of cypress-like coniferous trees (*Voltzia, Walchia*), with calamites on the lower more marshy grounds. The red marl group contains in some of its layers numerous valves of the little crustacean *Estheria minuta*, and a solitary species of lamellibranch, *Pullastra arenicola*. A number of teeth, spines, and sometimes entire skeletons of fish have been obtained (*Dipteronotus cyphus, Palæoniscus superstes, Hybodus Keuperi, Acrodus minimus, Sphenonchus minimus, Lophodus*, etc.). The bones, and still more frequently the footprints, of labyrinthodont and even of saurian reptiles occur in the Keuper beds—*Labyrinthodon* (4 species), *Cladyodon Lloydii, Hyperodapedon, Palæosaurus, Teratosaurus, Thecodontosaurus, Rhyncosaurus*, and footprints of *Cheirotherium*. The remains of a small marsupial (*Microlestes*) have likewise been discovered.

Rhætic.—At the top of the Red Marl certain thin-bedded strata form a gradation upwards into the base of the Jurassic system. As their colors are grey and blue, and contrast with the red marls on which they repose conformably, they were formerly classed without hesitation in the Jurassic series. Egerton, however, showed that, from the character of their included fish remains, they had more palæontological affinity with the Trias than with the Lias. Subsequent research, particularly among the Rhætic Alps and elsewhere on the Continent, brought to light a great series of strata of intermediate characters between the Trias and Lias. These results led to renewed examination of the so-called beds of passage in England, which were found to be truly representative of the massive formations of the Tyrolese and Swiss Alps. They are therefore now classed as Rhætic, and considered as the uppermost member of the Trias, but offering evidence of the gradual approach of the physical geography and characteristic fauna and flora of the Jurassic period.

The Rhætic beds extend as a continuous though very thin band at the top of the Trias, from the coast of Yorkshire across England to Lyme Regis on the Dorsetshire shores. They occur in scattered patches even up as far as Carlisle, and westwards on both sides of the Bristol Channel. Their thickness, on the average, is probably not more than 50 feet, though it rarely increases to 150 feet. They consist of thin-bedded grey and dark shales and clays, with bands of light-colored limestone. One of their most important subdivisions is the so-called Bone-bed—a pyritous, micaceous, and occasionally rippled sandstone, sometimes in several bands, abounding in fish bones, teeth, coprolites, and other organic remains. The grey marly beds in the lower portion of the series have yielded remains of the *Microlestes Rhæticus*. Among the reptilian fossils are some precursors of the great forms which distinguished the Jurassic period (*Ichthyosaurus* and *Plesiosaurus*). The fishes included *Acrodus minimus, Ceratodus altus, Hybodus minor, Nemacanthus monilifer*, etc. Some of the lamellibranchs are specially characteristic; such are *Cardium Rhæticum, Avicula contorta, Pecten Valoniensis*, and *Pullastra arenicola*.

Professor Ramsay has drawn attention to the probable geographical changes recorded by the Triassic rocks of England. Connecting them with the earlier and similar Permian sandstones and marls he points out that the great Continental period which began with the Old Red Sandstone closed with the New Red Marl, and was characterized by the existence of great lakes, many of which must have been salt, and by the abundance of labyrinthodont life. The Triassic rocks were, doubtless, laid down in one of these salt lakes round the margins of which the labyrinthodonts left their footprints on the soft sand. In the Rhætic series we see how these inland basins were gradually invaded by the sea, which brought into the region of Britain the rich fauna of the Jurassic period.

CONTINENTAL EUROPE.—The Trias is the most compactly distributed of all the geological formations of Europe. Its main area extends as a great basin from Basel down to the plains of Hanover, traversed along its centre by the course of the Rhine, and stretching from the flanks of the old high grounds of Saxony and Bohemia on the east across the Vosges mountains into France. This must have been a great inland sea, out of which the Harz mountains, and the high grounds of the Eifel, Hundsruck, and Taunus probably rose as islands. It may have extended up to the base of the Alps, for enormous masses of Triassic rocks now form part of these mountains. Traces of what were probably other basins occur eastward in the Carpathian district, along the southern front of the Alps, in the west and south of France, and over the eastern half of the Spanish peninsula. But these areas have been considerably obscured, sometimes by dislocation and denudation, sometimes by the overlap of more recent formations.

In the great German Triassic basin the deposits are as shown in the subjoined table.

Keuper.	Upper or Rhætic.—Grey sandy clays and fine-grained sandstones, containing *Equisetum, Asplenites*, and cycads (*Zamites, Pterophyllum*), sometimes forming thin seams of coal—*Cardium Rhæticum, Avicula contorta, Estheria minuta, Nothosaurus, Termatosaurus, Belodon*, and *Microlestes antiquus*.
	Middle (Bunte Keupermergel, Gypskeuper) —Bright red and mottled marls, with beds of gypsum and rock-salt. In some places where sandstones appear they contain numerous plants (*Equisetum columnare, Tæniopteris vittata, Pterophyllum*, etc.), and labyrinthodont and fish remains. 300 to 1000 feet.
	Lower (Lettenkohle, Kohlenkeuper).—Grey sandstones and dark marls and clays, with abundant plants, sometimes forming thin seams of an earthy hardly workable coal (Lettenkohle). The plants include, besides those above mentioned, the conifers *Araucaroxylon Thuringicum, Voltzia heterophylla*, etc. Some of the shales are crowded with small ostracod crustacea (*Estheria minuta*). Remains of fish (*Ceratodus*) and of the *Mastodonsaurus Jægeri* have been obtained. About 230 feet.
Muschelkalk.	Upper limestone in thick beds with argillaceous partings. It abounds in organic remains among which *Ceratites nodosus, Nautilus bidorsatus, Lima striata, Myophoria vulgaris, Trigonodus Sandbergeri, Terebratula vulgaris*, and *Encrinus liliiformis* are especially characteristic. It is a thoroughly marine formation, sometimes almost wholly made up of crinoid stems. 200 to 400 feet
	Middle Limestone and Anhydrite, consisting of dolomites with anhydrite, gypsum, and rock-salt. Nearly devoid of organic remains, though bones and teeth of saurians have been found. 200 to 400 feet.
	Lower limestone, consisting of limestones and dolomites, but on the whole poor in fossils, save in the limestone bands, some of which are full of *Terebratula vulgaris* and *Encrinus liliiformis*. 160 to 500 feet.
Bunter.	Upper (Röth).—Red and green marls, with gypsum in the lower part. 250 to 300 feet.
	Middle.—Coarse-grained sandstones, sometimes incoherent, with wayboards of *Estheria* shale.
	Lower.—Fine reddish argillaceous sandstone, often micaceous and fissile, with occasional interstratifications of dolomite and of the marly oolitic limestone called "Rogenstein."
	The Bunter division is usually barren of organic remains. The plants already known include *Equisetum arenaceum*, one or two ferns, and a few conifers (*Albertia* and *Voltzia*). The lamellibranch *Myophoria costata* is found in the upper division all over Germany. Numerous footprints occur on the sandstones, and the bones of labyrinthodonts as well as of fish have been obtained.

The Trias attains an enormous development in the eastern Alps, where it bears evidence of having been accumulated under very different conditions from those of the Trias in Germany. The great thickness of its limestones, and their unequivocally marine organisms, show that it must have accumulated in opener water, which remained clear and comparatively free from inroads of sandy and muddy sediment. It possesses, moreover, a high interest as being a massive formation of marine origin formed between Permian and Jurassic times, and containing a remarkable blending of true Palæozoic organisms with others as characteristically Mesozoic. It is divided into two great series:—(1) Lower Trias, consisting of (*a*) Werfen Shales and Guttenstein Limestone, and (*b*) Virgloria Limestone or Alpine Muschelkalk; and (2) Upper Trias, a varied series of strata in three leading groups, having a united thickness sometimes of thousands of feet.

North America.—Rocks which are regarded as equivalent to the European Trias cover a large area in North America. On the Atlantic coast they are found on Prince Edward's Island, New Brunswick, and Nova Scotia, in Connecticut, New York, Pennsylvania, and North Carolina. Spreading over an enormous extent of the western territories, they cross the Rocky Mountains into California and British Columbia. They consist mainly of red sandstones, passing sometimes into conglomerates, and often including shales and impure limestones. On the Pacific slope they contain distinctly marine organisms, which include a mingling of such Palæozoic genera as *Spirifer*, *Orthoceras*, and *Goniatites*, with the characteristically Secondary genus *Ammonites*. In the centre and east of the continent they are marked by the occurrence of terrestrial plants, and in Connecticut by abundant footprints of land animals. The fossil plants present a general facies like that of the European Triassic flora, among them cycads, including some of the European species of *Pterophyllum*. Ferns (*Pecopteris*, *Neuropteris*, *Clathropteris*), calamites, and conifers are the predominant forms. The fauna is remarkable chiefly for the number and variety of its vertebrates. The labyrinthodonts are represented by footprints, from which upwards of fifty species have been described. Saurian footprints have likewise been recognized, but in a few cases their bones also have been found. These saurians had some bird-like characteristics, among others that of three-toed hind feet, which produced impressions exactly like those of birds. It is by no means certain, therefore, that what have been described as ornithichnites were not really made by dinosaurs. A small insectivorous marsupial (*Dromatherium*), found in the Trias of North Carolina, is the oldest American mammal yet known.

Jurassic.

The next great period of geological time is termed the Jurassic, from the Jura Mountains, where the deposits of that age are well developed. It was in England, however, that they were first studied by William Smith, in whose hands they were made to lay the foundations of stratigraphical geology. The names adopted by him for the subdivisions he traced across the country have passed into universal use, and though some of them are uncouth English provincial names, they are as familiar to the geologists of France, Switzerland, and Germany as to those of England.

The Jurassic formations stretch across England in a varying band from the mouth of the Tees to the coast of Dorsetshire. They consist of harder sandstones and limestones interstratified with softer clays and shales. Hence they give rise to a characteristic type of scenery,—the more durable beds standing out as long ridges, sometimes even with low cliffs, while the clays underlie the level spaces between. Arranged in descending order, the following subdivisions of the English Jurassic system are recognized:—

			Maximum thicknesses. Feet.
Upper or Portland Oolites.	Purbeck.	Upper fresh-water beds.... Middle marine beds......... Lower fresh-water beds....	360
	Portland.	Portland Stone	70
		Portland Sands	150
		Kimeridge Clay	600
Middle or Oxford Oolites.	Coralline Oolite.	Coral Rag and Calcareous Grit	250
	Oxford Clay.	Oxford clay and Kellaways Rock	600
Lower or Bath Oolites.	Great Oolite.	Cornbrash, Bradford Clay	40
		and Forest Marble (in Dorsetshire 450 ft.)	30
		Great or Bath Oolite with Stonesfield slate (part of Northampton Sand)	130
	Fuller's Earth.	Fuller's Earth group	150
	Inferior Oolite.	Cheltenham beds	270
		Midford Sands (and perhaps part of Northampton Sands), "Dogger" of Yorkshire	160
Lias.	Upper Lias		400
	Marlstone		200
	Lower Lias		900

Although these names appear in tabular order as expressive of what is the predominant or normal succession of the beds, considerable differences occur when the rocks are traced across the country. Thus the Forest Marble attains a thickness of 450 feet in Dorsetshire, but dwindles down to only 15 feet at Blenheim Park. The Inferior Oolite consists of marine limestones and shales in Gloucestershire, but chiefly of massive estuarine sandstones and shales in Yorkshire. These differences help to bring before us some of the geographical features of the British area during the Jurassic period.

The Lias consists of three formations, well marked by physical and palæontological characters. In the lower member numerous thin blue and brown limestones with partings of dark shale are surmounted by similar shales with occasional nodular limestone bands, the whole being divided into seven zones, each characterized by the presence of one or more distinctive species of ammonite. From this point of the geological series up to the close of the Mesozoic formations, the ammonites play a chief part among the mollusks. The Middle Lias, consisting of argillaceous limestones (marlstones) with micaceous sands and clays is divided into five ammonite zones. In its Yorkshire development this subdivision is remarkable for containing a bed of earthy carbonate of iron 15 to 20 feet thick, which has been extensively worked in the Cleveland district. The upper division is composed chiefly of clays and shales with nodules of limestones, among which three ammonite zones have been noted in Yorkshire.

The organic remains of the Lias comprise leaves and other remains of cycads (*Palæozamia*), conifers (*Pinites*, *Cupressus*, *Peuce*), ferns (*Otopteris*, *Alethopteris*, etc.), and reeds (*Equisetites*). These fossils serve to indicate the general character of the flora, which seems now to have been mainly cycadaceous and coniferous, and to have presented a great contrast to the lycopodiaceous vegetation of Palæozoic times. The occurrence of land-plants dispersedly throughout the English Lias shows also that the strata, though chiefly marine, were deposited within such short distance from shore as to receive from time to time leaves, seeds, fruits, twigs, and stems from the land. Further evidence in the same direction is supplied by the numerous insect remains, which have been obtained principally from the Lower Lias. These were no doubt blown off the land and fell into shallow water, where they were preserved in the silt on the bottom. The *Neuroptera* are numerous and include several species of *Libellula*. The coleopterous forms comprise a number of beetles. There were likewise representatives of the orthopterous, hemipterous, and dipterous orders. These relics of insect-life are so abundant in some of the calcareous bands that the latter are known as insect-beds. With them are associated remains of terrestrial plants, cyprids, and mollusks, sometimes marine, sometimes apparently brackish-water. The marine life of the period has been abundantly preserved, so far at least as regards the comparatively shallow and juxta-littoral waters in which the Liassic strata were accumulated. Corals, though on the whole scarce, abound on some horizons (*Isastræa*, *Montlivaltia*, *Septastræa*, etc.). The crinoids were represented by thick growths of *Extracrinus* and *Pentacrinus*. There were several kinds of starfishes, and also of sea-urchins (*Cidaris*, *Diadema*, *Acrosalenia*)—all generically distinct from those of the Palæozoic periods. The contrast between the Liassic crustacea and those of the older systems, as Phillips has pointed out, is very decided, the ancient trilobites having entirely disappeared, and having been succeeded by tribes of long-tailed ten-footed lobsters and prawns. There is a similar striking difference between the mollusks of the Lias and those of the Palæozoic rocks, bearing witness to the great biological changes which had taken place in the long interval. The brachiopods are chiefly species of *Rhynchonella* and *Terebratula*—genera which, though occurring in Palæozoic rocks, play there a comparatively subordinate part. They include the last *Spiriferi* and *Leptænæ*. Of the lamellibranchs, a few of the most characteristic genera are *Gryphæa*, *Lima*, *Pecten*, *Monotis*, *Cardinia*, *Hippopodium*, *Myacites*, and *Pholadomya*. Gasteropods, though usually rare in such muddy strata as the greater part of the Lias, occasionally occur, but most frequently in the calcareous zones. Altogether 89 species are at present known, the chief genera being *Pleurotomaria*, *Turbo*, *Eucyclus*, *Cerithium* and *Chemnitzia*. The cephalopods, however, are the most abundant and characteristic shells of the Lias; the family of the ammonites numbers in Yorkshire at least 113 species. As already stated, some species are so distinctive of special horizons that the whole of the Lias has been subdivided into zones, each denoted by the name of its characteristic ammonite. In ascending order, these zones are named as follows:—In the Lower Lias,—1st, *Ammonites planorbis*; 2d, *A. angulatus*; 3d, *A. Bucklandi*; 4th, *A. tuberculatus*; 5th, *A. obtusus*; 6th, *A. oxynotus*; 7th, *A. varicostatus*. In the Middle Lias,—1st, *A. Jamesoni* and *armatus*; 2d, *A. capricornus*; 3d, *A. margaritatus*; 4th, *A. spinatus*; 5th, *A. annulatus*. In the Upper Lias,—1st, *A. serpentinus*; 2d, *A. communis*; 3d, *A. jurensis*. The genus *Nautilus* is also present. The dibranchiate cephalopods are represented by upwards of 40 species of the genus *Belemnites*. Numerous species of fishes have been obtained from the Lias. Some of these are placoids, known only by their teeth (*Acrodus*, *Ceratodus*), others only by their spines (*Nemacanthus*), and some by both teeth and spines (*Hybodus*). The ganoids are frequently found entire, the genera *Dapedius*, *Pholidophorus*, *Æchmodus*, *Lepidotus*, *Pachycormus*, and *Leptolepis* being among the most frequent. But undoubtedly the most important palæontological feature of the Lias is the number and extraordinary interest of its reptilian remains. These include the extinct order of enaliosaurs or sea-lizards, uniting characters which are not found together in any living forms. Among these are the genus *Ichthyosaurus*, a creature with a fish-like body, two pairs of strong swimming-paddles, and probably a vertical tail-fin. The head, joined to the body without any distinct neck, was furnished with two large eyes, having a ring of bony plates round the eyeball, and with teeth that had no distinct sockets. Some of the skeletons of this creature exceed 24 feet in length. Contemporaneous with it was the *Plesiosaurus*, distinguished by its long neck, the larger size of its paddles, the smaller size of its head, and the insertion of its teeth in special sockets, as in the higher saurians. These creatures seem to have haunted the shallow seas of the Liassic time. There were also huge winged bat-like reptiles (*Dimorphodon*), with large heads, having teeth in distinct sockets, eyes like the *Ichthyosaurus*, and one finger of each fore-foot prolonged to a great length, for the purpose of supporting a membrane for flight. The bones, like those of birds, were hollow and air-filled. Gigantic deinosaurs were likewise among the inhabitants of Britain during Liassic time. These were true reptiles, yet with peculiarities of structure, particularly in the hinder part of the skeleton, linking them with birds like the ostrich. To this order belongs the *Megalosaurus* from the Lias of Lyme Regis. Lastly, the true crocodiles had representatives in the Liassic waters and shores, in the genera *Teleosaurus* and *Steneosaurus*.

The Lower or Bath Oolites lie conformably upon the top of the Lias, with which they are connected by a general similarity of organic remains. Out of the 312 known species in the Upper Lias, about 39 or 40 pass up into the overlying formation. The lowest of the three subdivisions of the English Oolites consists in the south-west and centre of England of shelly marine limestones, with clays and sandstones; but, as these strata are traced northwards into Northampton, Rutland, and Lincolnshire, they pass into a series of strata indicative of deposit in the estuary of some river descending from the north, for, instead of the abundant cephalopods of the truly marine and typical series, we meet with fresh-water genera such as *Cyrena* and *Unio*, with marine forms such as *Ostrea* and *Modiola*, thin seams of lignite, and remains of terrestrial plants.—These indications of the proximity of land become still more marked in Yorkshire, where the strata (800 feet thick) consist chiefly of sandstones, shales with seams of ironstone and coal, and occasional horizons containing marine shells. It is deserving of notice that the Cornbrash, which forms the top of the Lower Oolite in the typical Gloucestershire district, occurs likewise in the same position in Yorkshire. Though rarely more than 8 feet thick, it runs across the country from Devonshire to Yorkshire. Thus a distinctly defined series of beds of an estuarine character, exactly representative of the marine formations of the south-west, shows us that at the close of the Lower Oolitic period the estuary of the northern tract was submerged, and a continuous sea-floor stretched across the whole of the south-east of England.

Thanks to the deposits of the Yorkshire estuarine series our knowledge of the Oolitic is much more ample than of the Liassic flora. With the exception of a few littoral fucoids all the plants are of terrestrial forms. They comprise about 60 species of ferns, among which the genera *Pecopteris*, *Sphenopteris*, *Phlebopteris*, and *Tæniopteris* are characteristic. Next in abundance come the cycads, of which more than 20 species are known, belonging to the genera *Otozamites*, *Zamites*, *Pterophyllum*, and *Cycadites*. Coniferous remains are not infrequent in the form of stems or fragments of wood, as well as in occasional twigs with attached leaves; the genera *Araucarites*, *Brachyphyllum*, *Thuytes*, *Peuce*, *Walchia*, *Cryptomerites*, and *Taxites* have been recognized. The Inferior Oolite presents a tolerably copious suite of invertebrate remains, which resemble generically those of the Lias. The predominance of *Rhynchonella* and *Terebratula* over the rest of the brachiopods becomes still more marked. *Gryphæa*, *Lima*, *Pecten*, *Cardium*, *Myacites*, *Mytilus*, *Pholadomya*, *Trigonia* are frequent shells, while ammonites and belemnites also occur, though much more sparingly than in the Lias below, and in some of the later subdivisions of the Oolitic series. The Fuller's Earth, though well-marked in the Bath district, where it is about 200 feet thick, dies out in Oxfordshire, and contains only a few distinctive fossils, most of its forms being also found in the Inferior Oolite.

The Great or Bath Oolite consists, in Gloucestershire and Oxfordshire, of three groups of strata. At the base comes a series of thin-bedded limestones with sands, known as the Stonesfield Slate; in the centre lies a mass of shelly and yellow or cream-colored often Oolitic limestones, with partings of marl or clay—the Great Oolite; while at the top lies a set of clays and shelly limestones, including the Bradford Clay, Forest Marble, and Cornbrash. The Stonesfield Slate, the lowest of these three zones, is a local but exceedingly important subdivision, which has furnished a large number of reptilian and some mammalian remains. It must have been deposited in shallow water close to thickly wooded shores.

About a dozen species of ferns have been found in the Stonesfield Slate, the genera *Pecopteris*, *Sphenopteris*, and *Tæniopteris* being still the prevalent forms. The cycads are chiefly species of *Palæozamia*, the conifers of *Thuytes*. With these drifted fragments of a terrestrial vegetation there occur remains of beetles, dragon-flies, and other insects which had been blown or washed off the land. The waters were tenanted by a few brachiopods (*Rhynchonella* and *Terebratula*), by lamellibranchs (*Gervillia*, *Lima*, *Ostrea*, *Pecten*, *Astarte*, *Modiola*, *Trigonia*, etc.), by gasteropods (*Natica*, *Nerita*, *Patella*, *Trochus*, etc.), by a few ammonites and belemnites, and by placoid and ganoid fishes, of which about 50 species are known. The reptiles comprise representatives of turtles, with peculiar species of *Ichthyosaurus* and *Plesiosaurus*. The genus *Teleosaurus*, which occurs in the Yorkshire Lias, is among the organisms of the Stonesfield Slate. It was a true carnivorous crocodile, measuring about 18 feet in length, and is judged by Phillips to have been in the habit of venturing more freely to sea than the gavial of the Ganges and the crocodile of the Nile. The huge deinosaur *Megalosaurus* frequented the shores of the Stonesfield lagoons, walking probably on its massive hind legs, and feeding on the mollusks, fishes, and perhaps the small mammals of the district. It is estimated to have had a length of 25 feet, and to have weighed 2 or 3 tons. The flying reptiles were likewise represented by the *Rhamphorhynchus*,—a harpy-like creature which was able to fly, to shuffle on land, or perch on rocks, perhaps even to dive in search of its prey. But the most important organic remains of the Stonesfield Slate are undoubtedly its mammalia, of which three genera *Amphitherium*, *Phascolotherium*, and *Stereognathus* have been determined. Only portions of lower jaws have yet been found, pointing doubtless to the fact that, as the animals were drifted from land, the lower jaws, unprotected by outer skin, were separated in decomposition from the rest of the body. These interesting relics were the first traces of mammalian life found in strata of such high antiquity. They are regarded as having belonged to small marsupial animals, to which living analogues exist in Australia. In the Great Oolite the remains of a gigantic saurian *Ceteosaurus* have been found. According to Phillips it was probably, when standing, not less than 10 feet in height and 50 feet in length, a marsh-loving or river-side animal, living on the ferns, cycads, and conifers among which it dwelt.

In the Middle or Oxford Oolites, the Oxford Clay, so called from the name of the county through which it passes in its course from the coast of Dorsetshire to that of Yorkshire, consists mainly of layers of stiff blue and brown clay. In its lower portion lies a marked zone of calcareous abundantly fossiliferous sandstone, known from a place in Wiltshire, as the Kelaways Rock, which, after dying out in the midland counties, reappears on the Yorkshire coast. This zone contains about 150 species of fossils, of which nearly a half are found in lower parts of the Jurassic series, and about the same number pass upward into higher zones.

Among its characteristic forms is *Ammonites Calloviensis*. The Oxford clay, from the nature of its material and the conditions of its deposit, is deficient in some forms of life which were no doubt abundant in neighboring areas of clearer water. Thus there are hardly any corals, few echinoderms, polyzoa, or brachiopods. Some lamellibranchs are abundant, particularly *Gryphæa* and *Ostrea* (both forming sometimes wide oyster-beds), *Lima*, *Avicula*, *Pecten*, *Astarte*, *Trigonia*—the whole having a great similarity to the assemblages in the Lower Oolite formations. The gasteropods are not so numerous as in the calcareous beds below, but belong mostly to the same genera. The ammonites are numerous,—*A. Duncani*, *A. Jason*, *A. Lamberti*, and *A. occulatus* being characteristic. Of the belemnites, which also are frequent, *B. hastatus* is found all the way from Dorsetshire to Yorkshire. Spines and teeth of placoid fishes and entire specimens of *Lepidotus* are occasionally to be met with. The reptiles, besides *Ichthyosaurus*, *Megalosaurus*, *Plesiosaurus* (4 species), *Steneosaurus*, and *Rhamphorhynchus*, comprise also *Pleiosaurus*—a marine saurian with large head, short neck, paddles similar to those of Plesiosaurus, approaching the type of the ichthyosaurians, but even surpassing them in size.

The Coralline Oolite can likewise be traced, with local modifications and partial interruptions, across England from Yorkshire to Dorsetshire. It is named from its beds full of masses of coral. It consists of three zones—a lower calcareous grit, a central rubbly limestone with corals (the true "coral rag" of William Smith), and an upper calcareous grit, which, though feebly represented further south, attains importance in Yorkshire. It is frequently entirely made up of comminuted shells, urchins, corals, and other marine organisms. The corals include the genera *Isastræa, Thamnastræa,* and *Thecosmilia.* The urchins belong to *Cidaris, Hemicidaris, Pigurus, Pigaster,* and other genera. There are likewise *Ammonites, Belemnites,* and *Nautili.*

The Upper or Portland Oolites bring before us the closing epochs of the long Jurassic period in England, with the records of some of the physical revolutions which led to this change. At their base lies the Kimeridge Clay, so named from the locality on the coast of Dorsetshire where it is so well exhibited, and whence it is traceable continuously, save where covered by the Chalk, into Yorkshire. Like the Oxford Clay below, it is distinguished by its thickness, persistence, and peculiar organic remains.

Mollusca appear in greatly diminished variety; *Gryphæa virgula, Ostræa deltoidea, Astarte Hartwellensis,* and *Cardium striatulum* are characteristic species. The reptiles are the most important of the palæontological contents of this zone. They include remains of turtles, 5 species of *Ichthyosaurus*, 5 of *Pleiosaurus*, 8 of *Plesiosaurus, Ceteosaurus, Megalosaurus,* and the crocodilians *Steneosaurus, Teleosaurus,* and *Goniopholis.*

The Portland beds are so named from the isle of Portland, where they directly succeed the Kimeridge Clay. A feeble representative of them is believed to overlie that clay on the Yorkshire coast, but it is in the southern counties that they attain their chief development. They consist, at Portland, of a lower sandy set of beds about 150 feet thick, and of an upper calcareous zone (containing the well-known limestone so largely used for building purposes under the name of Portland stone) about 70 feet thick.

The fossils, which very commonly occur as mere empty casts, include as characteristic species *Isastræa oblonga, Cardium dissimile, Trigonia gibbosa,* and *Terebra Portlandica.* There occur also remains of some of the great Oolitic saurians.

The Purbeck beds, so named from the Isle of Purbeck, where they are best developed, are usually connected with the foregoing formations as the highest zone of the Jurassic series of England. But they are certainly separated from the rest of that series by many peculiarities, which show that they were accumulated at a time when the physical geography and the animal and vegetable life of the region were undergoing a remarkable change.

They have been arranged in three groups. The lowest consists of fresh-water limestones and clays, with layers of ancient soil containing stumps of the trees which grew in them. The middle group comprises about 130 feet of strata with marine fossils, while the highest division shows a return of fresh-water conditions. Among the indications of the presence of the sea is an oyster bed (*Ostrea distorta*) 12 feet thick, with *Pecten, Modiola, Avicula, Thracia,* etc. The fresh-water bands contain still living genera of lacustrine and fluviatile shells—*Paludina, Limnæa, Planorbis, Physa, Valvata, Unio,* and *Cyclas.* Numerous fishes, both placoid and ganoid, haunted these Purbeck waters. Many insects, blown off from the adjacent land, sank and were entombed and preserved in the calcareous mud. These include coleopterous, orthopterous, hemipterous, neuropterous, and dipterous forms. Remains of several reptiles, chiefly chelonian, but including the Jurassic crocodile *Goniopholis*, have also been discovered. But the most remarkable organic remains of the Purbeck beds are those of 10 genera and 25 species of marsupial mammals, from the size of a mole to that of a polecat. They are believed to have been mostly insectivorous. One of them (*Triconodon major*) is regarded by Owen as carnivorous, and probably about the size of the existing *Dasyurus maugei* of Australia. These mammalian remains occur, almost wholly as lower jaws, in a stratum about 5 inches thick lying near the base of the Middle Purbeck group.

Continental Europe.—Jurassic rocks cover a vast area in central Europe. They rise from under the Cretaceous formations in the north-east of France, whence they range southwards down the valleys of the Saone and Rhone to the Mediterranean. They appear as a broken border round the old crystalline nucleus of Auvergne. Eastwards they range through the Jura Mountains up to the high grounds of Bohemia. They appear in the outer chains of the Alps on both sides, and on the south they rise along the centre of the Apennines, and here and there over the Spanish peninsula. Covered by more recent formations they underlie the great plain of northern Germany, whence they range eastwards and occupy large tracts in central and eastern Russia. According to Neumayr, three distinct geographical regions of deposit can be made out among the Jurassic rocks of Europe. (1.) The Mediterranean province, embracing the Pyrenees, Alps, and Carpathians, with all the tracts lying to the south. One of the biological characters of this area was the great abundance of ammonites belonging to the groups of *Heterophylli* (*Phylloceras*) and *Fimbriati* (*Lytoceras*). (2.) The central European province, comprising the tracts lying to the north of the Alpine ridge, and marked by the comparative rarity of the ammonites just mentioned, which are replaced by others of the groups *Inflati* (*Aspidoceras*) and *Oppellia*, and by abundant reefs and masses of coral. (3.) The boreal or Russian province, comprising the middle and north of Russia, Spitzbergen, and Greenland. The life in this area was much less varied than in the others, showing that in Jurassic times there was a perceptible diminution of temperature towards the north. The ammonites of the more southern tracts here disappear, together with the corals.

In France the following arrangement has been made of the Jurassic rocks, the subdivisions nearly corresponding to those first proposed in England:—

(Purbeck beds not recognized.)
Terrain Portlandien (Calcaire tacheté de Boulogne).
" Kimeridgien (Argile de Honfleur).
" Corallien (Calcaire Corallien).
" Oxfordien (Oolithe de Trouville).
" Callovien (Argiles de Dives = Kelaways Rock).
" Bathonien (Oolithe de Caen = Cornbrash, Terre à foulon).
" Bajocien ou Oolithe Inférieure (Oolithe de Bayeux).
" Toarcien (Marnes Liasiques supérieure = Upper Lias).
" Liasien (Marnes et calcaires à Belemnites = Middle Lias).
" Sinémurien (Calcaire à Gryphées = Lower Lias).

In north-western Germany the subjoined classification has been adopted.

Upper or White Jura (Malm).		Purbeck group (Serpulit, Münder Mergel, and Eimbeckhäuser Plattenkalk).
		Kimeridge group (Upper, with *Ammonites gigas* and *Exogyra virgula*; Lower or Nerineen-Schichten).
		Oxford group (Upper, with *Cidaris florigemma*: Lower, with *Gryphæa dilatata*).
Middle or Brown Jura (Dogger).	Upper	Clays with *Ammonites ornatus.*
		Shales with *Amm. macrocephalus.*
		Cornbrash with *Avicula echinata, Amm. posterus.*
		Shales with *Ostrea Knorri, Amm. ferrugineus.*
		Zone of *Amm. Parkinsoni.*
	Middle	Coronaten-Schichten, clays with *Belemnites giganteus, Amm. Humphresianus, Amm. Braikenridgi.*
	Lower	Shales with *Inoceramus polyplocus, Amm. Murchisonæ.*
		Clays and limestones with *Amm. opalinus.*
Lower or Black Jura (Lias).	Upper	Grey marls with *Ammonites jurensis.*
		Bituminous shales (Posidonien-schiefer) with *Amm. lythensis, A. communis, A. bifrons, Posidonia Bronni.*
	Middle	Clays with *Amm. amalthea.*
		Marls and limestones with *Amm. capricornus.*
		Dark clays and ferruginous marls with *Amm. brevispina.*
	Lower	Clays with *Amm. planicosta.*
		Blue-grey clays with *Amm. Bucklandi* (Arieten-schichten).
		Dark clays with *Amm. angulatus.*
		Dark clays and sandy layers with *Amm. planorbis* (*psilonotus*).

North America.—So far as yet known rocks of Jurassic age play but a very subordinate part in North American geology. Perhaps some of the red strata of the Trias belong to this division, for it is difficult, owing to paucity of fossil evidence, to draw a satisfactory line between the two systems. Strata containing fossils believed to represent those of the European Jurassic series have been met with in recent years during the explorations in the western domains of the United States. They occur among some of the eastern ranges of the Rocky Mountains, as well as on the western side of the watershed. They have been recognized also far to the north beyond the great region of Azoic and Palæozoic rocks in the arctic portion of the continent. They consist of limestones and marls, which appear seldom to exceed a few hundred feet in thickness. The fossils include species of *Pentacrinus, Monotis, Trigonia, Lima, Ammonites*, and *Belemnites*.

CRETACEOUS.

The next great series of geological formations is termed the Cretaceous system, from the fact that in England and western Europe one of its most important members is a thick band of white chalk (*creta*).

BRITAIN.—The Purbeck beds bring before us evidence of a great change in the geography of England towards the close of the Jurassic period. They show how the floor of the sea in which the thick and varied formations of that period were deposited came to be gradually elevated, and how into pools of fresh and brackish water the leaves, insects, and small marsupials of the adjacent land were washed down.

These evidences of terrestrial conditions are followed in the same region by a vast delta-formation, that of the Weald, which accumulated over the south of England, while the older parts of the Cretaceous system were being deposited in the north. Hence there are two types of that system, one where the strata are fluviatile or estuarine, termed the Wealden type, the other where they are marine, known as the Neocomian type. Arranged in descending order the following are the subdivisions of the English Cretaceous rocks:—

Upper Cretaceous.	Chalk	Upper Chalk with flints... Lower Chalk without flints Chalk Marl (Grey Chalk) Chloritic Marl................	.........600 to 1200 ft.
	Upper Greensand	Greenish-grey sandstones and sands	40 " 150 "
	Gault	Stiff blue clay with calcareous and pyritous nodules......................	100 " 150 "

	Fluviatile Type.		Marine Type.		
Lower Cretaceous or Neocomian.	Weald Clay, 1000 ft. Hastings beds consisting of— Tunbridge Wells Sand (140–380 ft.); Wadhurst Clay (120–180 ft.); Ashdown Sand (400 or 500 ft.).	Upper.	Folkstone beds	Lower Greensand.	70 to 100 ft.
			Sandgate beds		75 " 100 "
			Hythe beds....		80 " 300 "
			Atherfield clay		20 " 60 "
			Upper part of Speeton Clay...		150 "
		Middle.	Punfield beds, Tealby beds, and middle part of Speeton Clay..............................		150 "
		Lower.	Lower part of Speeton Clay...		200 "

Lower Cretaceous or Neocomian.—The fluviatile development of this series in the south of England consists of a great depth of sands and clays known generally as the Wealden series, from the Weald of Sussex and Kent, where they are best displayed.

They precisely resemble the deposits of a delta, and this is borne out by their organic remains, which consist partly of terrestrial plants (*Equisetum, Sphenopteris, Alethopteris, Thuytes*, cycads, and conifers), and fresh-water shells (*Unio*, 10 species; *Cyrena*, 5 species; with *Cyclas, Paludina, Melania*, etc.), with a few estuarine or marine forms as *Ostrea* and *Mytilus*, and ganoid fishes (*Lepidotus*) like the gar of American rivers. Among the spoils of the land floated down by this river were the carcases of huge deinosaurian reptiles (*Iguanodon, Hylæosaurus, Megalosaurus*), of the long necked plesiosaurs, and of winged pterodactyles. The deltoid formation in which these remains occur extends in an east and west direction for at least 200 miles, and from north to south for at least 100. Hence the delta must have been not less than 20,000 square miles in area. It has been compared with that of the Quorra; in reality, however, its extent must have been greater than its present visible area, for it has suffered from denudation, and is to a large extent concealed under more recent formations. The river probably descended from the north-west, draining a vast area, of which the existing mountain groups of Britain are perhaps merely fragments.

The marine type of the Lower Cretaceous rocks is now commonly termed Neocomian, from Neufchâtel (*Neocomum*), where it is well developed. In the south of England only the upper division appears, overlying conformably the Wealden series, and showing the gradual depression of the old delta and the advance of the sea. In Yorkshire, however, a thick deposit known as the Speeton Clay has been ascertained by Mr. Judd to pass down into the Jurassic system, and to contain a representation of the upper parts of the Neocomian of the Continent.

The lower division of the Speeton Clay contains, among other fossils, *Ammonites Noricus*. The central zone is marked by *Pecten cinctus, Ancyloceras Duvallii*, and *Meyeria ornata*. The upper division is characterized by *Perna Mulleti, Ammonites Deshayesii, Pecten orbicularis*. It is the fossils of this upper division which occur in the Lower Greensand of Kent. They amount to about 300 species, of which only 18 or 20 per cent. pass up into the Upper Cretaceous. This marked palæontological break, taken in connection with traces of unconformability between the Lower Greensand and the Gault, shows that a definite geological boundary-line can be drawn between the lower and upper parts of the Cretaceous system.

Upper Cretaceous.—At the base of this series lies the Gault—a dark blue stiff clay or marl, sometimes sandy and calcareous. It overlaps the older parts of the Cretaceous series, and in Wiltshire lies on Kimeridge Clay. Among the characteristic fossils of this division are *Cyclocyathus Fittoni, Caryophilia Bowerbankii, Nucula pectinata, Inoceramus sulcatus, Natica Gaultina, Rostellaria carinata, Ammonites dentatus* and *Hamites attenuatus*. In all, about 200 species of fossils occur, of which about 46 per cent. pass up into the Upper Greensand.

The Gault is overlaid by a group of sands and sandstones often of a greenish tint from the presence of glauconite grains. Hence the name Upper Greensand which is applied to them. These strata can be traced westwards into Devonshire, and eastwards to the headlands of Kent, but they die out towards the north. Their mineralogical characters and variable thickness seem to point to them as deposits of the shore of the sea in which the chalk was subsequently laid down upon them.

Among their characteristic fossils are the sponges *Siphonia pyriformis* and *S. costata*; urchins of the genera *Cidaris, Echinus* and *Salenia*; numerous *Terebratulæ* and *Rhynchonellæ*; many lamellibranchs, particularly of the genera *Exogyra, Ostrea, Gryphæa, Lima, Pecten*, and *Trigonia*; and gasteropods of the genera *Natica, Turritella*, and others. The cephalopods abound and comprise many forms of *Ammonites* (40 species), *Hamites, Scaphites, Baculites, Nautilus*, and *Belemnites*.

Chalk.—This conspicuous member of the Cretaceous system has at its base a white or pale yellow marl with green grains of glauconite, phosphatic nodules, and iron pyrites (Chloritic Marl), which is succeeded sometimes by a kind of argillaceous chalk (Chalk Marl) forming the base of the true Chalk. It can be traced from Flamborough Head in Yorkshire across the south-eastern counties to the coast of Dorset. Throughout this long course its western edge usually rises somewhat abruptly from the plains as a long winding escarpment, which from a distance often reminds one of an old coast-line. The upper half of the Chalk is generally distinguished by the presence of many nodular layers of flint. With the exception of these enclosures, however, the whole formation is a remarkably pure white pulverulent dull limestone, meagre to the touch, and soiling the fingers. It is composed mainly of crumbled foraminifera, with the mingled debris of urchins, corals, and mollusks. It must have been accumulated in a sea of some depth and tolerably free from sediment, like some of the foraminiferal ooze of the existing sea-bed. There is, however, no evidence that the depth of the water at all approached that of the abysses in which the present Atlantic globigerina-ooze is being laid down. Indeed, the character of the foraminifera, and the variety and association of the other organic remains, are not like those which have been found to obtain now on the deep floor of the Atlantic.

Somewhere about 800 species of fossils are known from the English Chalk. Occasional rare fragments of terrestrial wood occur, perforated by the teredo, and telling of a transport of some distance from land. Sponges are numerous. They have usually been silicified and preserved in the flint nodules.

Among the more characteristic genera are *Choanites, Cliona, Ventriculites, Brachiolites, Spongia*, and *Siphonia*. Careful preparation of a fragment of chalk usually brings to light remains, sometimes well preserved, of foraminifera (*Rotalina ornata, Cristellaria rotulata, Globigerina bulloides*). Corals are represented by about 15 species (*Parasmilia, Cœlosmilia, Caryophyllia*, etc.). The *echini* form one of the most conspicuous features among the Chalk fossils, from their individual numbers and their variety of forms. Among the more common genera the following may be named—*Ananchytes, Echinoconus, (Galerites), Cardiaster, Micraster, Cyphosoma, Cidaris, Pseudodiadema, Discoidea*, and *Salenia*. Among other star-fishes the genus *Goniaster* occurs in numerous species in the upper division of the Chalk. The crinoids were represented in the sea of the period by a *Comatula*, one or two *Pentacrinites, Marsupites*, and *Bourgueticrinus*. Polyzoa abound in the Upper Chalk (*Homœosolen, Pustulopora, Holostoma*, etc.). The brachiopods appear in the form of great numbers of *Rhynchonella, Terebratula*, and *Terebratulina*, with *Crania, Thecidea*, and *Kingena*. Among the lamellibranchs the genera *Ostrea, Pecten, Inoceramus*, and *Lima* are particularly frequent. Gasteropods are comparatively few, *Pleurotomaria perspectiva* being one of the few forms found both in the lower and upper division of the Chalk. Cephalopods, however, abound; characteristic species are *Belemnitella plena, B. mucronata, Nautilus Deslongchampsianus, Ammonites navicularis, A. varians, A. Rothomagensis, Turrilites costatus, Baculites baculoides, Scaphites æqualis*, and *Hamites armatus*. Upwards of 80 species of fish have been discovered. These include chimæroids (*Edaphodon, Ischyodus*), sharks (*Hybodus, Ptychodus, Lamna, Otodus*), ganoids (*Macropoma, Pycnodus*), and teleosteous or bony fishes (*Beryx, Enchodus, Saurocephalus*). Numerous reptilian remains have been found, more particularly in a bed about 1 foot thick lying at the base of the Chalk of Cambridge, and largely worked for phosphate of lime derived from reptilian coprolites and bones. Among the known forms are several chelonians, the great deinosaur *Acanthopholis*, several species of *Plesiosaurus*, 5 or 6 species of *Ichthyosaurus*, 10 species of *Pterodactylus* from the size of a pigeon upwards, one of them having a spread of wing amounting perhaps to 25 feet, 3 species of *Mosasaurus*, a crocodilian (*Polyptychodon*), and some others. At Cambridge also the bones of one or two species of birds have been found, probably belonging to *Natatores* allied to the living gulls.

CONTINENTAL EUROPE.—The Cretaceous system in many detached areas covers a large extent of the Continent. From the south of England it spreads southward across the north of France up to the base of the ancient central plateau of that country. Eastwards it ranges beneath the Tertiary and post-Tertiary deposits of the great plain, appearing on the north side at the southern end of Scandinavia and in Denmark, on the south side in Belgium and Hanover, round the flanks of the Harz, in Bohemia and Poland, eastwards into Russia, where it covers many thousand square miles up to the southern end of the Ural chain. To the south of the central axis in France, it underlies the great basin of the Garonne, flanks the chain of the Pyrenees on both sides, spreads out largely over the eastern side of the Spanish table-land, and reappears on the west side of the crystalline axis of that region along the coast of Portugal. It is seen at intervals along the north and south fronts of the Alps, extending down the valley of the Rhone to the Mediterranean, ranging along the chain of the Apennines into Sicily and the north of Africa, and widening out from the eastern shores of the Adriatic through Greece, and along the northern base of the Balkans to the Black Sea, round the southern shores of which it ranges in its progress into Asia, where it again covers an enormous area.

A series of rocks covering so vast an extent of surface must needs present many differences of type, alike in their lithological characters and in their organic contents. They bring before us the records of a time when one continuous sea stretched over all the centre with most of the south of Europe, covered the north of Africa, and swept eastwards to the far east of Asia. There were doubtless many islands and ridges in this wide expanse of water, whereby its areas of deposit and biological provinces must have been more or less sharply defined. Some of these barriers can still be traced, as will be immediately pointed out.

The accompanying table contains the subdivisions of the Cretaceous system which have been adopted in a few of the more important areas of Continental Europe.

It will be seen from this table that while there is sufficient palæontological similarity to allow a general parallelism to be drawn among the Cretaceous rocks of western Europe, there are yet strongly marked differences pointing to very distinct conditions of life, and probably, in many cases, to disconnected areas of deposit. Nowhere can these contrasts be more strikingly seen than in crossing from the Cretaceous basin of the Loire to that of the Garonne. In the north of France the Upper Cretaceous beds are precisely like those of England, the soft white Chalk forming a conspicuous feature in both countries; but, on the south side of the great axis of crystalline rocks, the soft chalk is replaced by hard limestones. There is a prevalence of calcareous matter, often sparry, throughout the whole series of formations, with comparatively few sandy or clayey beds. This mass of limestone attains its greatest development in the southern part of the department of the Dordogne, where it is said to be about 800 feet thick. But the lithological differences are not greater than those of the fossils. In the north of France, Belgium, and England, the singular molluscan family of the *Hippuritidæ* or *Rudistes* appears only occasionally and sporadically in the Cretaceous rocks, as if a stray individual had from time to time found its way into the region, but without being able to establish a colony there. In the south of France, however, the hippurites occur in prodigious quantity. They often mainly compose the limestones, hence called hippurite limestones (Rudisten-Kalke). They attained a great size, and seem to have grown on immense banks like our modern oyster. They appear in successive species on the different stages of the Cretaceous system, and can be used for marking palæontological horizons, as the cephalopods are elsewhere. But while these lamellibranchs played so important a part throughout the Cretaceous period in the south of France, the numerous ammonites and belemnites, so characteristic of the Chalk in England, were absent from that region. This very distinctive type of hippurite limestone has so much wider an extension than the English type of the Cretaceous system that it should be regarded as really the normal development. It ranges through the Alps into Dalmatia, and round the great Mediterranean basin far into Asia. Gümble has proposed to group the European Cretaceous rocks into three great regions:—(1) the northern province, or area of white chalk with *Belemnitella*, comprising England, northern France, Belgium, Denmark, Westphalia; (2) the Hercynian province, or area of *Exogyra columba*, embracing Bohemia, Moravia, Saxony, Silesia, and central Bavaria; and (3) the southern province, or

Table showing the Subdivisions of the Cretaceous System in the West of Europe.

	England.		Northern France.	North-West Germany and Denmark.		Southern France.
Senonian.			Danien, Craie supérieure et calcaire pisolitique (p.319).	Faxoe chalk. Maestricht chalk (p. 319).		
	Upper Chalk with flints.		Craie blanche (*Belemnitella mucronata*). Craie (*Belemnitella quadratas*).	Oberquadersandstein (*Belemnitella mucronata*, etc.).		Calcaires à rudistes (*Radiolites*).
	Lower Chalk without flints.		Craie (*Micraster cor-anguinum*).	Oberquadersandstein (*Micraster cor-anguinum*).		
Turonian.	Chalk Marl.		Craie marneuse.	Mittelquader, Mittelpläner (*Inoceramus Cuvieri* and *I. labiatus*).		Calcaires à *Hippurites cornu-vaccinum*, et à *Radiolites cornu-pastoris*.
	Chloritic Marl.		Craie glauconieuse.			Calcaires marneux (*Inoceramus labiatus*).
Cenomanian.	Upper Greensand.		Grès vert supérieur.	Unterquader, Unterpläner (*Ammonites Rotomagensis, A. varians*).		Calcaires à *Caprotina triangularis*, et à *Ammonites Rotomagensis*.
Gault.			Albien, argile marneuse ou sableuse.	Flammenmergel (*Avicula gryphæoides*). Clay (*Belemnites minimus*).		Albien, sables et grès verts ou ferrugineux à *Turrilites*.
	Gault.		Aptien, argiles à plicatules.	Marls, etc.: (*Ammonites tardefurcatus, Belemnites Ewaldi*). Clays (*Belemnites Brunsvicensis*).		Aptien (*Orbitulina lenticularis*). Calcaire à caprotines.
			Urgonien.	*Ancyloceras* beds.		
Neocomian or Hils.	Lower Greensand.		Argiles ostréennes (*Exogyra subplicata. Ostrea Leymerii*).	Hils clay (Hilsthon) with *Ammonites Noricus*, etc.		Néocomien supérieur (*Toxoceras complanatus*), calcaire à *Spatangus*.
	Weald Clay and Hastings Sand.	Punfield and Tealby beds and middle part of Speeton Clay.	Calcaires néocomiens et marnes bleues (*Toxaster complanatus*).	Hils conglomerate (*Toxoceras complanatus, Rhynchonella depressa*).	Weald clay (*Melania, Cyrena*).	Néocomien moyen, calcaire à *Aptychus*.
		Lower part of Speeton Clay.	Sable blanc et ferrugineux.		Deister-sandstein with coal seams.	Néocomien inférieur (*Toxoceras Campechei*).

area of hippurites, including the regions south of the crystalline axis of France, the Alps, and southern Europe.

The Wealden beds, with the Hasting Sands and Weald Clay, are found in north-west Germany. They contain abundant remains of terrestial vegetation, which is sometimes aggregated into thin seams of black glancing coal, occasionally even as much as 6½ feet thick. The marine or typical Neocomian series attains a great development among the eastern Alps, where it consists mainly of massive white and grey limestones, divided into zones according to their characteristic fossils. Some geologists place in it a part of the massive Vienna sandstone (Wiener Sandstein) which enters so largely into the structure of the outer Alps. The massive arenaceous formation formerly massed together under the general name of Quader-sandstein, but now found to be the equivalent of the calcareous bands of other regions, and capable of subdivision into the chief normal groups, forms a conspicuous feature in Saxony and Bohemia, as in the great gorge of the Elbe and the picturesque crags and pinnacles of Saxon Switzerland. From the Upper Cretaceous beds, in the neighborhood of Aix-la-Chapelle, consisting of white sands and laminated clays 400 feet thick, a large number of terrestrial plants have been obtained. The number of species is estimated at more than 400. Of these 70 or 80 are cryptogams, chiefly ferns (*Gleichenia, Lygodium, Asplenium*, etc.); there are numerous conifers (some akin to *Sequoia*), and three or four kinds of screw-pine (*Pandanus*). This flora has a much more modern aspect than any other yet found in Secondary formations. But its most important feature is the occurrence of numerous true exogenous plants—the earliest yet found in Europe. The prevalent forms are *Proteaceæ*, many of them being referred to genera still living in Australia or at the Cape of Good Hope. There occur also species of oak, bog-myrtle, etc. These interesting fragments serve to indicate the modern character of the flora of Europe towards the close of the Cretaceous period, and to show that the climate, doubtless greatly warmer than that which now prevails, nourished a vegetation like that of some parts of Australia or the Cape. Further information has been afforded regarding the extension of this flora by the discovery in North Greenland of a remarkable series of fossil plants. From certain Lower Cretaceous beds of that Arctic region, Heer has described 30 species of ferns, 9 cycads, and 17 conifers; while, from the Upper Cretaceous rocks of Noursoak, he enumerates species of poplar, fig, sassafras, credneria, and magnolia.

NORTH AMERICA.—The recent surveys of the western territories of the United States have greatly increased our knowledge of the Cretaceous system on the American continent, where it is now known to cover a vast expanse of surface, and to reach a thickness of sometimes 10,000 feet. Sparingly developed in the eastern States, from New Jersey into South Carolina, it spreads out over a wide area in the south, stretching round the end of the long Palæozoic ridge from Georgia through Alabama and Tennessee to the Ohio; and reappearing from under the Tertiary formations on the west side of the Mississippi over a large space in Texas and the south-west. Its maximum development is reached in the western States and Territories of the Rocky Mountain region—Wyoming, Utah, and Colorado. Cretaceous rocks have likewise been detected in Arctic America near the mouth of the Mackenzie River.

Much controversy has been carried on among American geologists regarding the upper limit of the Cretaceous system, some maintaining, from the character of the plants and of the shells, that the great plant-bearing series termed the Lignitic is of Tertiary age, others insisting, from the occurrence of true Cretaceous shells in and above the Lignitic series, that it must belong to the Cretaceous system. In the Upper Missouri region Hayden and Meek established the following subdivisions:—

5.	Fox Hills group.—Sandstones and sandy clays (*Belemnitella, Nautilus, Ammonites, Baculites, Mosasaurus*, etc.)	500 ft.
4.	Fort Pierre group.—Plastic clays (*Ammonites, Scaphites, Inoceramus*, etc.)	700 "
3.	Niobrara group.—Calcareous marl (*Ostrea congesta, Inoceramus problematicus*, fish remains)	200 "
2.	Fort Benton group.—Clays and limestones (*Scaphites, Ammonites, Pholadomya*, etc.)	800 "
1.	Dakotah group.—Sandstones, clays, and seams of lignite, with vast numbers of dicotyledonous leaves; a few marine shells. This is the great repository of the Cretaceous flora	400 "

American Cretaceous fossils include the earliest dicotyledonous plants yet found on this continent, upwards of 100 species having been found, of which one-half were allied to living American forms. Among them are species of oak, willow, poplar, beech, maple, hickory, fig, tulip-tree, sassafras, sequoia, American palm (*Sabal*), and cycads. The more characteristic mollusca are species of *Terebratula, Ostrea, Gryphæa, Inoceramus, Hippurites, Radiolites, Ammonites, Scaphites, Hamites, Baculites, Belemnites, Ancyloceras*, and *Turrilites*. Of the fishes of the Cretaceous seas 97 species are known, comprising large predaceous representatives of modern or osseous types like the salmon and saury, though cestracionts and ganoids still flourished. But the most remarkable feature in the American Cretaceous fauna, as at present known, is the great number, variety, and size of the reptiles. According to the enumeration of Cope, who includes, however, in his list the Lignitic group here placed among the Tertiary formations, there are known at present 18 species of deinosaurs, 4 pterosaurs, 14 crocodilians, 13 sauropterygians or sea-saurians, 48 testudinates (turtles, etc.), and 50 pythonomorphs or sea-serpents. One of the most extraordinary of these reptilian forms was the *Elasmosaurus*—a huge snake-like form 40 feet long, with slim arrow-shaped head on a swan-like neck rising 20 feet out of the water. This formidable sea-monster "probably often swam many feet below the surface, raising the head to the distant air for a breath, then withdrawing it and exploring the depths 40 feet below without altering the position of its body. It must have wandered far from land, and that many kinds of fishes formed its food is shown by the teeth and scales found in the position of its stomach" (Cope). But the real rulers of the American Cretaceous waters were the pythonomorphic saurians or sea-serpents. Some of them attained a length of 75 feet or more. They possessed a remarkable elongation of form, particularly in the tail; their heads were large, flat, and conic, with eyes directed partly upwards. They swam by means of two pairs of paddles, like the flippers of the whale, and the eel-like strokes of their flattened tail. Like snakes they had four rows of formidable teeth on the roof of the mouth, which served as weapons for seizing their prey. But the most remarkable feature in these creatures was the unique arrangement for permitting them to swallow their prey entire, in the manner of snakes. Each half of the lower jaw was articulated at a point nearly midway between the ear and the chin, so as greatly to widen the space between the jaws, and the throat must, consequently, have been loose and baggy like a pelican's. Nine species of birds have been obtained from the American Cretaceous rocks. Three of these belonged to the order of Natatores or swimmers, which includes our modern gulls, ducks, and geese; four were *Grallæ* or waders; while two belonged to a long extinct order, and united certain ichthyic and reptilian characters with those of birds. (See Cope, *Report of U. S. Geol. Surv. of Territories*, vol. ii., 1875; Marsh, *American Journ. Science*, 3d ser., i. to iv.; Leidy, *Smithsonian Contributions*, 1865, No. 192; Lesquereux, *Cretaceous Flora, Report of U. S. Geol. Surv. of Territories*, vol. vi.)

IV. TERTIARY OR CAINOZOIC.

The close of the Secondary periods was marked in the west of Europe by great geographical changes, during which the floor of the Cretaceous sea was raised partly into land and partly into shallow marine and estuarine waters. These events must have occupied a vast period of time, so that, when sedimentation once more began in the region, the organic remains of the Secondary ages had (save in a few low forms of life) entirely disappeared and given place to others of a distinctly more modern type. In England, the interval between the Cretaceous and the next geological period represented there by sedimentary formations is marked by the abrupt line which separates the top of the Chalk from all later accumulations, and by the evidence that the Chalk seems to have been in some places extensively denuded before even the oldest of what are called the Tertiary beds were deposited upon its surface. There is evidently here a considerable gap in the geological record. We have no data for ascertaining what was the general march of events in the south of England between the eras chronicled respectively by the Upper Chalk and the overlying Thanet beds.

Here and there on the Continent a few scraps of evidence are obtainable which help to fill up this gap. Thus, on the banks of the Meuse at Maestricht, a series of shelly and polyzoan limestones with a conglomeratic base (*Système Maestrichtien* of Dumont, who places it above his Senonian system in the Upper Cretaceous series) contains a mingling of true Cretaceous organisms with others which are characteristic of the older Tertiary formations. It contains, for example, the characteristic Upper Chalk crinoid, *Bourgeticrinus ellipticus*, in great numbers; also *Ostrea vesicularis, Baculites Faujasii, Belemnitella mucronata*, and the great reptile *Mosasaurus*; but with these occur such Tertiary genera as *Voluta, Fasciolaria*, and others. At Faxoe, on the Danish island of Seeland, the uppermost member of the

Senonian series contains in like manner a blending of well-known Upper Chalk organisms with the Tertiary genera *Cypræa*, *Oliva*, and *Mitra*. In the neighborhood of Paris also, and in scattered patches over the north of France, a formation known as the pisolitic limestone occurs, which was formerly classed with the Tertiary formations, seeing that its fossils had more affinities with later than with older rocks. But the discovery in it of numerous distinctively Upper Cretaceous forms has led to its being placed at the top of the Senonian series, from which, however, it is marked off by a decided unconformability, for it rests on a denuded surface of the White Chalk. These fragmentary formations are interesting, in so far as they help to show that, though in western Europe there is a tolerably abrupt separation between Cretaceous and Tertiary deposits, there was nevertheless no real break between the two periods. The one merged insensibly into the other; but the chronicles of the intervening ages have been in great measure destroyed.

In entering upon the Tertiary series of formations, we find ourselves upon the threshold of the modern type of life. The ages of lycopods, ferns, cycads, and yew-like conifers have passed away, and that of the dicotyledonous angiosperms—the hard-wood trees and evergreens of to-day—now succeeds them, but not by any sudden extinction and re-creation, for, as we have seen (*ante*, p. 319), some of these trees had already begun to make their appearance even in Cretaceous times. The ammonites, baculites, and other cephalopods, which had played so large a part in the molluscan life of the Secondary periods, now cease. The great reptiles, too, which in such wonderful variety of type were the dominant animals of the earth's surface, alike on land and sea, ever since the commencement of the Lias, now wane before the increase of the mammalia, which advance in ever-augmenting diversity of type until man appears at their head.

The name Tertiary, given in the early days of geology before much was known regarding fossils and their history, has retained its hold on the literature of the science. It is sometimes replaced by the term Cainozoic (*recent life*), which expresses the great fact that it is in the series of strata comprised under this designation that most recent species and genera have their earliest representatives. Taking as the basis of classification the percentage of living species of mollusca found in the different groups of the Tertiary series, Lyell proposed a scheme of arrangement which has been generally adopted. The older Tertiary formations, in which the number of still living species of shells is very small, where, in fact, we seem to see as it were the first beginnings of the modern life, he named *Eocene* (*dawn of the recent*), including under that title those parts of the Tertiary series of the London and Paris basins wherein the proportion of existing species of shells was only 3½ per cent. The middle Tertiary beds in the valleys of the Loire, Garonne, and Dordogne, containing 17 per cent. of living species, were termed *Miocene* (*less recent*). The younger Tertiary formations of Italy were included under the designation *Pliocene* (*more recent*), because they contained a majority or from 35 to 95 per cent. of living species. This newest series, however, was further subdivided into Older Pliocene (35 to 50 per cent. of living species) and Newer Pliocene (90 to 95 per cent.). This classification, with various modifications and amplifications, has been adopted for the Tertiary group not of Europe only but of the whole globe.

As the North American development of the Tertiary series differs in so many respects from that of Europe, it will be most conveniently considered by itself after the European classification has been described.

EOCENE.

GREAT BRITAIN.—The Eocene rocks of Britain are entirely confined to the south-east of the island, where they occupy two great depressions of the chalk, known respectively as the London and Hampshire basins. They have been arranged into the groups shown in the subjoined table.

Upper	Upper fresh-water and estuarine series.	Hempstead beds	170 ft.
		Bembridge "	115 "
		Osborne "	70 "
		Headon "	200 "
Middle...	Middle marine series.	Upper Bagshot Sand	250 to 300 ft.
		Middle Bagshot beds, including Barton Clay (300 feet) and Bracklesham beds (100 feet).	
		Lower Bagshot beds	100 " 150 "
		London Clay	50 " 500 "
Lower	Lower fresh-water, estuarine, and marine series.	Oldhaven beds	20 " 30 "
		Woolwich and Reading beds	15 " 163 "
		Thanet Sand	20 " 60 "

Grouped in relation to the physical changes which they record, these strata naturally stand in three divisions. At the base lies a series of beds laid down in fresh, estuarine, and sea-water, on an upraised denuded surface of Chalk. Then comes a central group bearing witness to the deepening of these shallow waters, and to the advance of the sea far up the former estuary. The upper group brings before us proof of the eventual retreat of the sea, and the conversion of the area once more into fresh-water lakes and rivers. This arrangement does not quite tally with that which is based on a comparison of the fossils with existing forms, and with those of other Tertiary districts, for it places the London Clay in the middle series, though the fossil evidence distinctly shows that formation to belong to the older Eocene groups.

Lower Eocene.—The Thanet Sand at the base of the London Tertiary basin consists of pale yellow and greenish sand, sometimes clayey, and containing at its bottom a layer of green-coated flints resting directly on the Chalk. According to Mr. Whitaker, it is doubtful if any proof of actual erosion of the chalk can anywhere be seen under the Tertiary deposits in England, and he states that the Thanet Sands everywhere lie upon an even surface of chalk with no visible unconformability. Professor Philips, on the other hand, describes the chalk at Reading as having been "literally ground down to a plain or undulated surface, as it is this day on some parts of the Yorkshire coast," and having likewise been abundantly bored by lithodomous shells. The fossils of the Thanet Sand comprise about 70 known species (all marine, except a few fragments of terrestrial vegetation). Among them are several foraminifera, numerous lamellibranchs (*Astarte tenera*, *Cyprina Morrisii*, *Ostrea Bellovacina*, etc.), a few species of gasteropods (*Natica subdepressa*, *Aporrhais Sowerbii*, etc.), a nautilus, and the teeth or palatal bones of fishes (*Lamna*, *Pisodus*).

The Woolwich and Reading beds, or Plastic Clay of the older geologists, consist of lenticular sheets of plastic clay, loam, sand, and pebble beds. The organic remains show that the sea of the Thanet Sand era gradually shallowed into an estuary. They amount to more than 100 species, and include a few plants of terrestrial growth such as *Ficus Forbesi*, *Grevillea Heeri*, and *Laurus Hookeri*. The lamellibranchs are partly estuarine or fresh-water (*Cyclas*, *Cyrena*, *Dreissena*, *Unio*), partly marine. Of the latter a characteristic species is *Ostrea Bellovacina*, which forms a thick oyster bed at the base of the series. *Ostrea tenera* is likewise abundant. The gasteropods include a similar mixture of marine with fluviatile species (*Cerithium funatum*, *Melania inquinata*, *Natica subdepressa*, *Fusus latus*, *Paludina lenta*, etc.). The fish are chiefly sharks (*Lamna*). Bones of turtles and scutes of crocodiles have been found. The highest organisms are bones of mammalia, one of which, the *Coryphodon*, was allied to the modern tapir.

The Oldhaven beds forming the base of the London Clay, though of trifling thickness, have yielded upwards of 150 species of fossils. Traces of *Ficus*, *Cinnamomum*, and *Coniferæ* have been obtained from them; but the organisms are chiefly marine and partly estuarine shells, the gasteropods being particularly abundant. The London Clay, as its name implies, is a mass of clay, stiff, brown, or bluish-grey, with septarian nodules. It extends through both the London and Hampshire basins, attaining a maximum thickness in the south of Essex. It has yielded a long and varied suite of organic remains, from which we can see that it must have been laid down in the sea beyond the mouth of a large estuary, into which abundant relics of the vegetation, and even sometimes of the fauna of the adjacent land were swept. Its fossils are mainly marine mollusca, and, taken in connection with the flora, indicate that the climate was somewhat tropical in character. The plants include the fruits or other remains of palms (*Nipadites*), custard-apple, acacia, gourds, melons, *Proteaceæ*, and *Coniferæ*. Crustacea abound (*Xanthopsis, Hoploparia*). Gasteropods are the prevalent mollusks, the common genera being *Pleurotoma* (45 species), *Fusus* (15 species), *Cypræa, Murex, Cassidaria, Pyrula*, and *Voluta*. The cephalopods are represented by 6 or more species of *Nautilus*, by *Belosepia sepioidea*, and *Beloptera Levesquei*. Nearly 100 species of fishes occur in this formation, the rays (*Myliobates*, 14 species) and sharks (*Lamna, Otodus*, etc.) being specially numerous. A swordfish (*Tetrapterus priscus*), and a saw-fish (*Pristis bisulcatus*) about 10 feet long, have been described by Agassiz from the London Clay of Sheppey, whence almost the whole of the fish remains have been obtained. The reptiles were numerous, but markedly unlike, as a whole, to those of Secondary times. Among them are numerous turtles and tortoises, two species of crocodile, and a sea-snake (*Palæophis*), estimated to have been 13 feet long. Remains of birds have also been met with; one of these (*Lithornis vulturinus*) appears to have been allied to the vulture, another (*Halcyornis toliapicus*) to our modern king-fisher, besides waders and other types. The mammals numbered among their species a hog (*Hyracotherium*), several tapirs (*Coryphodon*, etc.), an opossum (*Didelphys*), and a bat. The carcases of these animals must have been borne seawards by the great river which transported so much of the vegetation of the neighboring land.

Middle.—The Bagshot group consists of sand and bands of clay which, in the Hampshire basin, are tolerably fossiliferous. As developed in the Isle of Wight and at Bournemouth, their lower members have yielded a large number of terrestrial plants, among which the *Proteaceæ* are still numerous, together with species of fig, cinnamon, fan-palm (*Sabal*), oak, yew, cypress, laurel, lime, senna, and many more. Crocodilian forms still haunted the waters, and have left their bones with those of sea-snakes and turtles and of the tapirs and other denizens of the land, which still, as in the time of the London Clay, continued to be washed out to sea. Among these strata we now find one of the most typical organisms of the Eocene rocks of the Mediterranean basin, a foraminifer termed *Nummulites* (*N. lævigata, N. scabra, N. variolaria*). Characteristic fossils are *Voluta athleta, V. luctatrix, Murex asper, Fusus longævus, Cardita planicosta*, and *Chama squamosa*.

Upper.—The strata of this division of the English Eocene formations are entirely confined to Hampshire and the Isle of Wight. They consist of sands, clays, marls, and limestones, in thin-bedded alternations. These strata were accumulated partly in the sea, partly in brackish, and partly in fresh water. They were hence named by Edward Forbes the fluvio-marine series. Among the Marine fossils are—*Fusus porrectus, Oliva Branderi, Natica labellata, Ostrea callifera*, and *Nummulites lævigata*. The genera *Cerithium, Potamomya, Paludina, Planorbis, Limnæa*, and *Cyclas* are abundant, showing the brackish and fresh-water conditions in which many of the strata were deposited. Remains of turtles, snakes, crocodiles, and alligators continue to occur in these Upper Eocene beds. With these are found the bones of several very characteristic mammals also met with in the Paris basin,—the three-toed *Palæotherium*, resembling the living tapir; *Anoplotherium*, a more graceful animal with long tail, and two-toed feet, forming a kind of intermediate type between a hog and a deer or antelope; *Dichobune*, allied to the last named; also *Dichodon, Hyopotamus, Chœropotamus, Hyænodon*, etc. The top of the Eocene series in the Isle of Wight has been removed by denudation, so that we have no evidence in Britain of what took place after the close of the Eocene period.

Continental Europe.—Geologists on the continent of Europe, finding it impossible to carry out the principle of percentage of recent species, as originally formulated by Lyell in his terminology of the Tertiary series, have made various modifications of this nomenclature. By some the three terms Eocene, Miocene, and Pliocene are retained, but, following Beyrich, they subdivide the Miocene into two, keeping that term for the upper half and calling the lower Oligocene, which corresponds with Lyell's Lower Miocene. Others would consider the whole Tertiary and post-Tertiary series as divisible into three groups, the Eocene or Older Tertiary, corresponding pretty closely to the Lyellian use of the term, the Neogene or Younger Tertiary, embracing both Miocene and Pliocene, and the Diluvial and Alluvial.

In the Paris basin the Eocene formations assume a somewhat different type from that which they present in England, though the occurrence of a number of the same species of fossils in both allows of their being paralleled in a general way. The lower Eocene consists there of sand and clay answering in lithological character to the Thanet Sand and Plastic Clay of the London basin. The common species in that basin (*Ostrea Bellovacina*) occurs there in great numbers, while the brackish water-beds contain some of the common species at Woolwich, such as *Cyrena cuneiformis* and *Melania inquinata*. Beds of lignite occur in this division, likewise bones of *Coryphodon Eocænus, Viverra gigantea*, and the bird *Gastornis*. The Middle Eocene is made up of the characteristic "Calcaire grossier"—a mass of limestone, sometimes tender and crumbling, in other places so compact as to be largely quarried as a building stone. Some portions are entirely composed of minute foraminifera (miliolitic limestone). Among the characteristic fossils of this division are *Nummulites, Cerithium giganteum*, with bones of *Dichobune, Lophiodon, Paloplotherium*, etc. The Upper Eocene consists of sand (Sables moyens) overlaid by the great gypsum and gypseous marl group of Montmartre. This is the deposit from which so many of the mammals of the Eocene period have been recovered. It is divided into three zones, and among its fossils are upwards of 50 species of quadrupeds, including many Palæotheres, Anoplotheres, Paloplotheres, with *Xiphodon, Dichobune, Adapis, Chæropotamus, Myoxus, Canis Parisiensis, Viverra Parisiensis, Vespertilio, Didelphys Cuvieri*, and about 17 species of birds.

The Eocene formations of the north-west of Europe occupy but a few detached basins, and consist for the most part of soft clays, sands, marls, and thin limestones. They were laid down partly in estuaries, rivers, or lakes, partly in shallow seas near land. They contain abundantly the vegetation, with some remains of the quadrupeds and birds, of that land, and show that still in older Tertiary times, as during the long Palæozoic and Secondary ages, the chief area of land lay to the north-west. But when we turn to the corresponding formations in central and southern Europe, they present a totally different aspect. In the first place, they at once impress us with the idea of their antiquity, for they consist chiefly of massive, hard, crystalline, and sometimes even marble-like limestones, which suggest some of the Palæozoic rocks rather than those of so modern a date as the London Clay and Calcaire Grossier. Again, instead of being confined to a few local basins, they cover an enormous geographical area and play a notable part in the structure of some of the great mountain chains of the globe. Crowded as they are with nummulites, they must have been deposited not in estuaries and shallow bays but in a wide and clear sea, which, traced by the area of those limestones, must have ranged across the whole of the south of Europe and north of Africa, through Greece, Turkey, Asia Minor, and the heart of Asia, to the far shores of China and Japan. Since the time when this wide channel connected the Atlantic and the Pacific across the heart of the Old World, the great mountain ranges of the Pyrenees, Alps, Apennines, Carpathians, and of Central Asia, have been upheaved to their present altitude. Some of the prominent peaks along their flanks consist of the hardened and crumpled calcareous mud of the Eocene sea.

In the northern and southern Alps the Eocene formations consist of nummulitic limestone—a grey, yellow, sometimes reddish compact rock, usually containing and often made up of nummulites; nummulite sandstone; Vienna sandstone—an enormous mass of arenaceous rock almost destitute of organic remains, and referred partly to the Cretaceous and partly to the Eocene series; and Flysch—a massive development of dark shales or schists, sandstones, and argillaceous limestone, sometimes charged with the remains of fucoids and (at Matt, Glarus) of fish. The nummulitic series of southern Europe is divided into zones characterized by fossils, and brought into a kind of broad parallelism with the subdivisions of the English and French Eocene basins. In the eastern Alps, near Vienna and elsewhere, some of the nummulitic sandstones contain enormous blocks of granite, gneiss, and other crystalline rocks, which are believed to have been ice-borne, and therefore to prove the existence of Alpine glaciers even in Eocene times. These mountains already existed, as it were, in embryo, even far back in the Secondary and Palæozoic ages. During the later part of the Eocene period they seem to have been clothed with an abundant flora, among which the fan-palm, *Banksia, Dryandria*, and other plants remind one of the living vegetation of tropical America, the East Indies, and Australia. Out of these plants the important coal-seams of Häring in Tyrol were formed.

Miocene.

According to the original nomenclature proposed by Lyell, this subdivision of the Tertiary series was meant to include those strata in which 17 per cent. or thereabouts of the shells belong to still living species. As the system of nomenclature was adopted at a time when our knowledge both of living and fossil species was still very defective, it could not but require modification with the progress of science. Some strata, classed at one time as Miocene from their proportion of recent forms, might, on more extended research, prove to contain a much larger percentage, and therefore to be referable to a later part of the Tertiary series. The term, however, is used as a convenient and long-established designation for a series of strata younger than the Eocene, which they seem to have succeeded, though in some parts of the European area after enormous geographical changes.

GREAT BRITAIN.—Miocene formations, in the ordinary sense of the term, are almost entirely absent from the British Islands. In Devonshire, at Bovey Tracey, a small but interesting group of sand, clay, and lignite beds, from 200 to 300 feet thick, lies between the granite of Dartmoor and the Greensand hills, in what was evidently the hollow of a Miocene lake. From these beds Heer of Zurich, who has thrown so much light on the Miocene flora of both the Old World and the New, has described about 50 species of plants, which, he says, place this Devonshire group of strata on the same geological horizon with some part of the Lower Miocene formations of Switzerland. Among the species are a number of ferns (*Lastræa stiriaca, Pecopteris lignitum,* etc.); some conifers, particularly a *Wellingtonia* called the *Sequoia Couttsiæ*, the debris of which forms one of the lignite beds; a few grasses, water-lilies, and a palm. Leaves of oaks, figs, laurels, willows, and seeds of grapes have also been detected—the whole vegetation implying a subtropical climate. In the north of Ireland lies a great plateau of basalt, presenting along the coast of Antrim a magnificent range of mural escarpments. The basalt-beds mark successive outpourings of lava, which took place on a prodigious scale from the Antrim region northwards through the Western Islands and the Faroe Islands into Iceland, and even far up into Arctic Greenland. In Ireland the basalts attain a maximum thickness of 900 feet; in Mull about 3000 feet. They are associated with tuffs, pitchstones, trachytes, and granitoid rocks, which mark the position of the main vents of eruption. It is evident that long-continued and vigorous volcanic action took place in these north-western regions. The geological date of this activity can be approximately fixed by the fossil plants here and there to be found in leaf-beds between the sheets of basalt. They agree generally with species found in the Older Miocene beds of Switzerland; and hence the date of this marked volcanic era in the north-west of Europe and in Greenland is placed in the older part of the Miocene period. With these exceptions there are no Miocene rocks in Britain.

CONTINENTAL EUROPE.—The records of the Miocene period in Europe bring before us a scene very different from that which the region presented during the Eocene ages. The least amount of change took place in the north-west and north. It consisted chiefly in the upraising of the floor of the shallow sea which had stretched eastwards across the north of France, and the formation of numerous fresh-water lakes, lagoons, and morasses. But over the Alpine region a vast revolution took place. The Eocene sea had its bed elevated, and the Alps rose many thousand feet above their previous height, carrying up on their flanks the hardened, upturned, crumpled, and crystallized nummulite limestone. These vast corrugations of the earth's crust were general over the whole globe about the same geological period. Subterranean movements appear to have continued during Miocene times in the Alpine area; large lake-basins were formed over a great part of what is now Switzerland, and in these the deposits of the period took place. Hence the Miocene formations of Europe are in great measure of lacustrine and terrestrial formation. The sea, however, was allowed to pass across the south of France between the central axis and the Pyrenees. It likewise covered a wide area in eastern Europe, sweeping far up into the Vienna basin and the foot of the Austrian Alps. Traces of the occasional presence of the sea can likewise be followed across Belgium and North Germany, and even on the south side of the Eifel and Westphalian high grounds in the basin of Mainz.

In France, on the north side of the axis of old rocks, the upper parts of the Eocene series are covered by certain marls, clays, and limestones, containing *Ostrea cyathula*, and passing up into the thick sandstone of Fontainebleau, well known for its picturesque scenery. These are considered as the base of the Miocene (or Oligocene) series. They contain *Fusus elongatus, Aporrhais speciosa, Pectunculus obovatus, Cyrena semistriata, Cerithium plicatum,* etc. They are succeeded by some fresh-water limestones (Calcaire de Beauce) full of *Paludina, Planorbis, Limnæa,* and *Helix*. These strata show very instructively the gradual shallowing of the sea in the north of France, and its converson into fresh-water lakes and land. Further to the south a subsequent depression took place, in which the shelly sands and marls (faluns) of Touraine were accumulated. These strata lie in scattered patches, and seldom exceed 50 feet in thickness. They contain chiefly marine shells (*Cypræa, Oliva, Mitra, Terebra, Fasciolaria, Conus,* etc.), also remains of the *Dichobune* and *Chæropotamus*, with some of the huge early pachyderms—*Mastodon, Dinotherium,* rhinoceros, hippopotamus, and species of dolphin, morse, etc.

In North Germany the older Miocene rocks are marine where they pass westwards into the Belgian area, but as they are followed southwards they bear evidence of increasing proximity to land, till at last they contain abundant seams of lignite, and hence have been termed the Brown-coal series. They appear to underlie most of the great north Germanic plain, on the south side of which they rise up into the Rhine valley, Thuringia, Saxony, and Silesia. The Brown-coal series consists of sandstones, conglomerates, and clays, with leaf-beds and seams of lignite. The last, which have been largely worked as fuel, are mainly composed of remains of conifers (*Taxites, Taxoxylon, Cupressinoxylon, Sequoia*), but with them are associated in the neighboring strata, leaves and other fragments of oak, beech, maple, fig, laurel, cinnamomum, magnolia, sassafras, palmacites, etc. These strata, are overlaid by marine beds containing *Ostrea, Cardita, Pleurotoma, Voluta,* and numerous corals. The subterranean movements above referred to as having long affected the Alpine region were felt likewise in North Germany, for we find these marine beds succeeded by a second lignitic formation, seen at Grosser Hubenecken, on the eastern horn of the Gulf of Dantzic. But this could only have been a local uplift, for marine sands and clays are next found with a wide diffusion over the plains of northern Germany.

Nowhere in Europe do the Miocene formations play so important a part in the scenery of the land, or present on the whole so interesting and full a picture of the state of Europe when they were deposited, as in Switzerland. Rising into massive mountains, as in the well-known Righi and Rossberg, they attain a thickness of more than 6000 feet. While they include indications of the presence of the sea, they have preserved with marvellous perfection a large number of the plants which clothed the Alps, and of the insects which flitted through the woodlands. They are termed "Molasse" by the Swiss geologists, and have been divided into the following groups:—

Upper fresh-water Molasse and brown-coal, consisting of sandstones, marls, and limestones, with a few lignite-seams and fresh-water shells, and including the remarkable group of plant and insect-bearing beds of Oeningen.

Upper marine Molasse (Helvetian stage)—sandstones and calcareous conglomerates, with 37 per cent. of shells, which are to be found living partly in the Mediterranean, and partly in tropical seas.

Lower fresh-water Molasse (Mainz stage)—sandstones with abundant remains of terrestrial vegetation, and containing also an intercalated marine band with *Cerithium, Venus,* etc.

Lower brown-coal or red Molasse (Aquitanian stage)—the most massive member of the whole series, consisting of red sandstones, marls, and conglomerates (Nagelfluh), resting upon variegated red marls. It contains seams of lignite, and a vast abundance of the remains of terrestrial vegetation.

Lower marine Molasse (Tongrian stage)—sandstone containing marine and brackish-water shells, among which is the *Ostrea cyathula*, above mentioned as a characteristic shell, at the base of the Miocene series in the north of France.

By far the larger portion of these strata is of lacustrine origin. They must have been formed in a large lake, the area of which probably underwent gradual subsidence during the period of deposition, so that the sea gained occasional admission into it. We may form some idea of the importance of the lake from the fact already stated, that the deposits formed in its waters are upwards of 6000 feet thick. Thanks to the untiring labors of Professor Heer, we know more of the vegetation of the mountains round that lake than we do of that of any other ancient geological period. The woods were marked by the predominance of an arborescent vegetation, among which evergreen forms were conspicuous, the whole having a decidedly American aspect. Among the plants were palms of American type, the Californian coniferous genus *Sequoia*, a great variety of maples, oaks, hornbeams, poplars, planes, willows, laurels, evergreen oaks, with vines, clematis, cypresses, and many more. In the Oeningen beds, so gently have the leaves, flowers, and fruits fallen, and so well have they been preserved, that we may actually trace the alternation of the seasons by the succession of different conditions of the plants. Selecting 482 of those plants which admit of comparison, Heer remarks that 131 might be referred to a temperate, 266 to a sub-tropical, and 85 to a tropical zone. American types are most frequent among them; European types stand next in number, followed in order of abundance by Asiatic, African, and Australian. Great numbers of insects (between 800 and 900 species) have been obtained from Oeningen. Judging from the proportions of species found there, the total insect fauna may be presumed to have been then richer in some respects than it now is in any part of Europe. The wood-beetles were specially numerous and large. Nor did the large animals of the land escape preservation in the silt of the lake. We know, from bones found in the Molasse, that among the inhabitants of that land were species of tapir, mastodon, rhinoceros, and deer. The woods were haunted by musk-deer, apes, opossums, three-toed horses, and some of the strange, long-extinct Tertiary ruminants, akin to those of Eocene times. There were also frogs, toads, lizards, snakes, squirrels, hares, beavers, and a number of small carnivores. On the lake the huge *Dinotherium* floated, mooring himself perhaps to its banks by the two strong tusks in his under jaws. The waters were likewise tenanted by numerous fishes (of which 32 species have been described, all save one referable to existing genera), crocodiles, and chelonians.

Contemporaneously with the existence of the great Swiss Miocene lake, one or more large sheets of fresh water lay in the heart of France. In these basins a series of marls and limestones (1500 feet thick) accumulated, from which have been obtained the remains of nearly 100 species of mammals, including some palæotheres, like those of the Paris Eocene basin, a few genera found also in the Lower Miocene beds of Mainz, crocodiles, snakes, and birds. This water basin appears to have been destroyed by volcanic explosions, which afterwards poured out the great sheets of lava, and formed the numerous cones and *puys* so conspicuous on the plateau of Auvergne.

The sea which during the later part of the Miocene period stretched across the south of France ran also up the present valley of the Danube to the foot of the Alps and the high grounds of Bohemia and Moravia. In this wide eastern bay or Vienna basin a series of deposits was laid down, which have been grouped in four divisions,—the two lower classed as Miocene, and the two upper as Pliocene. The lowest group (Mediterranean stage or Marine Tegel) has yielded more than 1000 species of mollusca (*Conus, Ancillaria, Pyrula, Murex, Cardium,* etc.), with remains of *Mastodon, Dinotherium,* and other mammals. The second group (Sarmatian stage) consists of brackish-water beds showing the partial uprise of the bottom of the Vienna basin. It contains *Cerithium, Paludina, Rissoa,* with bones of dolphins, seals, turtles, and fish. The two uppermost divisions (Congeria stage and Belvedere stage), referred to the Pliocene series, are fresh-water formations, showing the final freshening and disappearance of the Miocene sea in the south-east of Europe.

In Styria and Carinthia the lower Aquitanian or Mediterranean stage bears witness in its plants and lignites to the proximity of land during its formation, while its shells are of fresh and brackish water genera. It has subsequently been upheaved, and the later Miocene strata lie unconformably on its edges. The subterranean movements east of the Alps culminated in the outpouring of enormous sheets of trachyte, andesite, propylite, and basalt in Hungary and along the flanks of the Carpathian chain into Transylvania. In Croatia the older Miocene marls, with their abundant land-plants, insects, etc., contain two beds of sulphur (the upper 4 to 16 inches thick, the under 10 to 15 inches), which have been worked at Radoboj. At Hrastreigg, Buchberg, and elsewhere, coal is worked in the Aquitanian stage in a bed sometimes 65 feet thick. In Transylvania, and along the base of the Carpathian mountains, extensive masses of rock-salt and gypsum are interstratified in the Tertiary formations. The largest of these, that of Parajd, has a maximum length of about 2500 yards, a breadth of 1800 yards, and a depth nearly 200 yards, and is estimated to contain 3500 millions of cubic feet of salt.

Greenland.—One of the most remarkable geological discoveries of recent times has been that of Miocene plant beds in North Greenland. Heer has described a flora extending at least up to 70° N. lat., containing 137 species, of which 46 are found also in the central European Miocene basins. More than half of the plants are trees, including 30 species of conifers (*Sequoia, Thujopsis, Salisburia,* etc.), besides beeches, oaks, planes, poplars, maples, walnuts, limes, magnolias, and many more. These plants grew on the spot, for their fruits in various stages of growth have been obtained from the beds. From Spitzbergen (78° 56′ N. lat.) 136 species of fossil plants have been named by Heer. But the latest English Arctic expedition brought to light a bed of coal, black and lustrous like one of the Palæozoic fuels, from 81° 45′ N. lat. It is from 25 to 30 feet thick, and is covered by black shales and sandstones full of land-plants. Heer notices 26 species, 18 of which had already been found in the Arctic Miocene zone. As in Spitzbergen, the conifers are most numerous (pines, firs, spruces, and cypresses), but there occur also the arctic poplar, two species of birch, two of hazel, an elm, and a viburnum. In addition to these terrestrial trees and shrubs the stagnant waters of the time bore water-lilies, while their banks were clothed with reeds and sedges. When we remember that this vegetation grew luxuriantly within 8° 15′ of the North Pole, in a region which is now in darkness for half of the year, and is almost continuously buried under snow and ice, we can realize the difficulty of the problem in the distribution of climate which these facts present to the geologist.

Pliocene.

Great Britain.—The Miocene period seems to have passed away without any notable portion of the British Islands being depressed under the sea. Save the great outpouring of lava in the north-west, and the rise of hundreds of "dykes" of basalt along cracks of the crust in the north of England and throughout Scotland, the area of Britain seems to have remained as a part of the mainland of Europe, little affected by the subterranean movements which, as we have seen, were so potent among the Alps and in eastern Europe. At length the south-eastern counties began to subside, and on their submerged surface some sandbanks and shelly deposits were laid down, very much as similar accumulations now take place at the bottom of the North Sea. These formations are termed the Crag, and are subdivided, according to their proportion of living species of shells, into the following groups:—

Chillesford beds	Chillesford clay	1 to	8 ft.
	Chillesford Sand with shells	5 "	8 "
Norwich (fluvio-marine, mammaliferous) Crag		5 "	10 "
Red Crag			25 "
White (Suffolk, coralline) Crag		40 "	60 "

The White Crag consists of shelly sands and marls. It contains 316 species of shells, of which 84 per cent. are still living. Among these are *Terebratula grandis, Lingula Dumortieri, Pecten opercularis, Pholadomya histerna, Pyrula reticulata.* The name coralline was given to the formation from the immense number of coral-like polyzoa which it contains, no fewer than 130 species having been described. The Red Crag is also a thin and local formation, consisting of a dark-red or brown ferruginous shelly sand. Of its mollusks, 92 per cent. are believed to be still living species, and, out of 25 species of corals, 14 are still natives of British seas. Some of the typical shells of this subdivision are *Trophon antiquum* (*Fusus contrarius*), *Voluta Lamberti, Purpura tetragona, Pecten opercularis, Pectunculus glycimeris,* and *Cyprina rustica.* Numerous mammalian remains have been obtained from these sands, including bones of *Mastodon Arvernensis* and *M. tapiroides, Elephas meridionalis, Rhinoceros Schleiermacheri, Tapirus priscus, Sus antiquus, Equus plicideus, Hipparion, Hyæna antiqua, Felis pardoides,* and *Cervus anoceros.* The Norwich or Fluvio-marine or Mammaliferous Crag consists of a few feet of shelly sand and gravel, containing, so far as known, 139 species of shells, of which 93 per cent. are still living. About 20 of the species are land or fresh-water shells. The name of mammaliferous was given from the large number of bones, chiefly of extinct species of elephant, recovered from this deposit. These fossils comprise *Mastodon Arvernensis, Elephas meridionalis, E. antiquus,* a hippopotamus, horse, and deer, likewise the living species of otter and beaver. One interesting feature in this formation is the decided mixture in it of *northern* species of shells, such as *Rhynchonella psittacea, Scalaria Grœlandica,* and *Astarte borealis.* These may be regarded as the forerunners of the great invasion of Arctic plants and animals which, in the beginning of the Quaternary ages, came southward into Europe, together with the severe climate of the north. The Chillesford beds occur likewise as a thin local deposit in Suffolk and Norfolk. Of the shells which they contain, about two-thirds still live in Arctic waters. It is evident that, in these fragmentary accumulations of the Crag series we have merely the remnants of some thin sheets of shelly sands and gravels laid down in the shallow waters of the North Sea, while that great lowering of the European climate was beginning which culminated in the succeeding or Glacial period.

Continental Europe.—Marine strata, sometimes of considerable thickness, were laid down over different portions of the European area during the Pliocene period. The most extensive of these occur in Italy and Sicily; in the latter island they have since been upheaved to a height of 3000 feet above the sea. They have likewise been raised into the chain of heights flanking the Apennine Mountains, where they are known as the Subapennine series. In the shore waters and estuaries of that ancient Italy some of the same huge mammals lived as were contemporaneously denizens of England,—the Auvergne mastodon, *Rhinoceros Etruscus*, *Elephas Meridionalis*, *Hippopotamus major*, with bears and hyænas.

Eastwards we obtain evidence of the gradual exclusion of the sea from the areas of the European continent which it had covered during the Miocene period. The Congeria stage (above referred to) of the Vienna basin brings before us the picture of an isolated gulf gradually freshening by the inpouring of rivers like the modern Caspian, but with bays nearly cut off from the main body of water, and undergoing so copious an evaporation without counterbalancing inflow that their salt was deposited over the bottom as in the Karaboghaz of the Caspian (*ante*, p. 248).

Tertiary Series of North America.

Tertiary formations of marine origin extend in a strip of low land along the Atlantic border of the United States, from the coast of New Jersey southward round the margin of the Gulf of Mexico, whence they run up the valley of the Mississippi to beyond the mouth of the Ohio. On the western sea-board they also occur in the coast ranges of California and Oregon, where they sometimes have a thickness of 3000 or 4000 feet, and reach a height of 3000 feet above the sea. Over the Rocky Mountain region Tertiary strata cover an extensive area, but are chiefly of fresh-water origin, though containing marine interstratifications. The following are the subdivisions into which they have been grouped, together with their supposed European equivalents:—

4. Sumpter series = Pliocene.
3. Yorktown " = Miocene, with perhaps part of Pliocene.
2. Alabama " = Middle and Upper Eocene.
1. Lignitic " = Lower Eocene.

1. *Lignitic.*—As already mentioned, it is still matter of dispute whether this formation should not be included wholly or in large measure in the Cretaceous system below. It consists mainly of lacustrine strata, with occasional brackish water and marine bands. Its name is derived from the beds of fossil fuel which it contains. The mollusca in some of the shell-bearing beds comprise species of *Inoceramus*, *Anchura*, *Gyrodes*, *Cardium*, *Cyrena*, *Melampus*, *Ostrea*, and *Anomia*. Other strata contain the modern lacustrine and fluviatile genera *Physa*, *Valvata*, *Cyrena*, *Corbula*, and *Unio*. An abundant terrestrial flora has been disinterred from the Lignitic strata. It resembles in many respects the present flora of North America, comprising as it does species of oak, poplar, maple, elm, dogwood, beech, hickory, ilex, plane, fig, cinnamon, laurel, magnolia, smilax, thuja, sequoia, and several palms. A few of the species are common to the Middle Tertiary flora of Europe, and a number of them have been met with in the Tertiary beds of the Arctic regions. Some of the seams of vegetable matter are true bituminous coals and even anthracites.

It was stated in the account of the North American Cretaceous rocks that considerable difference of opinion exists as to the line to be drawn between these rocks and those of Tertiary age. According to Cope, the Vertebrate remains of the Lignitic series bind it indissolubly to the Mesozoic formations. Lesquereux, on the other hand, insists that the vegetation is unequivocally Tertiary. The former writer, admitting the force of the evidence furnished by the fossil plants, concludes that "there is no alternative but to accept the result that a Tertiary flora was contemporaneous with a Cretaceous fauna, establishing an uninterrupted succession of life across what is generally regarded as one of the greatest breaks in geologic time." The Lignitic series was disturbed along the Rocky Mountain region before the deposition of the succeeding Tertiary formations, for these lie unconformably upon it. So great have been the changes in some regions that the strata have assumed the character of hard slates like those of Palæozoic date, if indeed they have not become in California thoroughly crystalline masses.

2. *Alabama Group.*—The strata included in this group are believed to represent the Middle and Upper Eocene of Europe. As their name implies, they are well developed in the State of Alabama, where they consist of two sub-groups,—(1) the Clayborne beds—clays, marls, limestones, lignite, and sands, and (2) the Vicksburg beds—lignitic clays, limestones, and marls,—the whole attaining a thickness of nearly 250 feet. But the strata thicken into South Carolina. Towards the west the marine fossils give place to leaf-beds and lignites. In the Green River basin the strata attain a thickness of more than 2000 feet, lying on the disturbed Lignitic group and containing beds of coal, with remains of fish and of tapiroid pachyderms. The fossils of the Alabama group in the eastern States comprise numerous sharks, some of which are specifically, and more are generically, the same as some of the English Eocene forms, such as *Lamna elegans* and *Carcharodon Megalodon;* also bones of several crocodiles and snakes. In the lacustrine and fluviatile deposits of the west there have been found also the remains of several birds, and a large number of mammals, including marsupials, numerous representatives of the tapirs, with double pairs of nasal horns, an early form of horse (*Orohippus*) not larger than a fox, and with four toes in the fore foot, rodents, insectivores, bats, carnivores, and a number of forms allied to the living lemurs and marmosets. The richness of this fauna is remarkable, particularly in the mammals.

3. *Yorktown Group.*—Under this name are classed strata of sand and clay, which extend over a large area in the seaward part of the eastern States. Their organic remains (comprising mollusks, with remains of sharks, seals, walruses, whales, etc.) show them to have been chiefly laid down in a shallow sea in Miocene time. Westward, in the Upper Missouri region, and across the Rocky Mountains into California and Oregon, strata assigned to the same geological period were laid down in great lakes, and attain thicknesses of 1000 to 4000 or 5000 feet. The organic remains of these ancient lakes embrace examples of three-toed horses (*Anchitherium*), of horned tapir-like animals (*Titanotherium*), of forms related to the hog, rhinoceros, camel, lama, deer, musk-ox, hare, squirrel, beaver, hyæna, wolf, panther, and tiger. The intermediate types indicated by Cuvier among the Paris Tertiary beds have been greatly increased from the American Tertiary groups by the researches of Marsh and Leidy.

4. *Sumpter Group* or *Pliocene.*—In the Carolina States beds of loam, clay, or sand, lying in hollows of the older Tertiary deposits, and containing from 40 to 60 per cent. of living marine shells, are referred to the Pliocene age. In the Upper Missouri region, the Yorktown group is overlaid by other fresh-water beds, which are believed to be Pliocene. These strata contain land and fresh-water shells, probably of existing species. But their most remarkable organic remains are the mammalia, which continue the wonderful series in the strata underneath. Dana thus summarizes the facts:—"Leidy has determined a large number of Pliocene mammals, all now extinct. They include three species of camel (*Procamelus*); a rhinoceros as large as the Indian species; a mastodon smaller than *M. Americanus*, L., of the Quaternary; an elephant (*E. Americanus*), occurring also in the Quaternary; four or five species of the horse family, one of which was closely like the modern horse; a species of deer (*Cervus Warreni*, L.); others near the musk-deer of Asia; species of *Merechyus*, allied to *Oreodon* (a genus intermediate between deer, camel, and hog); a wolf larger than any living species; a small fox; a tiger (*Felis augustus*, L.) as large as the Bengal tiger, besides other carnivores; a small beaver; a porcupine. The collection of animals has a strikingly Oriental character, except in the preponderance of herbivores."

V. POST-TERTIARY OR QUATERNARY.

Under this division are included the various superficial deposits in which all the mollusca are of still living species. It is usually subdivided into two series—(1) an older group of deposits in which many of the mammals are of extinct species,—to this group the names of Pleistocene, Post-Pliocene, or Diluvial have been given: and (2) a later series, wherein the mammals are all of still living species, to which the name of Recent or Alluvial has been assigned. These subdivisions, however, are confessedly very artificial, and it is often exceedingly difficult to draw any line between them.

In Europe and North America a tolerably sharp demarcation can usually be made between the Pliocene formations and those now to be described. The Crag deposits of the south-east of England show traces of a gradual lowering of the temperature during later Pliocene times. This change of climate continued to augment until at last thoroughly arctic conditions prevailed, under which the oldest of the Post-Tertiary or Pleistocene deposits were accumulated.

It is hardly possible to arrange these deposits in a strict chronological order, because we have no means of deciding, in many cases, their relative antiquity. The following table is rather an enumeration of the more important of them than an arrangement in their exact sequence:—

Recent......	River alluvia, peat mosses, lake deposits, blown sand, marine deposits, raised beaches.

Pleistocene or Glacial..	Brick-earth, valley gravels, old marine terraces, cavern-deposits. Moraine-stuff, Kame or Esker series, Clyde-beds, Upper Boulder clays, Interglacial beds, Lower Till, ice-worn rock-surfaces. Pre-glacial forests and land surface.

PLEISTOCENE OR GLACIAL.

Under the name of the Glacial Period or Ice Age, a remarkable geological episode in the history of the northern hemisphere is denoted. We have seen in the foregoing section on the Crag deposits that there is evidence of a gradual refrigeration of the climate at the close of the Tertiary ages. This change of temperature affected the higher latitudes alike of the Old and the New World. It reached such a height that the whole of the north of Europe was buried under snow and ice, extending southwards even as far as Saxony. The Alps and Pyrenees were loaded with vast snow-fields, from which enormous glaciers descended into the plains, overriding ranges of minor hills on their way. The greater portion of Britain was similarly ice-covered. The effect of the movement of the ice was necessarily to remove the soils and superficial deposits of the land surface. Hence in the areas of country so affected, the ground having been scraped and smoothed, the glacial accumulations laid down upon it rest abruptly, and without any connection, on whatever underlies them. Considerable local differences may be observed in the nature and succession of the different deposits of the glacial period, as they are traced from district to district. It is hardly possible to determine, in some cases, whether certain portions of the series are coeval or belong to different epochs. But the following are the leading facts which have been established for the North-European area. First, there was a gradual increase of the cold, though with warm intervals, until the conditions of modern North Greenland extended as far south as Middlesex, Wales, the south-west of Ireland, and 50° N. lat. in central Europe. This was the culmination of the Glacial period. Then followed a considerable depression of the land and the spread of cold arctic water over the submerged tracts, with abundant floating ice; next came a re-elevation, with renewed augmentation of the snow-fields and glaciers. Very gradually, and after intervals of increase and diminution, the ice retired towards the north, and with it the arctic flora and fauna that had peopled the European plains. The existing snow-fields and glaciers of the Pyrenees, Switzerland, and Norway are remnants of the great ice-sheets of the glacial period, while the arctic plants of the mountains are relics of the northern vegetation which was universal from Norway to Spain.

Ice-worn Rocks.—Beginning at the base of the deposits from which this interesting history is compiled, we find the solid rocks over the whole of northern Europe to present the characteristic smoothed flowing outlines which can be produced only by the grinding action of land-ice (*ante*, p. 250). Where they have been long exposed, this peculiar surface is apt to be effaced by the disintegrating action of the weather, though it retains its hold with extraordinary pertinacity. Along the fjords of Norway and the sea-lochs of the west of Scotland, it may be seen slipping into the water, smooth, bare, polished, and grooved as if the ice had only recently retreated. But where the protecting cover of clay or other superficial deposits has been newly removed, the peculiar ice-worn surface is as fresh as that by the side of a modern glacier. Observations of the directions of the striæ have shown that on the whole these markings diverge from the main masses of high ground. In Scandinavia they run westwards and south-westwards on the Norwegian coasts, and eastwards or south-eastwards across the lower grounds of Sweden. When the ice descended into the basin of the Baltic and the plains of northern Germany, it moved southwards and south-westwards, but seems to have slightly changed its direction in different areas and at different times. Its movements can be made out partly from the striæ on the solid rock, but more generally from the glacial drift which it has left behind. Thus it can be shown to have moved down the Baltic into the North Sea. At Berlin its movement must have been from east to west. But at Leipsic, as recently ascertained by Credner, it came from N. N. W. to S. S. E., being doubtless shed off in that direction by the high grounds of the Harz mountains. Its southern limit can be traced with tolerable clearness from Jevennaar in Holland eastwards across the Rhine valley, along the base of the Westphalian hills, round the projecting promontory of the Harz, and then southwards through Saxony to the roots of the Erzgebirge. Passing next south-eastwards along the flanks of the Riesen and Sudeten chain, it sweeps across Poland into Russia, circling round by Kieff, and northwards by Nijni Novgorod towards the Urals.

It has been estimated that, excluding Finland, Scandinavia, and the British Isles, the ice must have covered not less than 1,700,000 square kilometres of the present lowlands of Europe. Its influence on the solid rocks over which it passed has not been everywhere equal. Over much of the north German plain, indeed, the rocks are concealed under drift. But in the more undulating hilly ground, particularly in the north and north-west, the ice has effected the most extraordinary abrasion. It is hardly possible, indeed, to describe adequately in words these regions of most intense glaciation. The old gneiss of Norway and Sutherlandshire, for example, has been so eroded, smoothed, and polished, that it stands up in endless rounded hummocks, many of them still smooth and flowing like dolphins' backs, with little pools, tarns, and larger lakes lying between them. Seen from a height the ground appears like a billowy sea of cold grey stone. The lakes, every one of them lying in a hollow of erosion, seem scattered broadcast over the landscape. So enduring is the rock, that even after the lapse of so long an interval, it retains its ice-worn aspect almost as unimpaired as if the work of the glacier had been done only a few generations since.

Some idea of the massiveness of the ice-sheet is obtainable from a consideration of the way in which the striæ run across important hill ranges, and athwart what might seem to be their natural direction. Whilst there was a general southward movement from the great snow-fields of Scandinavia, the high grounds of Britain were important enough to have their own independent ice, which, as the striæ show, radiated outward, some of it passing westwards into the Atlantic and some of it eastward into the North Sea. So thick must it have been as it moved off the Scottish Highlands that it went across the broad plains of Perthshire, filling them up to a depth of at least 2000 feet, and passing across the range of the Ochil Hills, which at a distance of 12 miles runs parallel with the Highland mountains, and reaches a height of 2352 feet. In such cases it has been observed that the striæ along the lower slopes of the hill barrier run either parallel with the trend of the ground or slant up obliquely, while those on the summits may cross the ridge at right angles to its course. This shows that there must have been a differential movement in the great ice-sheet, the lower parts, as in a river, becoming embayed and being forced to move in a direction sometimes even at a right angle to that of the general advance. On the lower grounds, also, the striæ, converging from different sides, unite at last in one general trend as the various ice-sheets must have done, as they descended from the high grounds on either side and coalesced into one common mass. This is well seen in the great central valley of Scotland. Still more marked is the deflexion of the striæ in Caithness and the Orkney and Shetland Islands. In these districts the general direction of the striation is from S. S. E., which, in Caithness, is nearly at right angles to what might have been anticipated. This deflexion has been attributed to the coalescence of the ice from Norway and from the northern Highlands in the basin of the North Sea, and its subsequent progress along the resultant line into the Atlantic. But it may have been due to the fan-shaped spreading out of the vast mass of ice descending into the Moray Firth; for the striæ on the south side of that inlet run E. by S., and at last S. E., on the north-east of Aberdeenshire, showing that the ice, on the one hand, turned southwards into the North Sea, until it met the N. E. stream from Kincardineshire and the valleys of the Dee and Don, while on the other, it moved northward so as no doubt to join the Scandinavian sheet, and march with it into the Atlantic. The basin of the North Sea must have been choked up with ice in its northern parts, if not entirely. At that time England and the north-west of France were united, so that any portion of the North Sea basin not invaded by land-ice must have formed a lake, with its outlet by the hollow through which the Strait of Dover has since been opened. It has been suggested that during such a condition of things the widespread freshwater deposit termed Loess was formed, which covers so large a space in the lower plains of the Rhine and the north of Belgium, and appears in the valleys of the south-east of England.

The ice is computed to have been at least between 6000 and 7000 feet thick in Norway, measured from the present sea-level. From the height at which its transported debris has been observed on the Harz, it is believed to have been at least 1470 feet thick there, and to have gradually risen in elevation as one vast plateau, like that which at the present time covers the interior of Greenland. Among the Alps it attained almost incredible dimensions. The present snowfields and glaciers of these mountains, large though they are, form no more than the mere shrunken remnants of the great mantle of snow and ice which then overspread Switzerland. In the Bernese Oberland, for example, the valleys were filled to the brim with ice, which, moving northwards, crossed the great plain, and actually overrode a part of the Jura mountains. Huge fragments of granite and other rocks from the central chain of the Alps are found high on the slopes of that range of heights.

Boulder-clay or Till.—Under this name is included the debris which accumulated and was pushed onward under the ice-sheet, the "grund-moräne" or "moraine profonde" (*ante*, p. 250). All over the low grounds of North Germany, Denmark, and Holland lies a stony or earthy clay passing into sand or gravel, in which, together with locally derived debris, there is a greater or less proportion of fragments from the north. Some of the rocks of Scandinavia, Finland, and the Upper Baltic are of so distinctive a kind that they can be recognized in small pieces in the boulder-clay. Thus the peculiar syenite of Lanrwig in the south of Norway has been recognized abundantly in the drift of Denmark; it occurs in that of Hamburg, and in the boulder-clay of the Holderness cliffs in Yorkshire. The well-known Rhombenporphyr of southern Norway has likewise been recognized at Holderness. Fragments of the Silurian rocks from Gothland, or from the Russian islands Dago or Oesel, have been met with as far as the north of Holland. These transported fragments, so abundant within the line of demarcation just traced, are an impressive testimony to the movements of the northern ice-sheet and floating ice.

The boulder-clay is not spread as a uniform sheet over the ground, but varies greatly in thickness and in irregularity of surface. Round the mountainous centres of dispersion it is apt to occur in long ridges or "drums" which run in the general direction of the rock-striation.

In those areas which served as independent centres of dispersion for the ice-sheet, the boulder-clay partakes largely of the local character of the rocks of each district where it occurs. Thus in Scotland the clay varies in color and composition as it is traced from district to district. Over the Carboniferous rocks it is dark, over the red sandstones it is red, over the Silurian rocks it is fawn-colored. The great majority of the stones also are of local origin, not always from the immediately adjacent rocks, but from points within a distance of a few miles. Evidence of transport, however, can be gathered from the stones, for they are found in almost every case to include a proportion of fragments which have come from beyond the district. The direction indicated by the percentage of travelled stones is always the same for each region. Thus, in the lower part of the valley of the Firth of Forth, while most of the fragments are from the surrounding Carboniferous formations, from 5 to 20 per cent. is found to have come eastward from the Old Red Sandstone range of the Ochil Hills—a distance of 25 or 30 miles, while 2 to 5 per cent. are pieces of the Highland rocks, which must have come from the high grounds at least 50 miles to the north-west. The evidence of dispersion revealed by the stones in the boulder-clay harmonizes with that of the striæ on the rocks. Every main mass of elevated ground in Britain seems to have caused the ice to move outward from it for a certain distance, until the stream coalesced with that descending from some other height. In Scotland the ice was massive enough to move out into the basin of the North Sea (then doubtless in great part usurped by the glaciers) until it met that which was streaming down from Scandinavia. Hence no Scandinavian blocks have ever been found in Scotland. But the Norwegian ice which crept southwards across Denmark, may once have extended across the North Sea to the Yorkshire coast, if the Scandinavian stones of Holderness were not carried on floating ice.

The stones in the boulder-clay have a characteristic form and surface. They are usually oblong, have one or more flat sides or "soles," are smoothed or polished, and have their edges worn round. Where they consist of a fine-grained enduring rock, they are almost invariably found to be striated, the striæ running with the long axis of the stone. These markings are precisely similar to those on the solid rocks underneath the boulder-clay, and like them have manifestly been produced by the friction of stones and grains of sand as the whole mass of debris was being steadily pushed on in one given direction by the resistless advance of the ice (*ante*, p. 250).

Interglacial Beds.—The boulder-clay is not one uniform mass of material. In a limited section, indeed, it usually appears as an unstratified mass of stiff stony clay. But it is found on further examination to be split up with various inconstant and local interstratifications. Beds of sand, gravel, fine clay, and peaty layers occur in this way in different platforms in the boulder-clay. In Scotland and elsewhere these interpolated beds bear witness to intervals when the ice retired from the area, and the land, so far as uncovered, was clothed with vegetation and traversed by herds of the hairy mammoth, reindeer, and musk-ox. Hence the long glacial period must have been interrupted by episodes probably of considerable duration when a milder climate prevailed. Such an alternation of conditions is explained on the hypothesis discussed in previous pages (*ante*, pp. 194–196).

Evidences of Submergence.—After the ice had attained its greatest development, the land, which perhaps in north-western Europe stood at a higher level above the sea than it has done since, began to subside. The ice-fields were carried down below the sea-level, where they broke up and cumbered the sea with floating bergs. The heaps of loose debris which had gathered under the ice, being now exposed to waves, ground-swell, and marine currents, were thereby more or less washed down and reassorted. Coast-ice, no doubt, still formed along the shores, and was broken up into moving floes, as happens every year now in northern Greenland. The proofs of this phase of the long glacial period are contained in the sands, gravels, erratic blocks, and stratified clays which overlie the coarse older till. It is difficult to determine the extent of the submergence, for when the land rose the more elevated portions continued to be the seats of glaciers, which, moving over the surface, destroyed the deposits which would otherwise have remained as witnesses of the presence of the sea. The most satisfactory evidence is undoubtedly that supplied by beds of marine shells. These have been observed on Moel Tryfan, in North Wales, at a height of no less than 1350 feet, but as the same kind of deposits in which they occur extend to a much greater height, the submergence probably considerably exceeded the limit at which the shells occur. In Cheshire beds of shells have been met with at a height of 1200 feet. In Scotland the highest level from which they have yet been obtained is 524 feet; and in this instance they lie in one of the interstratifications in the boulder-clay. The coast of Scotland is fringed by a succession of raised beaches which, up to that at 100 feet above the present mean tide-level, are often remarkably fresh. The 100-feet terrace forms a wide plateau in the estuary of the Forth, and the 50-feet terrace is as conspicuous on the Clyde. The elevation of the land has brought up within tide-marks some of the clays deposited over the sea-floor during the time of the submergence. In the Clyde basin and some of the western fjords these clays (Clyde beds) are full of shells. Comparing the species with those of the adjacent seas, we find them to be more boreal in character; nearly the whole of the species still live in Scottish seas, though a few are extremely rare. Some of the more characteristic northern shells in these deposits are *Pecten Islandicus, Tellina calcarea, Leda truncata, L. lanceolata, Saxicava rugosa, Panopæa Norvegica, Trophon clathratum,* and *Natica clausa.*

That ice continued to float about in these waters is shown by the striated stones contained in the fine clays, and by the remarkably contorted structure which these clays occasionally display. Sections may be seen where, upon perfectly undisturbed horizontal strata of clay and sand, other similar strata have been violently crumpled, while horizontal beds lie directly upon them. These contortions must have been produced by the horizontal pressure of some heavy body moving upon the originally flat beds. No doubt the agent was ice in the form of large stranding masses which were driven aground in the fjords or shallow waters where the clays accumulated. Another indication of the presence of floating ice is furnished by large boulders scattered over the country, and lying sometimes on the stratified sands and gravels, though no doubt many of the so-called erratics belong to the time of the chief glaciation.

One of the most puzzling members of the Drift is the series of sands and gravels which cover the low grounds in many places, and rise up to heights of 1000 feet and more. These deposits are sometimes spread out in undulating sheets, which, in the lower districts, seem to merge insensibly into the marine terraces and raised beaches. But they are also very commonly disposed in remarkable mounds and in ridges which run across valleys, along hill-sides, and even over watersheds. These ridges are known in Scotland as kames, in Ireland as eskers, and in Scandinavia as osar. They consist sometimes of coarse gravel or earthy detritus, but more usually of clean, well-stratified sand and gravel, the stratification towards the surface corresponding with the external slopes of the ground, in such a manner as to prove that the ridges are original forms of deposit, and not the result of the irregular erosion of a general bed of sand and gravel. Some writers have compared these features to the submarine banks formed in the pathway of tidal currents near the shore. Others have supposed them rather to be of terrestrial origin, due to the melting of the great snow-fields and glaciers, and the consequent discharge of large quantities of water over the country. But no very satisfactory explanation has yet been given.

Re-emergence.—Later Glaciers.—When the land began to rise again, the temperature all over central and northern Europe was still severe. Vast sheets of ice still held sway over the mountains, and continued to descend into the lower tracts and to go out to sea. To this period are ascribed certain terraces or "parallel-roads" which run along the sides of valleys in the Scottish Highlands. It is believed that the mass of ice descending from some of the loftier snow-fields of this time was so great as to accumulate in front of lateral valleys, and to so choke them up as to cause the water to accumulate in them and flow out in an opposite direction by the *col* at the head. In these natural reservoirs the level at which the water stood for a time was marked by a horizontal ledge or platform due partly to erosion of the hill-side and partly to the arrest of the descending debris when it entered the water.

Every group of mountains nourished its own glaciers; even small islands, such as Arran in Scotland, had their snowfields, whence glaciers crept down into the valleys and shed their moraines. It would appear indeed that some of the northern glaciers of Scotland continued to reach the sea-level even when the land had risen to within 50 feet or less of its present elevation. On the east side of Sutherlandshire the moraines descend to the 50-feet raised beach; on the west side of the same county they come down still lower. The higher mountains of Europe still show the descendants of these later glaciers, but the ice has retreated from the lower elevations. In the Vosges the glaciers have long disappeared, but their moraines remain still fresh. In Wales, Cumberland, and the southern uplands and Highlands of Scotland, moraines, perched blocks, and *roches moutonnées* attest the abundance and persistence of the last glaciers. It is sometimes possible to trace the stages in the gradual retreat of the ice towards its parent snow-fields, for the crescent-shaped moraine mounds lie one behind another until they finally die out about the head of the valley, near what must have been the edge of the snow-field.

We know as yet very little of the fauna and flora of the land during the Glacial Period in Europe. The vegetation was doubtless in great measure the same as that of arctic Norway at the present day. The animals included the musk-ox, lemming, rein-deer, and other still living arctic forms, but included some which have become extinct, such as the hairy mammoth and woolly rhinoceros. During the milder inter-glacial periods denizens of warmer regions found their way northwards into Europe. Thus the hippopotamus haunted the rivers of the south of England. By degrees, as the climate ameliorated, the arctic vegetation was finally extirpated from the lower grounds of central and western Europe, and plants loving a milder temperature, which had doubtless been natives of Europe before the period of great cold, were enabled to reoccupy the sites whence they had been driven. On the higher mountains, where the climate is still not wholly uncongenial for them, colonies of this once general arctic flora still survive. The arctic animals have also been driven away to their northern homes, or have become wholly extinct. And thus, as imperceptibly as it began, the long and varied Ice Age came to an end as it merged into the next succeeding geological period.

RECENT OR HUMAN PERIOD.

That long succession of ages to which the name of the Glacial Period has been given shaded without abrupt change of any kind into what is termed the Human or Recent Period. Indeed it may be said with truth that the Glacial Period still exists in Europe. The snow-fields and glaciers have disappeared from Britain, but they still linger among the Pyrenees, remain in larger mass among the Alps, and spread over wide areas in northern Scandinavia. This dovetailing or overlapping of geological periods has been the rule from the beginning of time, the apparently abrupt transitions in the geological record being due to imperfections in the chronicle.

The question has often been asked whether man was coeval with the Ice Age. To give an answer, we must know within what limits the term Ice Age is used, and to what particular country or district the question refers. For it is evident that even to-day man is contemporary with the Ice Age in the Alpine valleys and in Finmark. There can be no doubt that he inhabited Europe after the greatest extension of the ice, but while the rivers were still larger than now from the melting snow, and flowed at higher levels.

The proofs of the existence of man in former geological periods are not to be sought for in the occurrence of his own bodily remains, as in the case of other animals. His bones are indeed now and then to be found, but in the vast majority of cases his former presence is revealed by the implements he has left behind him, formed of stone, metal, or bone. Many years ago the archæologists of Denmark, adopting the subdivisions of the Latin poets, classified the prehistoric traces of man in three great divisions—those of (1) the Stone Age, (2) the Bronze Age, and (3) the Iron Age. There can be no doubt that, on the whole, this has been the general order of succession. Men used stone and bone before they had discovered the use of metal. Nevertheless, the use of stone long survived the introduction of bronze and iron. In fact, in many European countries where metal has been known for many centuries, there are districts where stone implements are still employed, or where they were in use until quite recently. It is obvious also that, as there are still barbarous tribes unacquainted with the fabrication of metal, the Stone Age is not yet extinct in many parts of the world. In this instance we again see how geological periods run into each other. The nature or shape of the implement cannot therefore be always a very satisfactory proof of antiquity. We must judge of it by the circumstances under which it was found. From the fact that in north-western Europe the ruder kind of stone weapons occurs in what are certainly the older deposits, while others of more highly finished workmanship are found in later accumulations, the Stone Age has been subdivided into an early or Palæolithic and a later or Neolithic epoch. There can be no doubt, however, that the later was in great measure coeval with the age of bronze, and even to some extent of iron.

The deposits which contain the history of the human period are cavern-loam, river-alluvia, lake-bottoms, peat-mosses, sand-dunes, and other superficial accumulations.

Most calcareous districts abound in underground tunnels and caverns which have been dissolved by the passage of water from the surface (*ante*, p. 241). In a large number of cases these cavities have communicated with the outer surface, so that terrestrial animals, including man himself, have made use of them as places of retreat, or have fallen or been washed into them. The floors of some of them are covered with loam or cave-earth, resulting from the deposit of the silt carried in the water which formerly flowed through them. Very commonly also, a deposit of stalagmite has formed from the drip of the roof. Hence any organic remains which may have found their way to these floors have been sealed up and admirably preserved.

Above the present levels of the rivers there lie platforms or terraces of alluvium, sometimes to a height of 80 or 100 feet. These deposits are fragments of the river gravels and loams laid down when the streams flowed at that elevation, and therefore before the valleys were widened and deepened to their present form. River action is at the best but slow. To erode the valleys to so great a depth beneath the level of the upper alluvia, must have demanded a period of many centuries. There can therefore be no doubt of the high antiquity of these deposits. They have yielded the remains of many mammals, some of them extinct, together with the flint flakes made by man. From the nature and structure of some of the high-lying gravels, there can be little doubt that they were formed at a time when the rivers were larger than now, and were liable to be frozen and to be obstructed by large accumulations of ice. We are thus able to connect the formations of the human period with some of the later phases of the Ice Age in the west of Europe.

From the evidence of caverns and river-alluvia of Britain, Germany, and France, Dawkins enumerates about fifty mammals as among the chief inhabitants of Europe during the early human period. They include many of the animals still found wild in Europe, Asia, or Africa, such as the marmot, hare, beaver, lemming, leopard, lynx, wild cat, otter, brown bear, wolf, fox, African elephant, musk sheep, chamois, wild boar, horse, reindeer, and hippopotamus. It will be observed what a remarkable mixture there is in this list of forms now found in alpine or arctic regions, on the one hand, with others only now to be seen in warm latitudes. Probably there continued to be great alternations of climate and changes in the distribution of food, so that migrations successively from opposite quarters took place into central and western Europe. But among the denizens of these regions were some that have been long extinct, such as the mammoth, *Elephas antiquus*, *Machairodus latidens*, the woolly rhinoceros, the Irish elk, and others. That man was the contemporary of these extinct forms is shown both by the association of his flint weapons with their remains, and by the discovery of a tusk of the mammoth with an admirable outline of the animal carved upon it. This valuable relic, with bones of the reindeer and stag admirably sculptured into likenesses of these animals, was found in one of the caves of Perigord in central France.

From the beds of lakes, and from peat-mosses, evidences of more advanced civilization have been obtained. In Switzerland and elsewhere, remains of wooden pile-dwellings have been observed during times when the water has been low. Associated with these are weapons and implements of stone, in other cases of bronze and of iron, pottery, rude kinds of cloth, seeds of different cereals, and bones of domesticated animals. The dog, swine, goat, horned sheep, and other familiar animals appear as the companions of man. But there is evidence that some of the creatures which he tamed to his use were not natives of Europe, but had their original stocks in central Asia, and that some of his grains must likewise have been introduced. Hence we have glimpses into some of the early human migrations from that eastern centre whence so many successive waves of population have invaded Europe.

The later chronicles of the geologist merge insensibly into those of the archæologist. The latter claims as his field whatever belongs to the history of man on the globe; the former includes the history of man in that larger history of the earth of which a brief outline has been given in the foregoing pages.

POST-TERTIARY SERIES IN NORTH AMERICA.

The general succession of events in post-Tertiary times appears to have been nearly the same over the northern hemisphere both in the New and the Old World. In North America we have the same sharply-defined line between the older post-Tertiary deposits and previous formations, due to the glacial conditions which, overspreading these regions, in great measure destroyed the superficial accumulations of the immediately preceding eras. The Quaternary or post-Tertiary formations are grouped by American geologists in the following subdivisions:—

4. Recent and Prehistoric	Peat, alluvium, blown sand, "alkali" deposits, geyser deposits, cave deposits, artificial mounds.
3. Terrace.....	River terraces, loess. Raised beaches.
2. Champlain.....	*Saxicava* sand, Champlain clays, *Leda* clay.
1. Glacial.........	Boulder clays, unstratified clays, sands, and gravels.

1. *Glacial.*—As in Europe, the glacial deposits increase in thickness and variety from south to north. The southern limit of the unstratified drift lies somewhere in the neighborhood of the 39th parallel of north latitude, and the deposit ranges from the Atlantic westward to the meridian of 98°. It spreads, therefore, across British North America, and is found over a considerable area of the north-eastern States. It rises to a height of 5800 feet among the White Mountains. The absence of any true boulder-drift on the Rocky Mountain slopes, where it might have been looked for, is remarkable.

Underneath the boulder-clay the solid rocks, as in Europe, are often well striated. The direction of the striæ is generally southward, varying to south-east and south-west according to the form of the ground. In recent years extensive ice-worn rock-surfaces have been observed among the Rocky Mountains by Hayden, King, and others, proving that these elevations formerly possessed their glaciers, if they were not buried under the great ice-sheet.

The drift bears witness to a general southerly transport of material, and, in conjunction with the striated rocks, shows that the great ice-sheet moved from north to south at least as far as about the latitude of Washington. Logan mentions that in some parts of Canada the glacial drift and boulders run in ridges north and south, thus corresponding with the general direction of transport, like the "drums" in Britain. As in Europe, the coarse boulder-clay at the base of the Quaternary deposits is essentially unfossiliferous.

2. *Champlain.*—Under this name American geologists class the sands, gravels, and clays which overlie the lower boulder-drift. These deposits include coarse unstratified gravels, as well as finely-stratified clays. In eastern Canada they are well developed, and show the following subdivisions:—

Upper.	St. Maurice and Sorel sands; *Saxicava* sand of Montreal; upper sand and gravel of Beauport; upper Champlain clay and sand of Vermont.
Lower.	*Leda* clay of the St. Lawrence and Ottawa; lower shell-sand of Beauport; lower Champlain clay of Vermont.

The lower subdivisions consist chiefly of clays, which rise to a height of 600 feet above the sea. They have some interstratified beds of siliceous sand, but few boulders. They contain marine organisms, such as *Leda truncata*, *Saxicava rugosa*, *Tellina Grœnlandica*, bones of seals, whales, etc. On the banks of the Ottawa, in Gloucester, the clays contain numerous nodules which have been formed round organic bodies, particularly the fish *Mallotus villosus* or capeling of the Lower St. Lawrence. Dawson also obtained numerous remains of terrestrial marsh plants, grasses, carices, mosses, and algæ. This writer states that about 100 species of marine invertebrates have been obtained from the clays of the St. Lawrence valley. All except four or five species in the older part of the deposits are shells of the boreal or Arctic regions of the Atlantic; and about half are found also in the glacial clays of Britain. The great majority are now living in the Gulf of St. Lawrence, and neighboring coasts, especially off Labrador.[1]

3. *Terrace.*—This division includes the terraced deposits of alluvial material so marked along the river valleys and lake margins in the northern part of the United States and in Canada, and found also in some degree along the sea-coast. These deposits occur in successive platforms or terraces, marking the contraction in volume of the lakes and rivers, consequent, probably, upon intermittent upheavals of the land. They are well developed round the great lakes. Thus in the basin of Lake Huron deposits of fine sand and clay containing fresh-water shells rise to a height of 40 feet or more above the present level of the water, and run back from the shore sometimes for 20 miles. Regular terraces, corresponding to former water-levels of the lake, run for miles along the shores at heights of 120, 150, and 200 feet. Shingle beaches and mounds or ridges, exactly like those now in course of formation along the exposed shores of Lake Huron, can be recognized at heights of 60, 70, and 100 feet. Unfossiliferous terraces occur abundantly on the margin of Lake Superior. At one point mentioned by Logan, no fewer than seven of these ancient beaches occur at intervals up to a height of 331 feet above the present level of the lake.[2] Most of the rivers are bordered with lines of terraces, as in the well-known example of the Connecticut valley described by Hitchcock. The rivers are believed to have had their maximum volume at the beginning of the Terrace epoch, swollen doubtless by the melting of the still existing ice-sheets and snow-fields. Their work consisted partly in depositing fine alluvium or loess over their flood-plains, partly in scouring their channels out of the Champlain formations. Greater elevation towards the interior, by augmenting their slope, increased their excavating power.

Terraces of marine origin likewise occur both on the coast and far inland. On the coast of Maine they occur at heights of 150 to 200 feet, round Lake Champlain at least as high as 300 feet, and at Montreal nearly 500 feet above the present level of the sea. In the absence of organic remains, however, it is not always possible to distinguish between terraces of marine origin marking former sea-margins, and those left by the retirement of rivers and lakes. In the Bay of Fundy evidence has been cited by Dawson to prove subsidence, for he has observed there a submerged forest of pine and beech lying 25 feet below high-water mark.[1]

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[1] *Acadian Geology*, p. 76.

[2] *Geology of Canada*, p. 910.

4. *Recent and Prehistoric.*—The deposits in this group are essentially the same with those in Europe; and, as in that continent so in America, no definite lines can be drawn within which they should be confined. They cannot be sharply separated from the Terrace series, on the one hand, nor from modern accumulations, on the other. Besides the marshes, peat-bogs, and other organic deposits which belong to an early period in the human occupation of America, some of the younger alluvia of the river-valleys and lakes can no doubt claim a high antiquity, though they have not supplied the same copious evidence of early man which gives so much interest to the corresponding European formations. Heaps of shells of edible species occur on the coasts of Nova Scotia, Maine, etc. The large mounds of artificial origin in the Mississippi valley have excited much attention.

PART VII.—PHYSIOGRAPHICAL GEOLOGY.

In the investigation of the geological history of any country, two questions present themselves. We have first to consider the nature and arrangement of the rocks which underlie the surface, and to ascertain from them what has been the march of events, what changes in geography have successively taken place, and what races of plants and animals have come and gone. The gradual geological evolution of the earth has been sketched in the foregoing part of this article. But besides the history of the solid rocks beneath the surface of the land, there is that of the surface itself. Mountains and plains, valleys and ravines, cliffs, peaks, passes, lakes, and the many other features of a country demand attention. By what processes have these varied outlines been impressed upon the surface of the globe? Are they of different ages, and if so, how can their history be ascertained?

The branch of geological inquiry which endeavors to answer these questions has been termed Physiography or Physiographical Geology. Its investigations evidently demand an acquaintance with Stratigraphical Geology. We must be able to trace out the former geographical conditions of the globe before we can adequately reason on the origin of those now existing. Hence the consideration of this branch of the subject has necessarily been reserved for this concluding section.

The stratified formations, of which the succession and history have been traced in the previous pages, were chiefly laid down on the sea-floor in wide horizontal or gently inclined sheets. They have since been upraised into land; their horizontality has been in great part destroyed; and they have been enormously wasted by denuding agents. In considering therefore how they have acquired their present external forms, we have to deal with the effects of two kinds of forces, one acting from below, the other on the surface.

These stratified rocks were, on the whole, deposited in shallow water, and have been repeatedly upraised and denuded, so that the younger have been formed out of the waste of the older. They have their modern counterparts, not in the deposits of the great ocean-basins, but in those of comparatively shallow seas. The inference to be drawn from these facts is that the present continental regions, through many local oscillations, have existed as terrestrial ridges from a remote geological antiquity, and that the ocean basins in like manner have, on the whole, retained their identity. When the geologist asks himself how the present distribution of sea and land is to be accounted for, he finds that the answer to the question goes back to early Palæozoic times, whence he can in some cases trace the gradual growth of a continent downward through the long cycles of geological time. But there still remains the problem to account for the original wrinkling of the surface of the globe, whereby the present great ridges and hollows were produced.

It is now generally agreed that these inequalities have been produced by unequal contraction of the earth's mass, the interior contracting more than the outer crust, which must therefore have accommodated itself to this diminution of diameter by undergoing corrugation. But there seems to have been some original distribution of materials in the globe that initiated the depressions on the areas which they have retained. It has been already pointed out (*ante*, p. 199) that the matter underlying the oceans is more dense than that beneath the continents, and that, partly at least, to this cause must the present position of the oceans be attributed. The early and persistent subsidence of these areas, with the consequent increase of density, seems to have determined the main contours of the earth's surface.

From what has been stated in part iv., the reader will understand that rocks which were originally horizontal, or nearly so, have been crumpled over tracts thousands of square miles in extent, so as to occupy now a superficial area greatly less than that which they originally covered. It is evident that they have been horizontally compressed, and that this result can only have been achieved as a consequence of the subsidence of such a curved surface as that of our globe. The difficulty of explaining these corrugations on the hypothesis of the contraction of a solid globe is undoubtedly great. Mr. O. Fisher, indeed, believes that the present inequalities of contour on the earth's surface are from sixty-six to eleven and a half times as great as they would have been had they resulted from the contraction of a solid globe; and he has suggested that the earth need not have become solid throughout simultaneously, and consequently may have been considerably larger than it is now at the time when a solid crust was first formed.[2]

The geological phenomena long ago led to a belief in the liquidity of the earth's interior. Since this belief has been so weightily opposed by the physical arguments already adduced (*ante*, p. 200), geologists have endeavored to modify it in such a way as, if possible, to satisfy the requirements of physics, while at the same time providing an adequate explanation of the corrugation of the earth's crust. Mr. Hopkins, Professor Dana, Professor Shaler, and Mr. Fisher have, on different grounds, advocated the existence of a fluid or viscous substratum beneath the crust, the contraction and consolidation of which produce the corrugations of the rocks and of the surface. "The increase of temperature," says Mr. Fisher, "though rapid near the surface, becomes less and less as we descend, so that, if the earth were once wholly melted, the temperature near the centre is not very greatly above what it is at a depth which, compared to the earth's radius, is small. Consequently, if it requires great pressure to solidify the materials at such a temperature, it is probable that the melting temperature may be reached before the pressure is sufficient to solidify." The crust, of course, must be able to sustain itself on the corrugated surface of the supposed viscous layer without breaking up and sinking. The same writer has even suggested that the observed amount of corrugation is more than can be accounted for even on this hypothesis, and that the shrinkage may have been due not merely to cooling, but to the escape of water from the interior in the form of the superheated steam of volcanic vents.[3] More recently Herr Siemens has been led, from observations made in May, 1878, at Vesuvius, to conclude that vast quantities of hydrogen gas, or combustible compounds of hydrogen, exist in the earth's interior, and that these, rising and exploding in the funnels of volcanoes, give rise to the detonations and clouds of steam.[4]

Leaving the vexed question of the condition of the earth's interior, the hypothesis of secular cooling and contraction furnishes a natural explanation of the origin of the dominant elevations and depressions of the surface, and of the intense crumpling which the rocks in many regions have undergone. Taking 0·09 as the coefficient of contraction for a supposed stratum 500 miles thick, lying beneath 25 miles of crust, and passing from a fused into a solid state, Mr. Fisher found that every 100 miles measured along a great circle on the surface would have been one mile larger before the contraction, and that this might produce a triangular elevation of "25 square miles on a base of 100 miles, which would give a range of mountains half a mile high. If only 50 miles out of the hundred were disturbed, the range would be a mile high, and so on."[5]

The effects of this lateral pressure may show themselves either in broad dome-like elevations, or in narrower and loftier ridges of mountain. The structure of the crust is so complex, and the resistance offered by it to the pressure is consequently so varied, that abundant cause is furnished for almost any diversity in the forms and distribution of the wrinkles into which it is thrown. It is evident, however, that the folds have tended to follow a linear direction. In North America, from early geological times, they have kept on the whole on the lines of meridians. In the Old World, on the contrary, they have chosen diverse trends, but the last great crumplings—those of the Alps, Caucasus, and the great mountain ranges of central Asia—have risen along parallels of latitude.

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[1] *Acadian Geology*, p. 28.

[2] *Cambridge Phil. Trans.*, vol. xii. pt. ii., 1875.

[3] *Phil. Mag.*, October, 1875.

[4] *Monatsbericht der K. preuss. Akad. Wissenschaft*, 1878, p. 558.

[5] *Cambridge Phil. Trans.*, vol. xi. pt. iii.

Mountain chains must therefore be regarded as evidence of the shrinkage of the earth's mass. They may be the result of one movement, or of a long succession of such movements. Formed on lines of weakness in the crust, they have again and again given relief from the strain of compression by undergoing fresh crumpling and upheaval. The successive stages of uplift are usually not difficult to trace. The chief guide is supplied by unconformability, as explained on p. 281. Let us suppose, for example, that a mountain range consists of upraised Lower Silurian rocks, upon the upturned and denuded edges of which the Carboniferous Limestone lies transgressively. The original upheaval of that range must have taken place at the period of geological time represented by the interval between the Lower Silurian and the Carboniferous Limestone formations. If, in following the range along its course, we found at last the Carboniferous Limestone also highly inclined and covered unconformably by the Upper Coal-measures, we should know that a second uplift of that portion of the ground had taken place between the time of the Limestone and that of the Upper Coal-measures. By this simple and obvious kind of evidence the relative ages of different mountain-chains may be compared. In most great mountain-chains, however, the rocks have been so intensely crumpled, and even inverted, that much labor may be required before their true relations can be determined.

The Alps offer an instructive example of a great mountain chain formed by repeated movements during a long succession of geological periods. As has been already stated, the central portions of the chain consist of gneiss, schists, granite, and other crystalline rocks, partly referable to the Archæan series, but many of which appear to be metamorphosed formations of Palæozoic, Secondary, and even of older Tertiary age.

It would appear therefore that the first outlines of the Alps were traced out even in Archæan times, and that after submergence, and the deposit of Palæozoic formations along their flanks, if not over most of their site, they were re-elevated into land. From the relations of the Mesozoic rocks to each other, we may infer that several renewed uplifts after successive denudations took place before the beginning of the Tertiary formations. A large part of the range was, as we have seen, submerged during the Eocene period under the waters of that wide sea which spread across the centre of the Old World, and in which the Nummulitic Limestone and Flysch were deposited. But about the close of that period the grand upheaval took place to which the present magnitude of the mountains is chiefly due. The older Tertiary rocks, previously horizontal under the sea, were raised up into land, crumpled, dislocated, inverted, together with all the older formations of the chain. So intense was the compression to which the Eocene clays and sands were subjected that they were converted into rocks as hard and crystalline as many of the Palæozoic masses. It is strange to reflect that the enduring materials out of which so many of the mountains, cliffs, and pinnacles of the Alps have been formed are of no higher geological antiquity than the London Clay and other soft Eocene deposits of the south of England. After the paroxysm of elevation had ended, one or more large lakes were formed along the northern base of the mountains. In these hollows the Swiss molasse accumulated to a depth of more than 6000 feet—a great pile of slowly formed gravels, sands, and clays. That the sea gained occasional access to the region is shown by the interpolation of bands containing marine organisms, as already stated (*ante*, p. 322). Not improbably a gradual subsidence of the region was going on during the formation of the molasse. But towards the close of the Miocene period another great epoch of mountain-making was ushered in. The lakes disappeared, and their thick sediments were thrust up into large, broken, mountain masses. The Righi, Rossberg, and other prominent heights along the northern flank of the Alps are formed of these upturned lacustrine deposits. Since that great movement no paroxysm seems to have affected the Alpine region. Ceaseless changes, indeed, have been in progress, but they have been due not so much to subterranean causes as to those subaerial forces which are still so active.

The gradual evolution of a continent during a long succession of geological periods has been admirably worked out for North America by Dana, King, Hayden, Newberry, Powell, Dawson, and others. The general character of the structure is extreme simplicity, as compared with that of the Old World. In the Rocky Mountain region, for example, while the Palæozoic formations lie unconformably upon the Archæan gneiss, there is, according to King, a regular conformable sequence from the Lower Silurian to the Jurassic rocks. During the enormous interval of time represented by these massive formations what is now the axis of the continent remained undisturbed save by a gentle and protracted subsidence. In the great depression thus produced all the Palæozoic and a great part of the Mesozoic rocks were accumulated. At the close of the Jurassic period the first great upheavals took place. Two lofty ranges of mountains,—the Sierra Nevada (now with summits more than 14,000 feet high) and the Wahsatch,—400 miles apart, were pushed up from the great subsiding area. These movements were followed by a prolonged subsidence, during which Cretaceous sediments accumulated over the Rocky Mountain region to a depth of 9000 feet or more. Then came another vast uplift, whereby the Cretaceous sediments were elevated into the crest of the mountains, and a parallel coast-range was formed fronting the Pacific. Intense metamorphism of the Cretaceous rocks is stated to have taken place. During the Tertiary ages the Rocky Mountains were permanently raised above the sea, and gradually elevated to their present height. Vast lakes existed among them, in which, as in the Miocene basins of the Alps, enormous masses of sediment accumulated. The slopes of the land were clothed with an abundant vegetation, in which, as already stated (*ante*, p. 324), we may trace the ancestors of many of the living trees of North America. One of the most striking features in the later phases of this history was the outpouring of great floods of trachyte and other lavas from many points and fissures over a vast space of the Rocky Mountains. In the Snake River region these lavas have a depth of 700 to 1000 feet, over an area 300 miles in breadth.

These examples show that the elevation of mountains has been occasional and, so to speak, paroxysmal. Long intervals elapsed when a slow subsidence took place, but at last a point was reached when the descending crust, unable any longer to withstand the accumulated lateral pressure, was forced to find relief by rising into mountain ridges. With this effort the elevatory movements ceased. They were followed either by a stationary period, or more usually by a renewal of the gradual depression, until eventually relief was again obtained by upheaval, sometimes along new lines, but often on those which had previously been used.

We see also how, by such enormous compression, the rocks should have acquired a cleavage structure (*ante*, p. 272). Soft clays have been squeezed and folded till they have become hard fissile slates. So intense have been the corrugation and compression that the strata have undergone a chemical rearrangement of their particles; they have been "metamorphosed" or changed into schists and gneisses, if indeed some portions of them have not been actually fused and intruded into the surrounding masses as igneous rocks.

The consideration of these changes enables us to realize why the strata of a great mountain chain should rise into steeper folds as they are traced away from the plains, until they are found at last folded back upon themselves, and the older are made to overlie the younger. Instead of overlying the central and more ancient masses of the range, they seem really to dip into and under them, so that a section across the region might convey the impression of a great syncline instead of a great and complicated anticline. This fan-shaped arrangement of the rocks may be observed even in the single mountains of a great chain. Mount Blanc is a familiar example.

Another piece of geological structure is sometimes brought vividly before us by the examination of these regions of disturbance. Not only have the rocks been crumpled and inverted; they have likewise been traversed by great dislocations. Those on one side of a fissure have been pushed bodily over those on the other side, or they have experienced a vertical displacement of hundreds or even thousands of feet. As a rule, however, dislocations are more easily traced, if they are not also larger and more numerous, among the low grounds than among the mountains. One of the most remarkable and important faults in Europe is that which bounds the southern edge of the Belgian coal-field. It can be traced across Belgium, has recently been detected in the Boulonnais (*ante*, p. 310, *note*), and may not improbably run beneath the Secondary and Tertiary rocks of the south of England. It is a remarkable fact that faults which have a vertical displacement of many thousands of feet produce little or no effect upon the surface. The great Belgian fault, for example, is crossed by the valleys of the Meuse, and other northerly-flowing streams. Yet so indistinctly is it marked in the Meuse valley that no one would suspect its existence from any peculiarity in the general form of the ground, and even an experienced geologist, until he had learned the structure of the district, would scarcely detect any fault at all.

With the fractures along mountain chains we may connect the hot springs so frequently to be met with in these regions. But the most important connection with the heated interior is that established by volcanic vents. The theory of secular contraction, while affording a rational explanation of the origin of the great terrestrial ridges, serves at the same time to show why volcanoes should so frequently rise along these ridges (*ante*, p. 226). The elevation of the crust, by diminishing the pressure on the parts beneath the upraised tracts, permits them to assume a liquid condition, and to rise within reach of the surface when, driven upwards by the expansion of superheated vapors, they are ejected in the form of lava or ashes.

It appears therefore that the present contours of the earth's surface must be due in large measure to the effects of the contraction of a cooling globe. The crust has been repeatedly corrugated, sometimes suffering sudden and paroxysmal shocks, at other times undergoing slow and long-continued upheaval and depression.

But these subterranean movements form only one phase of the operations by which the outlines of the land have been produced. They have ridged up the solid crust above the sea-level, and have thus given rise to land, but the land as we now see it has acquired its features from the prolonged and varied action of the epigene agents upon rocks of very varied heights and powers of resistance.

It is evident that, as a whole, the land suffers ceaseless erosion from the time that it appears above water. It is likewise clear, from the nature of the materials composing most of the rocks of the land, that they have been derived from old denudations of the same kind. And thus, side by side with the various upheavals and subsidences, there has been a continuous removal of materials from the land, and an equally persistent deposit of these materials under water, and consequent growth of new rocks.

This degradation of the surface may be aptly compared to a process of sculpturing, which begins as soon as the land emerges from the sea, and never ceases so long as any portion of the land remains above water. The implements employed by nature in this great work are those epigene forces whose operations have already been described. Each of them, like a special kind of graving tool, produces its own characteristic impress on the land. The work of rain, of frost, of rivers, of glaciers, can be readily discriminated, though they all combine harmoniously towards the achievement of their one common task. Hence the present contours of the land must depend partly (1) on the vigor with which the several epigene agents perform their work of erosion, (2) on the original configuration of the ground, and the influence it may have had in guiding the operations of these agents, and (3) on the varying structure and powers of resistance possessed by the rocks.

1. Taking a broad view of denudation, we may conveniently group together the action of air, frost, springs, rivers, glaciers, and the other agents which wear down the surface of the land, under the one common designation of subaerial, and that of the sea as marine. The general results of subaerial action are—to furrow and channel the land, to erode valleys, to sharpen and splinter the ridges of mountains, and thus, while roughening, to lower the general surface and carry out the detritus to the sea. The action of the sea, on the other hand, is to plane down the land to the level at which the influence of breakers and ground-swell ceases to have any erosive effect; the flat platform, so often visible between tide-marks on a rocky exposed coast-line, is an impressive illustration of the tendency of marine denudation. The combined result of subaerial and marine action, if unimpeded by any subterranean movement, would evidently be to reduce the land to one general level under the sea. For, except in that upper marginal zone where the waves and tidal currents play, the waters of the ocean protect the solid rocks which they cover. And the rocks indeed can find no permanent protection anywhere else. But to reduce a large area of land such as a continent to the condition of a submarine plain, would require a longer period of time than seems to have elapsed between two epochs of upheaval. Traces of ancient plains of marine denudation are to be met with in Scandinavia and in Scotland, on but a comparatively small scale, as if there had been time for only a narrow platform to be formed before the next paroxysm of contraction and uplift completely renovated the geography of the region.

Instead of trying to estimate how much work is done by each of the subaerial agents in eroding the land, we gain a much more impressive idea of the reality and magnitude of their work as a whole by treating their operations as one great process, the effects of which can be actually measured. The true gauge of the present yearly waste of the surface of the land is furnished by the amount of mineral matter carried every year into the sea by rivers. This mineral matter is partly in mechanical suspension, partly in chemical solution, and is to no small extent pushed in the form of shingle and sand along the bottoms of the streams. Some data respecting its amount have been already given (*ante*, pp. 243, 247). If we take the ratios furnished by the Mississippi as a fair average, which, from the vast area and varied climatal and geographical characters of the region drained by that river, they probably are, then we learn that $\frac{1}{6000}$th of a foot is worn away from the general surface of the land every year. At this rate, if the present erosion could be sustained, the whole American continent, of which, according to Humboldt, the mean height is 748 feet, would be worn down to the sea-level in about $4\frac{1}{2}$ millions of years —a comparatively short period in geological chronology. It is obvious, however, that the denudation is not equally distributed over the whole surface of the land. If $\frac{1}{6000}$th of a foot is the mean rate from the whole surface, then some parts, including the more level grounds, must lose very much less than that amount, while other parts, such as the slopes and valleys, must lose very much more. The proportions between these extremes must continually vary throughout every country, according to angle of declivity, nature of surface, amount and distribution of rainfall, and whether the rain is spread over the year or concentrated into a short period.

The proportion between the area covered by the more level ground of a country, where the rate of denudation is least, and that of the declivities, valleys, and stream channels, where that rate is greatest, may be assumed as nine to one. The extent of the annual waste may be further taken to be nine times greater over the latter than over the former, so that, while the more level parts of the surface have been lowered 1 foot, the valleys have lost 9 feet. Taking the mean rates of waste over the whole area to be $\frac{1}{6000}$th of a foot per annum, we find that on these data the annual loss amounts to $\frac{5}{9}$ths of a foot from the flatter grounds and 5 feet from the valleys in 6000 years. This is equal to a loss of 1 foot from the former in 10,800 years and from the later in 1200 years, or to $\frac{1}{12}$th of an inch from the one in 75 and from the other in $8\frac{1}{2}$ years. At this rate of erosion, a valley 1000 feet deep may be excavated in 1,200,000 years. These estimates are only approximations to the truth, but they are valuable in directing attention to the real efficacy of the apparently insignificant subaerial denudation now in progress. Any other estimates of the relative amount of material worn away from the different parts of the surface may be taken, but the mean annual loss from the whole area, as ascertained by the river discharge, remains unaffected. If we represent too large an amount as removed from the valleys we diminish the loss from the open country, or if we make the contingent derived from the latter too great we lessen that from the former.

2. From this reasoning it follows that, apart altogether from irregularities of surface due to inequalities of upheaval, every area of land exposed to ordinary subaerial action must, in the end, be channelled into a system of valleys. Even a smooth featureless tract elevated uniformly above the sea would eventually be widely and deeply eroded. Nor would this require a long geological period, for, at the present rate of waste in the Mississippi basin, valleys 800 feet might be carved out in a million years. Undoubtedly the original features superinduced by subterranean action would guide and modify the operations of running water, though their influence would certainly wane as the features themselves slowly disappeared. In no case probably would the aboriginal contour remain through a succession of geological periods. Traces of it might still be discernible, but they would be well-nigh effaced by the new outlines produced by the superficial agents. In the vast

tablelands of Colorado and the western Territories of the United States an impressive picture is visible of the results of mere subaerial erosion on undisturbed and nearly level strata. Systems of stream-courses and valleys, river gorges unexampled elsewhere in the world for depth and length, vast winding lines of escarpment, like ranges of seacliffs, terraced slopes rising from plateau to plateau, huge buttresses and solitary stacks standing like islands out of the plains, great mountain masses towering into picturesque peaks and pinnacles cleft by innumerable gullies, yet everywhere marked by the parallel bars of the horizontal strata out of which they have been carved—these are the orderly symmetrical characteristics of a country where the scenery is due entirely to the action of subaerial agents on the one hand and the varying resistance of perfectly regular stratified rocks on the other. The Alps, on the contrary, present an instructive example of the kind of scenery that arises where a mass of high ground has resulted from the intense corrugation and upheaval of a complicated series of stratified and crystalline rocks, subsequently for a vast period carved by rain, frost, springs, and glaciers. We see how, on the outer flanks of those mountains among the ridges of the Jura, the strata begin to undulate in long wave-like ridges, and how, as we enter the main chain, the undulations assume a more gigantic tumultuous character, until, along the central heights, the mountains lift themselves towards the sky like the storm-swept crests of vast earth billows. The whole aspect of the ground suggests intense commotion. Where the strata appear along the cliffs or slopes they may often be seen twisted and crumpled on the most gigantic scale. Out of this complicated mass of material the subaerial forces have been ceaselessly at work since its first elevation. They have cut out valleys, sometimes along the original depressions, sometimes down the slopes. They have eroded lake-basins, dug out corries or *cirques*, notched and furrowed the ridges, splintered the crests, and have left no part of the original surface unmodified. But they have not effaced all traces of the convulsions by which the Alps were upheaved.

3. The details of the sculpture of the land have mainly depended on the nature of the materials on which nature's erosive tools have been employed. The joints by which all rocks are traversed have served as dominant lines along which the rain has filtered, and the springs have risen, and the frost wedges have been driven. On the high bare scarps of a high mountain the inner structure of the mass is laid open, and there the system of joints is seen to have determined the lines of crest, the vertical walls of cliff and precipice, the forms of buttress and recess, the position of cleft and chasm, the outline of spire and pinnacle. On the lower slopes even under the tapestry of verdure which nature delights to hang where she can over her naked rocks, we may detect the same pervading influence of the joints upon the forms assumed by ravines and crags. Each kind of rock, too, gives rise to its own characteristic form of scenery. The massive crystalline rocks, such as granite. yield each in its own fashion to the resistless attacks of the denuding forces. They are broadly marked off from the stratified rocks in which the parallel bands of the bedding form a leading feature in every cliff and bare mountain slope. Among the latter rocks also very distinctive types of surface may be observed. A range of sandstone hills, for example, presents a marked contrast to one of limestone.

In the physiography of any region, the mountains are the dominant features. A true mountain chain consists of rocks which have been crumpled and pushed up in the manner already described. But ranges of hills almost mountainous in their bulk may be formed by the gradual erosion of valleys out of a mass of original high ground. In this way some ancient tablelands, those of Norway and of the Highlands of Scotland, for example, have been so channeled by deep fjords and glens that they now consist of massive rugged hills, either isolated or connected along the flanks. The forms of the valleys thus eroded have been governed partly by the structure and composition of the rocks, and partly by the relative potency of the different denuding agents. Where the influence of rain and frost has been slight, and the streams, supplied from distant sources, have had sufficient declivity, deep, narrow, precipitous ravines or gorges have been excavated. The cañons of the Colorado are a magnificent example of this result. Where, on the other hand, ordinary atmospheric action has been more rapid, the sides of the river channels have been attacked, and open sloping glens and valleys have been hollowed out. A gorge or defile is usually due to the action of a waterfall, which, beginning with some abrupt declivity or precipice in the course of the river when it first commenced to flow, or caused by some hard rock crossing the channel, has eaten its way backward, as already explained (p. 245).

Lakes may have been formed in several ways. 1. By subterranean movements as, for example, during those which gave rise to mountain chains. But these hollows, unless continually deepened by subsequent movements of a similar nature would be filled up by the sediment continually washed into them from the adjoining slopes. The numerous lakes in such a mountain system as the Alps cannot be due merely to this cause, unless we suppose the upheaval of the mountains to have been geologically quite recent, or that subsidence must take place continuously or periodically below each independent basin. But there is evidence that the upheaval of the lakes is not of recent date, while the idea of perpetuating lakes by continual subsidence would demand, not in the Alps merely, but all over the northern hemisphere where lakes are so abundant, an amount of subterranean movement of which, if it really existed, there would assuredly be plenty of other evidence. 2. By irregularities in the deposition of superficial accumulations prior to the elevation of the land or during the disappearance of the ice-sheet. The numerous tarns and lakes enclosed within mounds and ridges of drift-clay and gravel are examples. 3. By the accumulation of a barrier across the channel of a stream and the consequent ponding back of the water. This may be done, for instance, by a landslip, by the advance of a glacier across a valley, or by the throwing up of a bank by the sea across the mouth of a river. 4. By erosion. The only agent capable of excavating hollows out of the solid rock such as might form lake-basins is glacier-ice (*ante*, p. 250). It is a remarkable fact, of which the significance may now be seen, that the innumerable lake-basins of the northern hemisphere lie on surfaces of intensely ice-worn rock. The striæ can be seen on the smoother rock-surfaces slipping into the water on all sides. These striæ were produced by ice moving over the rock. If the ice could, as the striæ prove, descend into the rock-basins and mount up the farther side, smoothing and striating the rock as it went, it could erode the basins. It is hardly possible to convey in words an adequate conception of the enormous extent to which the north of Europe and North America has had its surface ground down by ice. The ordinary rough surfaces produced by atmospheric disintegration have been replaced by a peculiar flowing contour which is traceable even to below the sea-level.

In the general subaerial denudation of a country, innumerable minor features are worked out as the structure of the rocks controls the operations of the eroding agents. Thus, among comparatively undisturbed strata, a hard bed resting upon others of a softer kind is apt to form along its outcrop a line of cliff or escarpment. Though a long range of such cliffs resembles a coast that has been worn by the sea, it may be entirely due to mere atmospheric waste. Again, the more resisting portions of a rock may be seen projecting as crags or knolls. An igneous mass will stand out as a bold hill from amidst the more decomposable strata through which it has risen. These features, often so marked on the lower grounds, attain their most conspicuous development among the higher and barer parts of the mountains, where subaerial disintegration is most rapid. The torrents tear out deep gullies from the sides of the declivities. Corries are scooped out on the one hand, and naked precipices are left on the other. The harder bands of rock project as massive ribs down the slopes, shoot up into prominent *aiguilles*, or give to the summits the notched saw-like outlines they so often present.

Tablelands may sometimes arise from the abrasion of hard rocks and the production of a level plain by the action of the sea, or rather of that action combined with the previous degradation of the land by subaerial waste. But most of the great tablelands of the globe seem to be platforms of little disturbed strata which have been upraised bodily to a considerable elevation. No sooner, however, are they placed in that position than they are attacked by running water, and begin to be hollowed out into systems of valleys. As the valleys sink, the platforms between them grow into narrower and more definite ridges, until eventually the level tableland is converted into a complicated network of hills and valleys, wherein, nevertheless, the key to the whole arrangement is furnished by a knowledge of the disposition and effects of the flow of water. The examples of this process brought to light in the States of Colorado and Nevada, and in Wyoming and the other western Territories, by Newberry, King, Hayden, Powell, and other explorers, are among the most striking monuments of geological operations in the world.

The materials worn from the surface of the higher are spread out over the lower grounds. We have already traced how streams at once begin to drop their freight of sediment when, by the lessening of their declivity, their carrying power is diminished (pp. 245–6). The great plains of the earth's surface are due to this deposit of gravel, sand, and loam. They are thus monuments at once of the destructive and reproductive processes which have been in progress unceasingly since the first land rose above the sea and the first shower of rain fell. Every pebble and particle of their soil, once part of the distant mountains, has travelled slowly and fitfully downward. Again and again have these materials been shifted, ever moving downward and sea-ward. For centuries, perhaps, they have taken their share in the fertility of the plains and have ministered to the necessities of flower and tree, of the bird of the air, the beast of the field, and of man himself. But their destiny is still the great ocean. In that bourne alone can they find undisturbed repose, and there, slowly accumulating in massive beds, they will remain until, in the course of ages, renewed upheaval shall raise them into future land, there once more to pass through the same cycle of change. (A. GE.)

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GEOMETRY.—Part I.—Pure Geometry.—Geometry has been divided since the time of Euclid into an "elementary" and a "higher" part. The contents and limits of the former have been fixed by Euclid's *Elements*. The latter included at the time of the Greek mathematicians principally the properties of the conic sections and of a few other curves. The methods used in both were essentially the same. These began to be replaced during the 17th century by more powerful methods, invented by Roberval, Pascal, Desargues, and others. But the impetus which higher geometry received in their works was soon arrested, in consequence of the discoveries of Descartes,—the new calculus to which these gave rise absorbing the attention of mathematicians almost exclusively, until Monge, at the end of the 18th century, re-established "pure" as distinguished from Descartes's "co-ordinate" (or analytical) geometry. Since then the purely geometrical methods have been continuously extended, especially by Poncelet, Steiner, Von Staudt, and Cremona, and in England by Hirst and Henry Smith, to mention only a few of the leading names.

Whilst higher geometry thus made most rapid progress, the elementary part remained almost unaltered. It has been taught up to the present day on the basis of Euclid's *Elements*, the latter being either used directly as a text-book (in England), or being replaced (in most parts of the Continent) by text-books which are essentially Euclid's *Elements* rewritten, with a few additions about the mensuration of the circle, cone, cylinder, and sphere. Only within a very recent period have attempts been made to change the character of the elementary part by introducing some of the modern methods.

We shall give in this article—first, a survey of elementary geometry as contained in Euclid's *Elements*, and then, in form of an independent treatise, an introduction to higher geometry, based on modern methods. In the former part we shall suppose that a copy of Euclid's *Elements* is in the hands of the reader, so that we may dispense, as a rule, with giving proofs or drawing figures. We thus shall give only the contents of his propositions grouped together in such a way as to show their connection, and often expressed in words which differ from the verbal translation in order to make their meaning clear. It will make little difference which of the many English editions of Euclid's *Elements* the reader takes. Of these we may mention Simson's, Potts's, and Todhunter's.

Section I.—Elementary or Euclidian Geometry.

The Axioms.

§ 1. The object of geometry is to investigate the properties of space. The first step must consist in establishing those fundamental properties from which all others follow by processes of deductive reasoning. They are laid down in the Axioms, and these ought to form such a system that nothing need be added to them in order fully to characterize space, and that nothing may be left out without making the system incomplete. They must, in fact, completely "define" space. Several such systems are conceivable. Euclid has given one, others have been put forward in recent times by Riemann (*Abhandl. der königl. Gesellsch. zu Göttingen*, vol. xiii.), by Helmholz (*Göttinger Nachrichten*, June, 1868), and by Grassmann (*Ausdehnungslehre von 1844*). How many axioms the system ought to contain, and which system is the simplest, may be said to be still an open question. We shall consider only Euclid's system.

§ 2. The axioms are obtained from inspection of space and of solids in space,—hence from experience. The same source gives us the notions of the geometrical entities to which the axioms relate, viz., solids, surfaces, lines of curves, and points. A solid is directly given by experience; we have only to abstract all material from it in order to gain the notion of a geometrical solid. This has shape, size, position, and may be moved. Its boundary or boundaries are called surfaces. They separate one part of space from another, and are said to have no thickness. Their boundaries are curves or lines, and these have length only. Their boundaries, again, are points, which have no magnitude but only position. We thus come in three steps from solids to points which have no magnitude; in each step we lose one extension. Hence we say a solid has three dimensions, a surface two, a line one, and a point none. Space itself, of which a solid forms only a part, is also said to be of three dimensions. The same thing is intended to be expressed by saying that a solid has length, breadth, and thickness, a surface length and breadth, a line length only, and a point no extension whatsoever.

Euclid gives the essence of these statements as definitions:—

Def. 1, I. *A point is that which has no parts, or which has no magnitude.*
Def. 2, I. *A line is length without breadth.*
Def. 5, I. *A superficies is that which has only length and breadth.*
Def. 1, XI. *A solid is that which has length, breadth, and thickness.*

If we allow motion in geometry,—and it seems impossible to avoid it,—we may generate these entities by moving a point, a line, or a surface, thus:—

The path of a moving point is a line.
The path of a moving line is, in general, a surface.
The path of a moving surface is, in general, a solid.

And we may then assume that the lines, surfaces, and solids, as defined before, can all be generated in this manner. From this generation of the entities it follows again that the boundaries—the first and last position of the moving element—of a line, are points, and so on; and thus we come back to the considerations with which we started.

Euclid points this out in his definitions,—Def. 3, I., Def. 6, I., and Def. 2, XI. He does not, however, show the connection which these definitions have with those mentioned before. When points and lines have been defined, a statement like Def. 3, I., "The extremities of a line are points," is a proposition which either has to be proved, and then it is a theorem, or which has to be taken for granted, in which case it is an axiom. And so with Def. 6, I., and Def. 2, XI.

§ 3. Euclid's definitions mentioned above are attempts to describe, in a few words, notions which we have obtained by inspection of and abstraction from solids. A few more notions have to be added to these, principally those of the simplest line—the straight line, and of the simplest surface—the flat surface or plane. These notions we possess, but to define them accurately is difficult. Euclid's Definition 4, I., "A straight line is that which lies evenly between its extreme points," must be meaningless to any one who has not the notion of straightness in his mind. Neither does it state a property of the straight line which can be used in any further investigation. Such a property is given in Axiom 10, I. It is really this axiom, together with Postulates 2 and 3, which characterizes the straight line.

Whilst for the straight line the verbal definition and axiom are kept apart, Euclid mixes them up in the case of the plane. Here the Definition 7, I., includes an axiom. It defines a plane as a surface which has the property that every straight line which joins any two points in it lies altogether in the surface. But if we take a straight line and a point in such a surface, and draw all straight lines which join the latter to all points in the first line, the surface will be fully determined. This construction is therefore sufficient as a definition. That every other straight line which joins any two points in this surface lies altogether in it is a further property, and to assume it gives another axiom.

Thus a number of Euclid's axioms are hidden among his first definitions. A still greater confusion exists in the present editions of Euclid between the postulates and axioms so-called, but this is due to later editors and not to Euclid himself. The latter had the last three axioms put together with the postulates (αἰτήματα), so that these were meant to include all assumptions relating to space. The remaining assumptions which relate to magnitudes in general, viz., the first eight "axioms" in modern editions, were called "common notions" (κοιναὶ ἔννοιαι). Of the latter a few may be said to be definitions. Thus the eighth might be taken as a definition of "equal," and the seventh of halves. If we wish to collect the axioms used in Euclid's *Elements*, we have therefore to take the three postulates, the last three axioms as generally given, a few axioms hidden in the definitions, and an axiom used by Euclid in the proof of Prop. 4 and on a few other occasions, viz., that figures may be moved in space without change of shape or size.

We shall not enter into the investigation how far the assumptions which would be included in such a list are sufficient, and how far they are necessary. It may be sufficient here to state that from the beginning of a geometrical science to the present century attempts without end have been made to prove the last of Euclid's axioms, that only at the beginning of the present century the futility of this attempt was shown, and that only within the last twenty years the true nature of the connection between the axioms has become known through the researches of Riemann and Helmholz, although Grassmann had published already, in 1844, his classical but long-neglected *Ausdehnungslehre*.

§ 4. The assumptions actually made by Euclid may be stated as follows:—

1. Straight lines exist which have the property that any one of them may be produced both ways without limit, that through any two points in space such a line may be drawn, and that any two of them coincide throughout their indefinite extensions as soon as two points in the one coincide with two points in the other. (This gives the contents of Def. 4, part of Def. 35, the first two Postulates and Axiom 10.)
2. Plane surfaces or planes exist having the property laid down in Def. 7, that every straight line joining any two points in such a surface lies altogether in it.
3. Right angles, as defined in Def. 10, are possible, and all right angles are equal; that is to say, wherever in space we take a plane, and wherever in that plane we construct a right angle, all angles thus constructed will be equal, so that any one of them may be made to coincide with any other. (Axiom 11.)
4. The 12th Axiom of Euclid. This we shall not state now, but only introduce it when we cannot proceed any further without it.
5. Figures may be freely moved in space without change of shape or size. This is assumed by Euclid, but not stated as an axiom.
6. In any plane a circle may be described, having any point in that plane as centre, and its distance from any other point in that plane as radius. (Postulate 3.)

The definitions which have not been mentioned are all "nominal definitions," that is to say, they fix a name for a thing described. Many of them overdetermine a figure. (Compare notes to definitions in Simson's or Todhunter's edition.)

§ 5. Euclid's *Elements* are contained in thirteen books. Of these the first four and the sixth are devoted to "plane geometry," as the investigation of figures in a plane is generally called. The 5th book contains the theory of proportion which is used in Book VI. The 7th, 8th, and 9th books are purely arithmetical, whilst the 10th contains a most ingenious treatment of geometrical irrational quantities. These four books will be excluded from our survey. The remaining three books relate to figures in space, or, as it is generally called, to "solid geometry." The 7th, 8th, 9th, 10th, 13th, and part of the 11th and 12th books are now generally omitted from the school editions of the *Elements*. In the first four and in the 6th book it is to be understood that all figures are drawn in a plane.

Book I. of Euclid's "Elements."

§ 6. According to the third postulate it is possible to draw in any plane a circle which has its centre at any given point, and its radius equal to the distance of this point from any other point given in the plane. This makes it possible (Prop. 1) to construct on a given line AB an equilateral triangle, by drawing first a circle with A as centre and AB as radius, and then a circle with B as centre and BA as radius. The point where these circles intersect—that they intersect Euclid quietly assumes—is the vertex of the required triangle. Euclid does not suppose, however, that a circle may be drawn which has its radius equal to the distance between any two points unless one of the points be the centre. This implies also that we are not supposed to be able to make any straight line equal to any other straight line, or to carry a distance about in space. Euclid therefore next solves the problem: It is required along a given straight line from a point in it to set off a distance equal to the length of another straight line given anywhere in the plane. This is done in two steps. It is shown in Prop. 2 how a straight line may be drawn from a given point equal in length to another given straight line not drawn from that point. And then the problem itself is solved in Prop. 3, by drawing first through the given point some straight line of the required length, and then about the same point as centre a circle having this length as radius. This circle will cut off from the given straight line a length equal to the required one. Now-a-days, instead of going through this long process, we take a pair of compasses and set off the given length by its aid. This assumes that we may move a length about without changing it. But Euclid has not assumed it, and this proceeding would be fully justified by his desire not to take for granted more than was necessary, if he were not obliged at his very next step actually to make this assumption though without stating it.

§ 7. We now come (in Prop. 4) to the first theorem. It is the fundamental theorem of Euclid's whole system, there being only a very few propositions (like Props. 13, 14, 15, I.), except those in the 5th book and the first half of the 11th, which do not depend upon it. It is stated very accurately, though somewhat clumsily, as follows:—

If two triangles have two sides of the one equal to two sides of the other, each to each, and have also the angles contained by those sides equal to one another, they shall also have their bases or third sides equal; and the two triangles shall be equal; and their other angles shall be equal, each to each, namely, those to which the equal sides are opposite.

That is to say, the triangles are "identically" equal, and one may be considered as a copy of the other. The proof is very simple. The first triangle is taken up and placed on the second, so that the parts of the triangles which are known to be equal fall upon each other. It is then easily seen that also the remaining parts of one coincide with those of the other, and that they are therefore equal. This process of applying one figure to another Euclid scarcely uses again, though many proofs would be simplified by doing so. The process introduces motion into geometry, and includes, as already stated, the axiom that figures may be moved without change of shape or size.

If the last proposition be applied to an isosceles triangle, which has two sides equal, we obtain the theorem (Prop. 5), *if two sides of a triangle are equal, then the angles opposite these sides are equal.*

Euclid's proof is somewhat complicated and a stumbling-block to many schoolboys. The proof becomes much simpler if we consider the isosceles triangle ABC ($AB = AC$) twice over, once as a triangle BAC, and once as a triangle CAB; and now remember that AB, AC in the first are equal respectively to AC, AB in the second, and the angles included by these sides are equal. Hence the triangles are equal, and the angles in the one are equal to those in the other, viz,, those which are opposite equal sides, *i. e.*, angle ABC in the first equals angle ACB in the second, as they are opposite the equal sides AC, and AB in the two triangles.

There follows the converse theorem (Prop. 6). *If two angles in a triangle are equal, then the sides opposite them are equal,*—*i. e.*, the triangle is isosceles. The proof given consists in what is called a *reductio ad absurdum*, a kind of proof often used by Euclid, and principally in proving the converse of a previous theorem. It assumes that the theorem to be proved is wrong, and then shows that this assumption leads to an absurdity, *i. e.*, to a conclusion which is in contradiction to a proposition proved before—that therefore the assumption made cannot be true, and hence that the theorem is true. It is often stated that Euclid invented this kind of proof, but the method is most likely much older.

§ 8. It is next proved *that two triangles which have the three sides of the one equal respectively to those of the other are identically equal, hence that the angles of the one are equal respectively to those of the other, those being equal which are opposite equal sides.* This is Prop. 8, Prop. 7 containing only a first step towards its proof.

These theorems allow now of the solution of a number of problems, viz.:—

To bisect a given angle (Prop. 9).

To bisect a given finite straight line (Prop. 10).

To draw a straight line perpendicularly to a given straight line through a given point in it (Prop. 11), *and also through a given point not in it* (Prop. 12).

The solutions all depend upon properties of isosceles triangles.

§ 9. The next three theorems relate to angles only, and might have been proved before Prop. 4, or even at the very beginning. The first (Prop. 13) says, *The angles which one straight line makes with another straight line on one side of it either are two right angles or are together equal to two right angles.* This theorem would have been unnecessary if Euclid had admitted the notion of an angle such that its two limits are in the same straight line, and had besides defined the sum of two angles.

Its converse (Prop. 14) is of great use, inasmuch as it enables us in many cases to prove that two straight lines drawn from the same point are one the continuation of the other. So also is

Prop. 15. *If two straight lines cut one another, the vertical or opposite angles shall be equal.*

§ 10. Euclid returns now to properties of triangles. Of great importance for the next steps (though afterwards superseded by a more complete theorem) is

Prop. 16. *If one side of a triangle be produced, the exterior angles shall be greater than either of the interior opposite angles.*

Prop. 17. *Any two angles of a triangle are together less than two right angles*, is an immediate consequence of it. By the aid of these two, the following fundamental properties of triangles are easily proved:—

Prop. 18. *The greater side of every triangle has the greater angle opposite to it;*

Its converse, Prop. 19. *The greater angle of every triangle is subtended by the greater side, or has the greater side opposite to it;*

Prop. 20. *Any two sides of a triangle are together greater than the third side;*

And also Prop. 21. *If from the ends of the side of a triangle there be drawn two straight lines to a point within the triangle, these shall be less than the other two sides of the triangle, but shall contain a greater angle.*

§ 11. Having solved two problems (Props. 22, 23), he returns to two triangles which have two sides of the one equal respectively to two sides of the other. It is known (Prop. 4) that if the included angles are equal, then the third sides are equal; and conversely (Prop. 8), if the third sides are equal, then the angles included by the first sides are equal. From this it follows that if the included angles are not equal, the third sides are not equal, and conversely, that if the third sides are not equal, the included angles are not equal. Euclid now completes this knowledge by proving, that "*if the included angles are not equal, then the third side in that triangle is the greater which contains the greater angle;*" and conversely, that "*if the third sides are unequal, that triangle contains the greater angle which contains the greater side.*" These are Prop. 24 and Prop. 25.

§ 12. The next theorem (Prop. 26) says that *if two triangles have one side and two angles of the one equal respectively to one side and two angles of the other, viz., in both triangles either the angles adjacent to the equal side, or one angle adjacent and one angle opposite it, then the two triangles are identically equal.*

This theorem belongs to a group with Prop. 4 and Prop. 8. Its first case might have been given immediately after Prop. 4, but the second case requires Prop. 16 for its proof.

§ 13. We come now to the investigation of parallel straight lines, *i. e.*, of straight lines which lie in the same plane, and cannot be made to meet however far they be produced either way. The investigation, which starts from Prop. 16, will become clearer if a few names be explained which are not all used by Euclid. If two straight lines be cut by a third, the latter is now generally called a "transversal" of the figure. It forms at the two points where it cuts the given lines four angles with each. Those of the angles which lie between the given lines are called interior angles, and of these, again, any two which lie on opposite sides of the transversal but one at each of the two points are called "alternate angles."

We may now state Prop. 16 thus:—*If two straight lines which meet are cut by a transversal, their alternate angles are unequal.* For the lines will form a triangle, and one of the alternate angles will be an exterior angle to the triangle, the other interior and opposite to it.

From this follows at once the theorem contained in Prop. 27. *If two straight lines which are cut by a transversal make alternate angles equal, the lines cannot meet, however far they be produced, hence they are parallel.* This proves the existence of parallel lines.

Prop. 28 states the same fact in different forms. *If a straight line, falling on two other straight lines, make the exterior angle equal to the interior and opposite angle on the same side of the line, or make the interior angles on the same side together equal to two right angles, the two straight lines shall be parallel to one another.*

Hence we know that, "if two straight lines which are cut by a transversal meet, their alternate angles are not equal;" and hence that, "if alternate angles are equal, then the lines are parallel."

The question now arises, Are the propositions converse to these true or not? That is to say, "If alternate angles are unequal, do the lines meet?" And "if the lines are parallel, are alternate angles necessarily equal?"

The answer to either of these two questions implies the answer to the other. But it has been found impossible to prove that the negation or the affirmation of either is true.

The difficulty which thus arises is overcome by Euclid assuming that the first question has to be answered in the affirmative. This gives his last axiom (12), which we quote in his own words.

AXIOM 12.—*If a straight line meet two straight lines, so as to make the two interior angles on the same side of it taken together less than two right angles, these straight lines, being continually produced, shall at length meet on that side on which are the angles which are less than two right angles.*

The answer to the second of the above questions follows from this, and gives the theorem Prop. 29. *If a straight line fall on two parallel straight lines, it makes the alternate angles equal to one another, and the exterior angle equal to the interior and opposite angle on the same side, and also the two interior angles on the same side together equal to two right angles.*

§ 14. With this a new part of elementary geometry begins. The earlier propositions are independent of this axiom, and would be true even if a wrong assumption had been made in it. They all relate to figures in a plane. But a plane is only one among an infinite number of conceivable surfaces. We may draw figures on any one of them and study their properties. We may, for instance, take a sphere instead of the plane, and obtain "spherical" in the place of "plane" geometry. If on one of these surfaces lines and figures could be drawn, answering to all the definitions of our plane figures, and if the axioms with the exception of the last all hold, then all propositions up to the 28th will be true for these figures. This is the case in spherical geometry if we substitute "shortest line" or "great circle" for "straight line," "small circle" for "circle," and if, besides, we limit all figures to a part of the sphere which is less than a hemisphere, so that two points on it cannot be opposite ends of a diameter, and therefore determine always one and only one great circle.

For spherical triangles, therefore, all the important propositions 4, 8, 26; 5 and 6; and 18, 19, and 20 will hold good.

This remark will be sufficient to show the impossibility of proving Euclid's last axiom, which would mean proving that this axiom is a consequence of the others, and hence that the theory of parallels would hold on a spherical surface, where the other axioms do hold, whilst parallels do not even exist.

It follows that the axiom in question states an inherent difference between the plane and other surfaces, and that the plane is only fully characterized when this axiom is added to the other assumptions.

§ 15. The introduction of the new axiom and of parallel lines leads to a new class of propositions.

After proving (Prop. 30) that "*two lines which are each parallel to a third are parallel to each other,*" we obtain the new properties of triangles contained in Prop. 32. Of these the second part is the most important, viz., the theorem, *The three interior angles of every triangle are together equal to two right angles.*

As easy deductions not given by Euclid but added by Simson follow the propositions about the angles in polygons, they are given in English editions as corollaries to Prop. 32.

These theorems do not hold for spherical figures. The sum of the interior angles of a spherical triangle is always greater than two right angles, and increases with the area.

§ 16. The theory of parallels as such may be said to be finished with Props. 33 and 34, which state properties of the parallelogram, *i. e.*, of a quadrilateral formed by two pairs of parallels. They are—

Prop. 33. *The straight lines which join the extremities of two equal and parallel straight lines towards the same parts are themselves equal and parallel;* and

Prop. 34. *The opposite sides and angles of a parallelogram are equal to one another, and the diameter (diagonal) bisects the parallelogram, that is, divides it into two equal parts.*

§ 17. The rest of the first book relates to areas of figures. The theory is made to depend upon the theorems—

Prop. 35. *Parallelograms on the same base and between the same parallels are equal to one another;* and

Prop. 36. *Parallelograms on equal bases, and between the same parallels, are equal to one another.*

As each parallelogram is bisected by a diagonal, the last theorems hold also if the word parallelogram be replaced by "triangle," as is done in Props. 37 and 38.

It is to be remarked that Euclid proves these propositions only in the case when the parallelograms or triangles have their bases in the same straight line.

The theorems converse to the last form the contents of the next three propositions, viz.:—

Theorem (Props. 40 and 41).—*Equal triangles, on the same or on equal bases, in the same straight line, and on the same side of it, are between the same parallels.*

That the two cases here stated are given by Euclid in two separate propositions proved separately is characteristic of his method.

§ 18. To compare areas of other figures, Euclid shows first, in Prop. 42, how *to draw a parallelogram which is equal in area to a given triangle, and has one of its angles equal to a given angle.* If the given angle is right, then the problem is solved *to draw a "rectangle" equal in area to a given triangle.*

Next this parallelogram is transformed into another parallelogram, *which has one of its sides equal to a given straight line*, whilst its angles remain unaltered. This may be done by aid of the theorem in

Prop. 43. *The complements of the parallelograms which are about the diameter of any parallelogram are equal to one another.*

Thus the problem (Prop. 44) is solved *to construct a parallelogram on a given line, which is equal in area to a given triangle, and which has one angle equal to a given angle* (generally a right angle).

As every polygon can be divided into a number of triangles, we can now construct a parallelogram having a given angle, say a right angle, and being equal in area to a given polygon. For each of the triangles into which the polygon has been divided, a parallelogram may be constructed, having one side equal to a given straight line, and one angle equal to a given angle. If these parallelograms be placed side by side, they may be added together to form a single parallelogram, having still one side of the given length. This is done in Prop. 45.

Herewith a means is found to compare areas of different polygons. We need only construct two rectangles equal in area to the given polygons, and having each one side of given length. By comparing the unequal sides we are enabled to judge whether the areas are equal, or which is the greater. Euclid does not state this consequence, but the problem is taken up again at the end of the second book, where it is shown how to construct a square equal in area to a given polygon.

§ 19. The first book concludes with one of the most important theorems in the whole of geometry, and one which has been celebrated since the earliest times. It is stated, but on doubtful authority, that Pythagoras discovered it, and it has been called by his name. If we call that side in a right-angled triangle which is opposite the right angle the hypotenuse, we may state it as follows:—

Theorem of Pythagoras (Prop. 47).—*In every right-angled triangle the square on the hypotenuse is equal to the sum of the squares of the other sides.*

And conversely—

Prop. 48. *If the square described on one of the sides of a triangle be equal to the squares described on the other sides, then the angle contained by these two sides is a right angle.*

On this theorem (Prop. 47) almost all geometrical measurement depends, which cannot be directly obtained.

Book II.

§ 20. The propositions in the second book are very different in character from those in the first; they all relate to areas of rectangles and squares. Their true significance is best seen by stating them in an algebraic form. This is often done by expressing the lengths of lines by aid of numbers, which tell how many times a chosen unit is contained in the lines. If there is a unit to be found which is contained an exact number of times in each side of a rectangle, it is easily seen, and generally shown in the teaching of arithmetic, that the rectangle contains a number of unit squares equal to the product of the numbers which measure the sides, a unit square being the square on the unit line. If, however, no such unit can be found, this process requires that connection between lines and numbers which is only established by aid of ratios of lines, and which is therefore at this stage altogether inadmissible. But there exists another way of connecting these propositions with algebra, based on modern notions which seem destined greatly to change and to simplify mathematics. We shall introduce here as much of it as is required for our present purpose.

At the beginning of the second book we find a definition according to which "a rectangle is said to be 'contained' by the two sides which contain one of its right angles;" in the text this phraseology is extended by speaking of rectangles contained by any two straight lines, meaning the rectangle which has two adjacent sides equal to the two straight lines.

We shall denote a finite straight line by a single small letter, $a, b, c, \ldots x$, and the area of the rectangle contained by two lines a and b by ab, and this we shall call the product of the two lines a and b. It will be understood that this definition has nothing to do with the definition of a product of numbers.

We define as follows:—

The *sum* of two straight lines a and b means a straight line c which may be divided in two parts equal respectively to a and b. This sum is denoted by $a+b$.

The *difference* of two lines a and b (in symbols, $a-b$) means a line c which when added to b gives a; that is

$$a-b=c \text{ if } b+c=a.$$

The *product* of two lines a and b (in symbols, ab) means the area of the rectangle contained by the lines a and b. For aa, which means the square on the line a, we write a^2.

§ 21. The first ten of the fourteen propositions of the second book may then be written in the form of formulæ as follows:—

Prop. 1. $a(b+c+d+\ldots)=ab+ac+ad+\ldots$
" 2. $ab+ac=a^2$ if $b+c=a$.
" 3. $a(a+b)=a^2+ab$.
" 4. $(a+b)^2=a^2+2ab+b^2$.
" 5. $(a+b)(a-b)+b^2=a^2$.
" 6. $(a+b)(a-b)+b^2=a^2$.
" 7. $a^2+(a-b)^2=2a(a-b)+b^2$.
" 8. $4(a+b)a+b^2=(2a+b)^2$.
" 9. $(a+b)^2+(a-b)^2=2a^2+2b^2$.
" 10. $(a+b)^2+(a-b)^2=2a^2+2b^2$.

It will be seen that 5 and 6, and also 9 and 10, are identical. In Euclid's statement they do not look the same, the figures being arranged differently.

If the letters $a, b, c, \ldots$ denoted numbers, it follows from algebra that each of these formulæ is true. But this does not prove them in our case, where the letters denote lines, and their products areas without any reference to numbers. To prove them we have to discover the laws which rule the operations introduced, viz., addition and multiplication of segments. This we shall do now; and we shall find that these laws are the same with those which hold in algebraical addition and multiplication.

§ 22. In a sum of numbers we may change the order in which the numbers are added, and we may also add the numbers together in groups, and then add these groups. But this also holds for the sum of segments and for the sum of rectangles, as a little consideration shows. That the sum of rectangles has always a meaning follows from the Props. 43–45 in the first book. These laws about addition are reducible to the two—

$$a+b=b+a \quad . \quad . \quad . \quad (1),$$
$$a+(b+c)=a \quad +c \quad . \quad . \quad (2);$$

or, when expressed for rectangles,

$$ab+ed=cd+ab \quad . \quad . \quad . \quad (3),$$
$$ab+(cd+ef)=ab+cd+ef \quad . \quad (4).$$

The brackets mean that the terms in the bracket have been added together before they are added to another term. The more general cases for more terms may be deduced from the above.

For the product of two numbers we have the law that it remains unaltered if the factors be interchanged. This also holds for our geometrical product. For if ab denotes the area of the rectangle which has a as base and b as altitude, then ba will denote the area of the rectangle which has b as base and a as altitude. But in a rectangle we may take either of the two lines which contain it as base, and then the other will be the altitude. This gives

$$ab=ba \quad . \quad . \quad . \quad . \quad (5).$$

In order further to multiply a sum by a number, we have in algebra the rule:—Multiply each term of the sum, and add the products thus obtained. That this holds for our geometrical products is shown by Euclid in his first proposition of the second book, where he proves that the area of a rectangle whose base is the sum of a number of segments is equal to the sum of rectangles which have these segments separately as bases. In symbols this gives, in the simplest case,

$$\left.\begin{array}{r} a(b+c)=ab+ac \\ \text{and} \quad (b+c)a=ba+ca \end{array}\right\} \quad . \quad . \quad . \quad . \quad . \quad . \quad (6).$$

To these laws which have been investigated by Sir William Hamilton and by Hermann Grassmann, the former has given special names. He calls the laws expressed in

(1) and (3) the commutative law for addition;
(5) " " multiplication;
(2) and (4) the associative laws for addition;
(6) the distributive law.

§ 23. Having proved that these six laws hold, we can at once prove every one of the above propositions in their algebraical form.

The first is proved geometrically, it being one of the fundamental laws. The next two propositions are only special cases of the first. Of the others we shall prove one, viz., the fourth:—

$$\begin{array}{lrll} & (a+b)^2 = (a+b)\,(a+b) & = (a+b)a + (a+b)b & \text{by (6).} \\ \text{But} & (a+b)a & = aa + ba & \text{by (6).} \\ & & = aa + ab & \text{by (5).} \\ \text{and} & (a+b)b & = ab + bb & \text{by (6).} \\ \text{Therefore} & (a+b)^2 & \left.\begin{array}{l} = aa + ab + (ab + bb) \\ = aa + (ab + ab) + bb \\ = aa + 2ab + bb \end{array}\right\} & \text{by (4).} \end{array}$$

This gives the theorem in question.

In the same manner every one of the first ten propositions is proved.

It will be seen that the operations performed are exactly the same as if the letters denoted numbers.

Props. 5 and 6 may also be written thus—

$$(a+b)\,(a-b) = a^2 - b^2.$$

Prop. 7, which is an easy consequence of Prop. 4, may be transformed. If we denote by c the line $a + b$, so that

$$c = a + b,\ a = c - b,$$

we get

$$\begin{aligned} c^2 + (c-b)^2 &= 2c(c-b) + b^2 \\ &= 2c^2 - 2bc + b^2. \end{aligned}$$

Subtracting c^2 from both sides, and writing a for c, we get

$$(a-b)^2 = a^2 - 2ab + b^2.$$

In Euclid's *Elements* this form of the theorem does not appear, all propositions being so stated that the notion of subtraction does not enter into them.

§ 24. The remaining two theorems (Props. 12 and 13) connect the square on one side of a triangle with the sum of the squares on the other sides, in case that the angle between the latter is acute or obtuse. They are important theorems in trigonometry, where it is possible to include them in a single theorem.

§ 25. There are in the second book two problems, Props. 11 and 14.

If written in the above symbolic language, the former requires to find a line x such that $a(a - x) = x^2$. Prop. 11 contains, therefore, the solution of a quadratic equation, which we may write $x^2 + ax = a^2$. The solution is required later on in the construction of a regular decagon.

More important is the problem in the last proposition (Prop. 14). It requires the construction of a square equal in area to a given rectangle, hence a solution of the equation

$$x^2 = ab.$$

In Book I., 42–45, it has been shown how a rectangle may be constructed equal in area to a given figure bounded by straight lines. By aid of the new proposition we may therefore now determine a line such that the square on that line is equal in area to any given rectilinear figure, or we can *square* any such figure.

As of two squares that is the greater which has the greater side, it follows that now the comparison of two areas has been reduced to the comparison of two lines.

The problem of reducing other areas to squares is frequently met with among Greek mathematicians. We need only mention the problem of squaring the circle.

In the present day the comparison of areas is performed in a simpler way by reducing all areas to rectangles having a common base. Their altitudes give then a measure of their areas.

The construction of a rectangle having the base u, and being equal in area to a given rectangle, depends upon Prop. 43, I. This therefore gives a solution of the equation

$$ab = ux,$$

where x denotes the unknown altitude.

Book III.

§ 26. The third book of the *Elements* relates exclusively to properties of the circle. A circle and its circumference have been defined in book I., Def. 15. We restate it here in slightly different words:—

Definition.—The circumference of a circle is a plane curve such that all points in it have the same distance from a fixed point in the plane. This point is called the "centre" of the circle.

Of the new definitions, of which eleven are given at the beginning of the third book, a few only require special mention. The first, which says that circles with equal radii are equal, is in part a theorem, but easily proved by applying the one circle to the other. Or it may be considered proved by aid of Prop. 24, equal circles not being used till after this theorem.

In the second definition is explained what is meant by a line which "touches" a circle. Such a line is now generally called a tangent to the circle. The introduction of this name allows us to state many of Euclid's propositions in a much shorter form.

For the same reason we shall call a straight line joining two points on the circumference of a circle a "chord."

Definitions 4 and 5 may be replaced with a slight generalization by the following:—

Definition.—By the distance of a point from a line is meant the length of the perpendicular drawn from the point to the line.

§ 27. From the definition of a circle it follows that every circle has a centre. Prop. 1 requires to find it when the circle is given, *i. e.*, when its circumference is drawn.

To solve this problem a chord is drawn (that is, any two points in the circumference are joined), and through the point where this is bisected a perpendicular to it is erected. Euclid then proves, first, that no point off this perpendicular can be the centre, hence that the centre must lie in this line; and, secondly, that of the points on the perpendicular one only can be the centre, viz., the one which bisects the part of the perpendicular bounded by the circle. In the second part Euclid silently assumes that the perpendicular there used does cut the circumference in two, and only in two points. The proof therefore is incomplete. The proof of the first part, however, is exact. By drawing two non-parallel chords, and the perpendiculars which bisect them, the centre will be found as the point where these perpendiculars intersect.

§ 28. In Prop. 2 it is proved that a chord of a circle lies altogether within the circle.

What we have called the first part of Euclid's solution of Prop. 1 may be stated as a theorem:—

Theorem.—*Every straight line which bisects a chord, and is at right angles to it, passes through the centre of the circle.*

The converse to this gives Prop. 3, which may be stated thus:—

If a straight line through the centre of a circle bisect a chord, then it is perpendicular to the chord, and if it be perpendicular to the chord it bisects it.

An easy consequence of this is the following theorem, which is essentially the same as Prop. 4:—

Theorem (Prop. 4).—*Two chords of a circle, of which neither passes through the centre, cannot bisect each other.*

These last three theorems are fundamental for the theory of the circle. It is to be remarked that Euclid never proves that a straight line cannot have more than two points in common with a circumference.

§ 29. The next two propositions (5 and 6) might be replaced by a single and a simpler theorem, viz.:—

Theorem.—*Two circles which have a common centre, and whose circumferences have one point in common, coincide.*

Or more in agreement with Euclid's form:—

Theorem.—*Two different circles, whose circumferences have a point in common, cannot have the same centre.*

That Euclid treats of two cases is characteristic of Greek mathematics.

The next two propositions (7 and 8) again belong together. They may be combined thus:—

Theorem.—*If from a point in a plane of a circle, which is not the centre, straight lines be drawn to the different points of the circumference, then of all these lines one is the shortest, and one the longest, and these lie both in that straight line which joins the given point to the centre. Of all the remaining lines each is equal to one and only one other, and these equal lines lie on opposite sides of the shortest or longest, and make equal angles with them.*

Euclid distinguishes the two cases where the given point lies within or without the circle, omitting the case where it lies in the circumference.

From the last proposition it follows that if from a point more than two equal straight lines can be drawn to the circumference, this point must be the centre. This is Prop. 9.

As a consequence of this we get

Theorem.—*If the circumferences of the two circles have three points in common they coincide.*

For in this case the two circles have a common centre, because from the centre of the one three equal lines can be drawn to points on the circumference of the other. But two circles which have a common centre, and whose circumferences have a point in common, coincide. (Compare above statement of Props. 5 and 6.)

This theorem may also be stated thus:—

Through three points only one circumference may be drawn; or, *Three points determine a circle.*

Euclid does not give the theorem in this form. He proves, however, *that the two circles cannot cut another in more than two points* (Prop. 10), and *that two circles cannot touch one another in more points than one* (Prop. 13).

§ 30. Propositions 11 and 12 assert that *if two circles touch, then the point of contact lies on the line joining their centres.* This gives two propositions, because the circles may touch either internally or externally.

§ 31. Propositions 14 and 15 relate to the length of chords. The first says; *that equal chords are equidistant from the centre, and that chords which are equidistant from the centre are equal;*

Whilst Prop. 15 compares unequal chords, viz., *Of all chords the diameter is the greatest, and of other chords that is the greater which is nearer to the centre;* and conversely, *the greater chord is nearer to the centre.*

§ 32. In Prop. 16 the tangent to a circle is for the first time introduced. The proposition is meant to show that the straight line at the end point of the diameter, and at right angles to it is a tangent. The proposition itself does not state this. It runs thus:—

Prop. 16. *The straight line drawn at right angles to the diameter of a circle, from the extremity of it, falls without the circle; and no straight line can be drawn from the extremity, between that straight line and the circumference, so as not to cut the circle.*

Corollary.—The straight line at right angles to a diameter drawn through the end point of it touches the circle.

The statement of the proposition and its whole treatment show the difficulties which the tangents presented to Euclid.

Prop. 17 solves the problem *through a given point, either in the circumference or without it, to draw a tangent to a given circle.*

Closely connected with Prop. 16 are Props. 18 and 19, which state (Prop. 18), *that the line joining the centre of a circle to the point of contact of a tangent is perpendicular to the tangent;* and conversely (Prop. 19), *that the straight line through the point of contact of, and perpendicular to, a tangent to a circle passes through the centre of the circle.*

§ 33. The rest of the book relates to angles connected with a circle, viz., angles which have the vertex either at the centre or on the circumference, and which are called respectively angles at the centre and angles at the circumference. Between these two kinds of angles exists the important relation expressed as follows:—

Prop. 20. *The angle at the centre of a circle is double of the angle at the circumference on the same base, that is, on the same arc.*

This is of great importance for its consequences, of which the two following are the principal:—

Prop. 21. *The angles in the same segment of a circle are equal to one another;*

And Prop. 22. *The opposite angles of any quadrilateral figure inscribed in a circle are together equal to two right angles.*

Further consequences are:—

Prop. 23. *On the same straight line, and on the same side of it, there cannot be two similar segments of circles, not coinciding with one another;*

And Prop. 24. *Similar segments of circles on equal straight lines are equal to one another.*

The problem Prop. 25, *A segment of a circle being given to describe the circle of which it is a segment,* may be solved much more easily by aid of the construction described in relation to Prop. 1, III., in § 27.

§ 34. There follow four theorems connecting the angles at the centre, the arcs into which they divide the circumference, and the chords subtending these arcs. They are expressed for angles, arcs, and chords in equal circles, but they hold also for angles, arcs, and chords in the same circle.

The theorems are:—

Prop. 26. *In equal circles equal angles stand on equal arcs, whether they be at the centres or circumferences;*

Prop. 27 (converse to Prop. 26). *In equal circles the angles which stand on equal arcs are equal to one another, whether they be at the centres or the circumferences;*

Prop. 28. *In equal circles equal straight lines* (equal chords) *cut off equal arcs, the greater equal to the greater, and the less equal to the less;*

Prop. 29 (converse to Prop. 28). *In equal circles equal arcs are subtended by equal straight lines.*

§ 35. Other important consequences of Props. 20–22 are:—

Prop. 31. *In a circle the angle in a semicircle is a right angle; but the angle in a segment greater than a semicircle is less than a right angle; and the angle in a segment less than a semicircle is greater than a right angle;*

Prop. 32. *If a straight line touch a circle, and from the point of contact a straight line be drawn cutting the circle, the angles which this line makes with the line touching the circle shall be equal to the angles which are in the alternate segments of the circle.*

§ 36. Propositions 30, 33, 34, contain problems which are solved by aid of the propositions preceding them:—

Prop. 30. *To bisect a given arc, that is, to divide it into two equal parts;*

Prop. 33. *On a given straight line to describe a segment of a circle containing an angle equal to a given rectilineal angle;*

Prop. 34. *From a given circle to cut off a segment containing an angle equal to a given rectilineal angle.*

§ 37. If we draw chords through a point A within a circle, they will each be divided by A into two segments. Between these segments the law holds that the rectangle contained by them has the same area on whatever chord through A the segments are taken. The value of this rectangle changes, of course, with the position of A.

A similar theorem holds if the point A be taken without the circle. On every straight line through A, which cuts the circle in two points B and C, we have two segments AB and AC, and the rectangles contained by them are again equal to one another, and equal to the square on a tangent drawn from A to the circle.

The first of these theorems gives Prop. 35, and the second Prop. 36, with its corollary, whilst Prop. 37, the last of Book III., gives the converse to Prop. 36. The first two theorems may be combined in one:—

Theorem.—*If through a point A in the plane of a circle a straight line be drawn cutting the circle in B and C, then the rectangle $AB.AC$ has a constant value so long as the point A be fixed; and if from A a tangent AD can be drawn to the circle, touching at D, then the above rectangle equals the square on AD.*

Prop. 37 may be stated thus:—

Theorem.—*If from a point A without a circle a line be drawn cutting the circle in B and C, and another line to a point D on the circle, and if $AB.AC = AD^2$, then the line AD touches the circle at D.*

It is not difficult to prove also the converse to the general proposition as above stated. It may be expressed as follows:—

If four points ABCD be taken on the circumference of a circle, and if the lines AB, CD, produced if necessary, meet at E, then

$$EA \,.\, EB = EC \,.\, ED;$$

and conversely, if this relation holds then the four points lie on a circle, that is, the circle drawn through three of them passes through the fourth.

That a circle may always be drawn through three points, provided that they do not lie in a straight line, is proved only later on in Book IV.

Book IV.

§ 38. The fourth book contains only problems, all relating to the construction of triangles and polygons inscribed in and circumscribed about circles, and of circles inscribed in or circumscribed about triangles and polygons. They are nearly all given for their own sake, and not for future use in the construction of figures, as are most of those in the former books. In seven definitions at the beginning of the book it is explained what is understood by figures inscribed in or described about other figures, with special reference to the case where one figure is a circle. Instead, however, of saying that one figure is described about another, it is now generally said that the one figure is circumscribed about the other. We may then state the definitions 3 or 4 thus:—

Definition.—A polygon is said to be inscribed in a circle, and the circle is said to be circumscribed about the polygon, if the vertices of the polygon lie in the circumference of the circle.

And definitions 5 and 6 thus:—

Definition.—A polygon is said to be circumscribed about a circle, and a circle is said to be inscribed in a polygon, if the sides of the polygon are tangents to the circle.

§ 39. The first problem is merely constructive. It requires to draw in a given circle a chord equal to a given straight line, which is not greater than the diameter of the circle. The problem is not a determinate one, inasmuch as the chord may be drawn from any point in the circumference. This may be said of almost all problems in this book, especially of the next two. They are:—

Prop. 2. *In a given circle to inscribe a triangle equiangular to a given triangle;*

Prop. 3. *About a given circle to circumscribe a triangle equiangular to a given triangle.*

§ 40. Of somewhat greater interest are the next problems, where the triangles are given and the circles to be found.

Prop. 4. *To inscribe a circle in a given triangle.*

The result is that the problem has always a solution, viz., the centre of the circle is the point where the bisectors of two of the interior angles of the triangle meet. The solution shows, though Euclid does not state this, that the problem has but one solution; and also,

Theorem.—*The three bisectors of the interior angles of any triangle meet in a point, and this is the centre of the circle inscribed in the triangle.*

The solutions of most of the other problems contain also theorems. Of these we shall state those which are of special interest; Euclid does not state any one of them.

§ 41. Prop. 5. *To circumscribe a circle about a given triangle.*

The one solution which always exists contains the following:—

Theorem.—*The three straight lines which bisect the sides of a triangle at right angles meet in a point, and this point is the centre of the circle circumscribed about the triangle.*

Euclid adds in a corollary the following property:—

The centre of the circle circumscribed about a triangle lies within, on a side of, or without the triangle, according as the triangle is acute-angled, right-angled, or obtuse-angled.

§ 42. Whilst it is always possible to draw a circle which is inscribed in or circumscribed about a given triangle, this is not the case with quadrilaterals or polygons of more sides. Of those for which this is possible the regular polygons are the most interesting. In each of them a circle may be inscribed, and another may be circumscribed about it.

Euclid does not use the word regular, but he describes the polygons in question as *equiangular* and *equilateral.* We shall use the name regular polygon. The regular triangle is equilateral, the regular quadrilateral is the square.

Euclid considers the regular polygons of 4, 5, 6, and 15 sides. For each of the first three he solves the problems—(1) to inscribe such a polygon in a given circle; (2) to circumscribe it about a given circle; (3) to inscribe a circle in, and (4) to circumscribe a circle about, such a polygon.

For the regular triangle the problems are not repeated, because more general problems have been solved.

Props. 6, 7, 8, and 9 solve these problems for the square.

The general problem of inscribing in a given circle a regular polygon of n sides depends upon the problem of dividing the circumference of a circle into n equal parts, or what comes to the same thing, of drawing from the centre of the circle n radii such that the angles between consecutive radii are equal, that is, to divide the space about the centre into n equal angles. Thus, if it is required to inscribe a square in a circle, we have to draw four lines from the centre, making the four angles equal. This is done by drawing two diameters at right angles to one another. The ends of these diameters are the vertices of the required square. If, on the other hand, tangents be drawn at these ends, we obtain a square circumscribed about the circle.

§ 43. To construct a *regular pentagon*, we find it convenient first to construct a *regular decagon*. This requires to divide the space about the centre into ten equal angles. Each will be $\frac{1}{10}$th of a right angle, or $\frac{1}{5}$th of two right angles. If we suppose the decagon constructed, and if we join the centre to the end of one side, we get an isosceles triangle, where the angle at the centre equals $\frac{1}{5}$th of two right angles; hence each of the angles at the base will be $\frac{2}{5}$ths of two right angles, as all three angles together equal two right angles. Thus we have to construct an isosceles triangle, having the angle at the vertex equal to half an angle at the base. This is solved in Prop. 10, by aid of the problem in Prop. 11 of the second book. If we make the sides of this triangle equal to the radius of the given circle, then the base will be the side of the regular decagon inscribed in the circle. This side being known the decagon can be constructed, and if the vertices are joined alternately, leaving out half their number, we obtain the regular pentagon.

Euclid does not proceed thus. He wants the pentagon before the decagon. This, however, does not change the real nature of his solution, nor does his solution become simpler by not mentioning the decagon.

Once the regular pentagon is inscribed, it is easy to circumscribe another by drawing tangents at the vertices of the inscribed pentagon. This is shown in Prop. 12.

Prop. 13 and 14 teach how a circle may be inscribed in or circumscribed about any given regular pentagon.

§ 44. The *regular hexagon* is more easily constructed, as shown in Prop. 15. The result is that the side of the regular hexagon inscribed in a circle is equal to the radius of the circle.

For this polygon the other three problems mentioned are not solved.

§ 45. The book closes with Prop. 16. To inscribe a regular quindecagon in a given circle. That this may be done is easily seen. If we inscribe a regular pentagon and a regular hexagon in the circle, having one vertex in common, then the arc from the common vertex to the next vertex of the pentagon is $\frac{1}{5}$th of the circumference, and to the next vertex of the hexagon is $\frac{1}{6}$th of the circumference. The difference between these arcs is, therefore, $\frac{1}{5} - \frac{1}{6} = \frac{1}{30}$th of the circumference. The latter may, therefore, be divided into thirty, and hence also in fifteen equal parts, and the regular quindecagon be described.

§ 46. We conclude with a few theorems about regular polygons which are not given by Euclid.

THEOREM.—*The straight lines perpendicular to and bisecting the sides of any regular polygon meet in a point. The straight lines bisecting the angles in the regular polygon meet in the same point. This point is the centre of the circle circumscribed about and inscribed in the regular polygon.* The proof, which is easy, is left to the reader.

We can bisect any given arc (Prop. 30, III.). Hence we can divide a circumference into $2n$ equal parts as soon as it has been divided into n equal parts, or as soon as a regular polygon of n sides has been constructed. Hence—

THEOREM.—*If a regular polygon of* n *sides has been constructed, then a regular polygon of* 2n *sides, of* 4n, *of* 8n *sides, etc., may also be constructed.* Euclid shows how to construct regular polygons of 3, 4, 5, and 15 sides. It follows that we can construct regular polygons of

3, 6, 12, 24 . . .. sides.
4, 8, 16, 32 . . . "
5, 10, 20, 40 . . . "
15, 30, 60, 120 . . . "

The construction of any new regular polygon not included in one of these series will give rise to a new series. Till the beginning of this century nothing was added to the knowledge of regular polygons as given by Euclid. Then Gauss, in his celebrated *Arithmetic*, proved that every regular polygon of $2^n + 1$ sides may be constructed if this number $2^n + 1$ be prime, and that no others can be constructed by elementary methods. This shows that regular polygons of 7, 9, 13 sides cannot thus be constructed, but that a regular polygon of 17 sides is possible; for $17 = 2^4 + 1$. The next polygon is one of 257 sides. The construction becomes already rather complicated for 17 sides.

BOOK V.

§ 47. The fifth book of the *Elements* is not exclusively geometrical. It contains the theory of ratios and proportion of quantities in general. The treatment, as here given, is admirable, and in every respect superior to the algebraical method by which Euclid's theory is now generally replaced. It has, however, the reputation of being too difficult for schools, and is therefore very seldom read. We shall try to make the subject clear, and to show why the usual algebraical treatment of proportion is not really sound. We begin by quoting those definitions at the beginning of Book V. which are most important. These definitions have given rise to much discussion.

The only definitions which are essential for the fifth book are Defs. 1, 2, 4, 5, 6, and 7. Of the remainder 3, 8, and 9 are more than useless, and probably not Euclid's, but additions of later editors of whom Theon of Alexandria was the most prominent. Defs. 10 and 11 belong rather to the sixth book, whilst all the others are merely nominal. The really important ones are 4, 5, 6, and 7.

§ 48. To define a magnitude is not attempted by Euclid. The first two definitions state what is meant by a "part," that is, a submultiple or measure, and by a "multiple" of a given magnitude. The meaning of Def. 4 is that two given quantities can have a ratio to one another only in case that they are comparable as to their magnitude, that is if they are of the same kind.

Def. 3, which is probably due to Theon, professes to define a ratio, but is as meaningless as it is uncalled for, for all that is wanted is given in Defs. 5 and 7.

In Def. 5 it is explained what is meant by saying that two magnitudes have the same ratio to one another as two other magnitudes, and in Def. 7 what we have to understand by a greater or a less ratio. The 6th definition is only nominal, explaining the meaning of the word *proportional*.

Euclid represents magnitudes by lines, and often denotes them either by single letters or, like lines, by two letters. We shall use only single letters for the purpose. If a and b denote two magnitudes of the same kind, their ratio will be denoted by $a : b$; if c and d are two other magnitudes of the same kind, but possibly of a different kind from a and b, then if c and d have the same ratio to one another as a and b, this will be expressed by writing—

$$a : b : : c : d.$$

Further, if m is a (whole) number, ma shall denote the multiple of a which is obtained by taking it m times.

§ 49. The whole theory of ratios is based on Def. 5.

Def. 5. *The first of four magnitudes is said to have the same ratio to the second that the third has to the fourth when any equimultiples whatever of the first and the third being taken, and any equimultiples whatever of the second and the fourth, if the multiple of the first be less than that of the second, the multiple of the third is also less than that of the fourth; and if the multiple of the first is equal to that of the second, the multiple of the third is also equal to that of the fourth; and if the multiple of the first is greater than that of the second, the multiple of the third is also greater than that of the fourth.*

It will be well to show at once in an example how this definition can be used, by proving the first part of the first proposition in the sixth book. *Triangles of the same altitude are to one another as their bases*, or if a and b are the bases, and α and β the areas, of two triangles which have the same altitude, then $a : b : : \alpha : \beta$.

To prove this, we have, according to Definition 5, to show—

$$\text{if } ma > nb, \text{ then } m\alpha > n\beta,$$
$$\text{if } ma = nb, \text{ then } m\alpha = n\beta,$$
$$\text{if } ma < nb, \text{ then } m\alpha < n\beta.$$

That this is true is in our case easily seen. We may suppose that the triangles have a common vertex, and their bases in the same line. We set off the base a along the line containing the bases m times; we then join the different parts of division to the vertex, and get m triangles all equal to α. The triangle on ma as base equals, therefore, $m\alpha$. If we proceed in the same manner with the base b, setting it off n times, we find that the area of the triangle on the base nb equals $n\beta$, the vertex of all triangles being the same. But if two triangles have the same altitude, then their areas are equal if the bases are equal; hence $m\alpha = n\beta$ if $ma = nb$, and if their bases are unequal, then that has the greater area which is on the greater base; in other words, $m\alpha$ is greater than, equal to, or less than $n\beta$, according as ma is greater than, equal to, or less than nb which was to be proved.

§ 50. It will be seen that even in this example it does not become evident what a ratio really is. It is still an open question whether ratios are magnitudes which we can compare. We do not know whether the ratio of two lines is a magnitude of the same kind as the ratio of two areas. Though we might say that Def. 5 defines *equal* ratios, still we do not know whether they are equal in the sense of the axiom, that two things which are equal to a third are equal to one another. That this is the case requires a proof, and until this proof is given we shall use the : : instead of the sign =, which, however, we shall afterwards introduce.

As soon as it has been established that all ratios are like magnitudes, it becomes easy to show that, in some cases at least, they are numbers. This step was never made by Greek mathematicians. They distinguished always most carefully between continuous magnitudes and the discrete series of numbers. In modern times it has become the custom to ignore this difference.

If, in determining the ratio of two lines, a common measure can be found, which is contained m times in the first, and n times in the second, then the ratio of the two lines equals the ratio of the two numbers $m : n$. This is shown by Euclid in Prop. 5, X. But the ratio of two numbers is, as a rule, a fraction, and the Greeks did not, as we do, consider fractions as numbers. Far less had they any notion of introducing irrational numbers, which are neither whole nor fractional, as we are obliged to do if we wish to say that all ratios are numbers. The incommensurable numbers which are thus introduced as ratios of incommensurable quantities are now-a-days as familiar to us as fractions; but a proof is generally omitted that we may apply to them the rules which have been established for rational numbers only. Euclid's treatment of ratios avoids this difficulty. His definitions hold for commensurable as well as for incommensurable quantities. Even the notion of incommensurable quantities is avoided in Book V. But he proves that the more elementary rules of algebra hold for ratios. We shall state all his propositions in that algebraical form to which we are now accustomed. This may, of course, be done without changing the character of Euclid's method.

§ 51. Using the notation explained above we express the first propositions as follows:—

Prop. 1. If $a = ma', \ b = mb', \ c = mc'$,
then $a + b + c = m(a' + b' + c')$.

Prop. 2. If $a = mb$, and $c = md$,
$e = nb$, and $f = nd$,

then $a + e$ is the same multiple of b as $c + f$ is of d, viz.:—

$$a + e = (m + n)b, \text{ and } c + f = (m + n)d.$$

Prop. 3. If $a = mb$, $c = md$, then is na the same multiple of b that nc is of d, viz., $na = nmb$, $nc = nmd$.

Prop. 4. If $a : b :: c : d$,
then $ma : nb :: mc : nd$.

Prop. 5. If $a = mb$, and $c = md$,
then $a - c = m(b - d)$.

Prop. 6. If $a = mb$, $c = md$,

then are $a - nb$ and $c - nd$ either equal to, or equimultiples of, b and d, viz., $a - nb = (m - n)b$ and $c - nd = (m - n)d$, where $m - n$ may be unity.

All these propositions relate to *equimultiples*. Now follow propositions about ratios which are compared as to their magnitude.

§ 52. Prop. 7. If $a = b$, then $a : c :: b : c$ and $c : a :: c : b$.

The proof is simply this. As $a = b$ we know that $ma = mb$;

therefore if $ma > nc$, then $mb > nc$,
if $ma = nc$, then $mb = nc$,
if $ma < nc$, then $mb < nc$,

therefore the first proportion holds by Definition 5.

Prop. 8. If $a > b$, then $a : c > b : c$,
and $c : a < c : b$.
The proof depends on Definition 7.

Prop. 9 (converse to Prop. 7). If

$a : c :: b : c$,
or if $c : a :: c : b$, then $a = b$.

Prop. 10 (converse to Prop. 8). If

$a : c > b : c$, then $a > b$,
and if $c : a < c : b$, then $a < b$.

Prop. 11. If $a : b :: c : d$,
and $a : b :: e : f$,
then $c : d :: e : f$.

In words, *if two ratios are equal to a third, they are equal to one another.* After these propositions have been proved, we have a right to consider a ratio as a *magnitude*, for only now can we consider a ratio as something for which the axiom about magnitudes holds: things which are equal to a third are equal to one another.

We shall indicate this by writing in future the sign $=$ instead of $::$. The remaining propositions, which explain themselves, may then be stated as follows:—

§ 53. Prop. 12. If $a : b = c : d = e : f$,
then $a + c + e : b + d + f = a : b$.

Prop. 13. If $a : b = c : d$ and $c : d > e : f$,
then $a : b > e : f$.

Prop. 14. If $a : b = c : d$, and $a > c$, then $b > d$.

Prop. 15. Magnitudes have the same ratio to one another that their equimultiples have—

$$ma : mb = a : b.$$

Prop. 16. If a, b, c, d are magnitudes of the same kind, and
if $a : b = c : d$,
then $a : c = b : d$.

Prop. 17. If $a + b : b = c + d : d$,
then $a : b = c : d$.

Prop. 18 (converse to 17). If

$a : b = c : d$,
then $a + b : b = c + d : d$.

Prop. 19. If a, b, c, d are quantities of the same kind, and if

$a : b = c : d$,
then $a - c : b - d = a : b$.

§ 54. Prop. 20. *If there be three magnitudes, and other three, which have the same ratio, taken two and two, then if the first be greater than the third, the fourth shall be greater than the sixth; and if equal, equal; and if less, less.*

If we understand by

$$a : b : c : d : e : \ldots = a' : b' : c' : d' : e' : \ldots$$

that the ratio of any two consecutive magnitudes on the first side equals that of the corresponding magnitudes on the second side, we may write this theorem in symbols, thus:—

If a, b, c, be quantities of one, and d, e, f magnitudes of the same or any other kind, such that

$a : b : c = d : e : f$,
and if $a > c$, then $d > f$,
but if $a = c$, then $d = f$,
and if $a < c$, then $d < f$.

Prop 21. If $a : b = e : f$ and $b : c = d : e$,

or if $a : b : c = \frac{1}{f} : \frac{1}{e} : \frac{1}{d}$,

and if $a > c$, then $d > f$,
but if $a = c$, then $d = f$,
and if $a < c$, then $d < f$.

By aid of these two propositions the following two are proved.

§ 55. Prop. 22. *If there be any number of magnitudes, and as many others, which have the same ratio, taken two and two in order, the first shall have to the last of the first magnitudes the same ratio which the first of the others has to the last.*

We may state it more generally, thus:—

If $a : b : c : d : e : \ldots = a' : b' : c' : d' : e' : \ldots$,

then not only have two consecutive, but any two magnitudes on the first side, the same ratio as the corresponding magnitudes on the other. For instance—

$$a : c = a' : c'; \quad b : e = b' : e', \text{ etc.}$$

Prop. 23 we state only in symbols, viz.:—

If $a : b : c : d : e : \ldots = \frac{1}{a'} : \frac{1}{b'} : \frac{1}{c'} : \frac{1}{d'} : \frac{1}{e'} : \ldots$,

then $a : c = c' : a'$,
$b : e = e' : b'$,
and so on.

Prop. 24 comes to this: If $a : b = c : d$ and $e : b = f : d$, then

$$a + e : b = c + f : d.$$

Some of the proportions which are considered in the above propositions have special names. These we have omitted, as being of no use, since algebra has enabled us to bring the different operations contained in the propositions under a common point of view.

§ 56. The last proposition in the fifth book is of a different character.

Prop. 25. *If four magnitudes of the same kind be proportional, the greatest and least of them together shall be greater than the other two together.* In symbols—

If a, b, c, d, be magnitudes of the same kind, and if $a : b = c : d$, and if a is the greatest, hence d the least, then $a + d > b + c$.

§ 57. We return once again to the question, What is a ratio? We have seen that we may treat ratios as magnitudes, and that all ratios are magnitudes of the same kind, for we may compare any two as to their magnitude. It will presently be shown that ratios of lines may be considered as *quotients* of lines, so that a ratio appears as answer to the question, How often is one line contained in another? But the answer to this question is given by a number, at least in some cases, and in all cases if we admit incommensurable numbers. Considered from this point of view, we may say the fifth book of the *Elements* shows that some of the simpler algebraical operations hold for incommensurable numbers. In the ordinary algebraical treatment of numbers this proof is altogether omitted, or given by a process of limits which does not seem to be natural to the subject.

Book VI.

§ 58. The sixth book contains the theory of similar figures. After a few definitions explaining terms, the first proposition gives the first application of the theory of proportion.

Prop. 1. *Triangles and parallelograms of the same altitude are to one another as their bases.*

The proof has already been considered in § 49.

From this follows easily the important theorem

Prop. 2. *If a straight line be drawn parallel to one of the sides of a triangle, it shall cut the other sides, or those sides produced, proportionally; and if the sides or the sides produced be cut proportionally, the straight line which joins the points of section, shall be parallel to the remaining side of the triangle.*

§ 59. The next proposition, together with one added by Simson as Prop. A, may be expressed more conveniently if we introduce a modern phraseology, viz., if in a line AB we assume a point C between A and B, we shall say that C divides AB internally in the ratio AC : CB; but if C be taken in the line AB produced, we shall say that AB is divided externally in the ratio AC : CB.

The two propositions then come to this:

Theorem (Prop. 3).—*The bisector of an angle in a triangle divides the opposite side internally in a ratio equal to the ratio of the two sides including that angle;* and conversely, *if a line through the vertex of a triangle divide the base internally in the ratio of the two other sides, then that line bisects the angle at the vertex.*

Theorem (Simson's Prop. A).—*The line which bisects an exterior angle of a triangle divides the opposite side externally in the ratio of the other sides;* and conversely, *if a line through the vertex of a triangle divide the base externally in the ratio of the sides, then it bisects an exterior angle at the vertex of the triangle.*

If we combine both we have—

Theorem.—*The two lines which bisect the interior and exterior angles at one vertex of a triangle divide the opposite side internally and externally in the same ratio, viz., in the ratio of the other two sides.*

§ 60. The next four propositions contain the theory of similar triangles, of which four cases are considered. They may be stated together.

Theorem.—*Two triangles are similar,—*

1. (Prop. 4). *If the triangles are equiangular;*
2. (Prop. 5). *If the sides of the one are proportional to those of the other;*
3. (Prop. 6). *If two sides in one are proportional to two sides in the other, and if the angles contained by these sides are equal;*
4. (Prop. 7). *If two sides in one are proportional to two sides in the other, if the angles opposite homologous sides are equal, and if the angles opposite the other homologous sides are both acute, both right, or both obtuse; homologous sides being in each case those which are opposite equal angles.*

An important application of these theorems is at once made to a right-angled triangle, viz.:—

Prop. 8. *In a right-angled triangle, if a perpendicular be drawn from the right angle to the base, the triangles on each side of it are similar to the whole triangle, and to one another.*

Corollary.—From this it is manifest that the perpendicular drawn from the right angle of a right-angled triangle to the base is a mean proportional between the segments of the base, and also that each of the sides is a mean proportional between the base and the segment of the base adjacent to that side.

§ 61. There follow four propositions containing problems, viz., in language slightly different from Euclid's:—

Prop. 9. *To divide a straight line into a given number of equal parts.*

Prop. 10. *To divide a straight line in a given ratio.*

Prop. 11. *To find a third proportional to two given straight lines.*

Prop. 12. *To find a fourth proportional to three given straight lines.*

Prop. 13. *To find a mean proportional between two given straight lines.*

The last three may be written as equations with one unknown quantity,—viz., if we call the given straight lines a, b, c, and the required line x, we have to find a line x so that

Prop. 11. $a : b = b : x$;
Prop. 12. $a : b = c : x$;
Prop. 13. $a : x = x : b$;

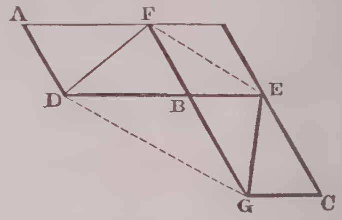
We shall see presently how these may be written without the signs of ratios.

§ 62. Euclid considers next proportions connected with parallelograms and triangles which are equal in area.

Prop. 14. *Equal parallelograms which have one angle of the one equal to one angle of the other have their sides about the equal angles reciprocally proportional; and parallelograms which have one angle of the one equal to one angle of the other, and their sides about the equal angles reciprocally proportional, are equal to one another.*

Prop. 15. *Equal triangles which have one angle of the one equal to one angle of the other, have their sides about the equal angles reciprocally proportional; and triangles which have one angle of the one equal to one angle of the other, and their sides about the equal angles reciprocally proportional, are equal to one another.*

The latter proposition is really the same as the former, for if, as in the accompanying diagram, in the figure belonging to the former the two equal parallelograms AB and BC be bisected by the lines DF and EG, and if EF be drawn, we get the figure belonging to the latter.



It is worth noticing that the lines FE and DG are parallel. We may state therefore the theorem—

Theorem.—*If two triangles are equal in area, and have one angle in the one vertically opposite to one angle in the other, then the two straight lines which join the remaining two vertices of the one to those of the other triangle are parallel.*

§ 63. A most important theorem is

Prop. 16. *If four straight lines be proportionals, the rectangle contained by the extremes is equal to the rectangle contained by the means; and if the rectangle contained by the extremes be equal to the rectangle contained by the means, the four straight lines are proportionals.*

In symbols, if a, b, c, d are the four lines, and

if $a : b = c : d$,
then $ad = bc$;
and conversely, if $ad = bc$,
then $a : b = c : d$,

where ad and bc denote (as in § 20) the areas of the rectangles contained by a and d and by b and c respectively.

This allows us to transform every proportion between four lines into an equation between two products.

It shows further that the operation of forming a product of two lines, and the operation of forming their ratio are each the inverse of the other.

If we now define a quotient $\frac{a}{b}$ of two lines as the *number* which multiplied into b gives a, so that

$$\frac{a}{b} b = a,$$

we see that from the equality of two quotients

$$\frac{a}{b} = \frac{c}{d}$$

follows, if we multiply both sides by bd,

$$\frac{a}{b} b \cdot d = \frac{c}{d} d \cdot b,$$

$$ad = cb.$$

But from this it follows according to the last theorem that

$$a : b = c : d.$$

Hence we conclude that the quotent $\frac{a}{b}$ and the ratio $a : b$ are different forms of the same magnitude, only with this important difference that the quotient $\frac{a}{b}$ would have a meaning only if a and b have a common measure, until we introduce incommensurable numbers, while the ratio $a : b$ has always a meaning, and thus gives rise to the introduction of incommensurable numbers.

Thus it is really the theory of ratios in the fifth book which enables us to extend the geometrical calculus given before in connection with Book II. It will also be seen that if we write the ratios in Book V. as quotients, or rather as fractions, then most of the theorems state properties of quotients or of fractions.

§ 64. Prop. 17 contains only a special case of 16. After the problem, Prop. 18. *On a given straight line to describe a rectilineal figure similar and similarly situated to a given rectilineal figure,* there follows another fundamental theorem:

Prop. 19. *Similar triangles are to one another in the duplicate ratio of their homologous sides.* In other words, the areas of similar triangles are to one another as the squares on homologous sides. This is generalized in

Prop. 20. *Similar polygons may be divided into the same number of similar triangles, having the same ratio to one another that the polygons have; and the polygons are to one another in the duplicate ratio of their homologous sides.*

§ 65. Prop. 21. *Rectilineal figures which are similar to the same rectilineal figure are also similar to each other,* is an immediate consequence of the definition of similar figures. As similar figures may be said to be equal in "shape" but not in "size," we may state it also thus:

"Figures which are equal in shape to a third are equal in shape to each other."

Prop. 22. *If four straight lines be proportionals, the similar rectilineal figures similarly described on them shall also be proportionals; and if the similar rectilineal figures similarly described on four straight lines be proportionals, those straight lines shall be proportionals.*

This is essentially the same as the following:—

If $a : b = c : d,$
then $a^2 : b^2 = c^2 : d^2$

§ 66. Now follows a proposition which has been much discussed with regard to Euclid's exact meaning in saying that a ratio is *compounded* of two other ratios, viz.:

Prop. 23. *Parallelograms which are equiangular to one another, have to one another the ratio which is compounded of the ratios of their sides.*

The proof of the proposition makes its meaning clear. In symbols the ratio $a : c$ is compounded of the two ratios $a : b$ and $b : c$, and if $a : b = a' : b'$, $b : c = b'' : c''$, then $a : c$ is compounded of $a' : b'$ and $a'' : b''$.

If we consider the ratios as numbers, we may say that the one ratio is the product of those of which it is compounded, or in symbols,

$$\frac{a}{c} = \frac{a}{b} \cdot \frac{b}{c} = \frac{a'}{b'} \cdot \frac{b''}{c''}, \text{ if } \frac{a}{b} = \frac{a'}{b'} \text{ and } \frac{b}{c} = \frac{b''}{c''}.$$

The theorem in Prop. 23 is the foundation of all mensuration of areas. From it we see at once that two rectangles have the ratio of their areas compounded of the ratios of their sides.

If A is the area of a rectangle contained by a and b, and B that of a rectangle contained by c and d, so that $A = ab$, $B = cd$, then $A : B = ab : cd$, and this is, the theorem says, compounded of the ratios $a : c$ and $b : d$. In forms of quotients,

$$\frac{a}{c} \cdot \frac{b}{d} = \frac{ab}{cd}.$$

This shows how to multiply quotients in our geometrical calculus.

Further, *Two triangles have the ratios of their areas compounded of the ratios of their bases and their altitude.* For a triangle is equal in area to half a parallelogram which has the same base and the same altitude.

To bring these theorems to the form in which they are usually given, we assume a straight line u as our unit of length (generally an inch, a foot, a mile, etc.), and determine the number α which expresses how often u is contained in a line a, so that α denotes the ratio $a : u$ whether commensurable or not, and that $a = \alpha u$. We call this number α the numerical value of a. If in the same manner β be the numerical value of a line b, we have

$$a : b = \alpha : \beta ;$$

in words: *The ratio of two lines (and of two like quantities in general) is equal to that of their numerical values.*

This is easily proved by observing that $a = \alpha u$, $b = \beta u$, therefore $a : b = \alpha u : \beta u$, and this may without difficulty be shown to equal $\alpha : \beta$.

If now a, b be the base and altitude of one, a', b' those of another parallelogram, α, β and α', β' their numerical values respectively, and A, A′ their areas, then

$$\frac{A}{A'} = \frac{a}{a'} \cdot \frac{b}{b'} = \frac{\alpha}{\alpha'} \cdot \frac{\beta}{\beta'} = \frac{\alpha\beta}{\alpha'\beta'}.$$

In words: *The areas of two parallelograms are to each other as the products of the numerical values of their bases and altitudes.*

If especially the second parallelogram is the unit square, *i. e.,* a square on the unit of length, then $\alpha' = \beta' = 1$, $A' = u^2$, and we have

$$\frac{A}{A'} = \alpha\beta \text{ . or } A = \alpha\beta \cdot u^2.$$

This gives the theorem: The number of unit squares contained in a parallelogram equals the product of the numerical values of base and altitude, and similarly the number of unit squares contained in a triangle equals half the product of the numerical values of base and altitude.

This is often stated by saying that the area of a parallelogram is equal to the product of the base and the altitude, meaning by this product the product of the numerical values, and not the product as defined above in § 20.

§ 68. Propositions 24 and 26 relate to parallelograms about diagonals, such as are considered in Book I., 43. They are—

Prop. 24. *Parallelograms about the diameter of any parallelogram are similar to the whole parallelogram and to one another;* and its converse (Prop. 26). *If two similar parallelograms have a common angle, and be similarly situated, they are about the same diameter.*

Between these is inserted a problem.

Prop. 25. *To describe a rectilineal figure which shall be similar to one given rectilinear figure, and equal to another given rectilineal figure.*

§ 69. Prop. 27 contains a theorem relating to the theory of maxima and minima. We may state it thus:

Prop. 27. *If a parallelogram be divided into two by a straight line cutting the base, and if on half the base another parallelogram be constructed similar to one of those parts, then this third parallelogram is greater than the other part.*

Of far greater interest than this general theorem is a special case of it, where the parallelograms are changed into rectangles, and where one of the parts into which the parallelogram is divided is made a square; for then the theorem changes into one which is easily recognized to be identical with the following:—

Theorem.—*Of all rectangles which have the same perimeter the square has the greatest area.*

This may also be stated thus:—

Theorem.—*Of all rectangles which have the same area the square has the least perimeter.*

§ 70. The next three propositions contain problems which may be said to be solutions of quadratic equations. The first two are, like the last, involved in somewhat obscure language. We transcribe them as follows:—

Problem.—To describe on a given base a parallelogram, and to divide it either internally (Prop. 28) or externally (Prop. 29) from a point on the base into two parallelograms, of which the one has a given size (is equal in area to a given figure), whilst the other has a given shape (is similar to a given parallelogram).

If we express this again in symbols, calling the given base a, the one part x, and the altitude y, we have to determine x and y in the first case from the equations

$$(a - x)y = k^2,$$
$$\frac{x}{y} = \frac{p}{q},$$

k^2 being the given size of the first, and p and q the base and altitude of the parallelogram which determine the shape of the second of the required parallelograms.

If we substitute the value of y, we get

$$(a - x)x = \frac{pk^2}{q},$$

or,

$$ax - x^2 = b^2$$

where a and b are known quantities, taking $b^2 = \frac{pk^2}{a}$.

The second case (Prop. 29) gives rise, in the same manner, to the quadratic

$$ax + x^2 = b^2.$$

The next problem—

Prop. 30. *To cut a given straight line in extreme and mean ratio,* leads to the equation

$$ax + x^2 = a^2.$$

This is therefore, only a special case of the last, and is, besides, an old acquaintance, being essentially the same problem as that proposed in II. 11.

Prop. 30 may therefore be solved in two ways, either by aid of Prop. 29 or by aid of II. 11. Euclid gives both solutions.

§ 71. Prop. 31 (Theorem). *In any right-angled triangle, any rectilineal figure described on the side subtending the right angle is equal to the similar and similarly-described figures on the sides containing the right angle,*—is a pretty generalization of the theorem in Pythagoras (I. 47).

Leaving out the next proposition, which is of little interest, we come to the last in this book.

Prop. 33. *In equal circles angles, whether at the centres or the circumferences, have the same ratio which the arcs on which they stand have to one another; so also have the sectors.*

Of this, the part relating to angles at the centre is of special importance; it enables us to measure angles by arcs.

With this closes that part of the *Elements* which is devoted to the study of figures in a plane.

Book XI.

§ 72. In this book figures are considered which are not confined to a plane, viz., first relations between lines and planes in space, and afterwards properties of solids.

Of new definitions we mention those which relate to the perpendicularity and the inclination of lines and planes.

Def. 3. *A straight line is perpendicular, or at right angles to a plane when it makes right angles with every straight line meeting it in that plane.*

The definition of perpendicular planes (Def. 4) offers no difficulty. Euclid defines the inclination of lines to planes and of planes to planes (Defs. 5 and 6) by aid of plane angles, included by straight lines, with which we have been made familiar in the first books.

The other important definitions are those of parallel planes, which never meet (Def. 8), and of solid angles formed by three or more planes meeting in a point (Def. 9).

To these we add the definition of a line parallel to a plane as a line which does not meet the plane.

§ 73. Before we investigate the contents of Book XI., it will be well to recapitulate shortly what we know of planes and lines from the definitions and axioms of the first book. There a plane has been defined as a surface which has the property that every straight line which joins two points in it lies altogether in it. This is equivalent to saying that a straight line which has two points in a plane has all points in the plane. Hence, a straight line which does not lie in the plane cannot have more than one point in common with the plane. This is virtually the same as Euclid's Prop. 1, viz.:—

Prop. 1. *One part of a straight line cannot be in a plane and another part without it.*

It also follows, as was pointed out in § 3, in discussing the definitions of Book I., that a plane is determined already by one straight line and a point without it, viz., if all lines be drawn through the point, and cutting the line they will form a plane.

This may be stated thus:—

A plane is determined—

1st, *By a straight line and a point which does not lie on it;*

2d, *By three points which do not lie in a straight line;* for if two of these points be joined by a straight line we have case 1;

3d, *By two intersecting straight lines;* for the point of intersection and two other points, one in each line, give case 2;

4th, *By two parallel lines* (Def. 35, I.).

The third case of this theorem is Euclid's.

Prop. 2. *Two straight lines which cut one another are in one plane, and three straight lines which meet one another are in one plane.*

And the fourth is Euclid's.

Prop. 7. *If two straight lines be parallel, the straight line drawn from any point in one to any point in the other is in the same plane with the parallels.* From the definition of a plane further follows:

Prop. 3. *If two planes cut one another, their common section is a straight line.*

§ 74. Whilst these propositions are virtually contained in the definition of a plane, the next gives us a new and fundamental property of space, showing at the same time that it is possible to have a straight line perpendicular to a plane, according to Def. 3. It states—

Theorem (Prop. 4).—*If a straight line is perpendicular to two straight lines in a plane which it meets, then it is perpendicular to all lines in the plane which it meets, and hence it is perpendicular to the plane.*

Def. 3 may be stated thus: If a straight line is perpendicular to a plane, then it is perpendicular to every line in the plane which it meets. The converse to this would be

Theorem.—*All straight lines which meet a given straight line in the same point, and are perpendicular to it, lie in a plane which is perpendicular to that line.*

This Euclid states thus:

Prop. 5. *If three straight lines meet all at one point, and a straight line stands at right angles to each of them at that point, the three straight lines shall be in one and the same plane.*

§ 75. There follow theorems relating to the theory of parallel lines in space, viz.:—

Theorem (Prop. 6).—*Any two lines which are perpendicular to the same plane are parallel to each other;* and conversely

Theorem (Prop. 8).—*If of two parallel straight lines one is perpendicular to a plane, the other is so also.*

Further, the important theorems

Prop. 9. *Two straight lines which are each of them parallel to the same straight line, and not in the same plane with it, are parallel to one another;* where the words, "and not in the same plane with it," may be left out, for they exclude the case of three parallels in a plane, which has been proved before; and

Theorem (Prop. 10).—*If two angles in different planes have the two limits of the one parallel to those of the other, then the angles are equal.* That their planes are parallel is shown later on in Prop. 15.

This theorem is not necessarily true, for the angles in question may be supplementary; but then the one angle will be equal to that which is adjacent and supplementary to the other, and this latter angle will also have its limits parallel to those of the first.

From this theorem it follows that if we take any two straight lines in space which do not meet, and if we draw through any point P in space two lines parallel to them, then the angle included by these lines will always be the same, whatever the position of the point P may be. This angle has in modern times been called the angle between the given lines:—

Definition.—*By the angles between two not intersecting lines we understand the angles which two intersecting lines include that are parallel respectively to the two given lines.*

§ 76. It is now possible to solve the following two problems:—

Problem.—*To draw a straight line perpendicular to a given plane from a given point which lies*

1. *Not in the plane* (Prop. 11).
2. *In the plane* (Prop. 12).

The second case is easily reduced to the first—viz., if by aid of the first we have drawn any perpendicular to the plane from some point without it, we need only draw through the given point in the plane a line parallel to it, in order to have the required perpendicular given. The solution of the first part is of interest in itself. It depends upon a construction which may be expressed as a theorem.

Theorem.—*If from a point A without a plane a perpendicular AB be drawn to the plane, and if from the foot B of this perpendicular another perpendicular BC be drawn to any straight line in the plane, then the straight line joining A to the foot C of this second perpendicular will also be perpendicular to the line in the plane.*

The theory of perpendiculars to a plane is concluded by the theorem—

Prop. 13. *Through any point in space, whether in or without a plane, only one straight line can be drawn perpendicular to the plane.*

§ 77. The next four propositions treat of parallel planes. It is shown *that planes which have a common perpendicular are parallel* (Prop. 14); *that two planes are parallel if two intersecting straight lines in the one are parallel respectively to two straight lines in the other plane* (Prop. 15); *that parallel planes are cut by any plane in parallel straight lines* (Prop. 16); and lastly *that any two straight lines are cut proportionally by a series of parallel planes* (Prop. 17).

This theory is made more complete by adding the following theorems, which are easy deductions from the last:—*Two parallel planes have common perpendiculars* (converse to 14); and *Two planes which are parallel to a third plane are parallel to each other.*

It will be noted that Prop. 15 at once allows of the solution of the problem: "Through a given point to draw a plane parallel to a given plane." And it is also easily proved that this problem allows always of one, and only of one, solution.

§ 78. We come now to planes which are perpendicular to one another. Two theorems relate to them.

Prop. 18. *If a straight line be at right angles to a plane, every plane which passes through it shall be at right angles to that plane.*

Prop. 19. *If two planes which cut one another be each of them perpendicular to a third plane, their common section shall be perpendicular to the same plane.*

§ 79. If three planes pass through a common point, and if they bound each other, a solid angle of three faces, or a *trihedral* angle, is formed, and similarly by more planes a solid angle of more faces, or a *polyhedral* angle. These have many properties which are quite analogous to those of triangles and polygons in a plane. Euclid states some, viz.:—

Prop. 20. *If a solid angle be contained by three plane angles, any two of them are together greater than the third.*

But the next—

Prop. 21. *Every solid angle is contained by plane angles, which are together less than four right angles*—has no analogous theorem in the plane.

We may mention, however, that the theorems about triangles contained in the propositions of Book I., which do not depend upon the theory of parallels (that is all up to Prop. 27) have their corresponding theorems about trihedral angles. The latter are formed, if for "side of a triangle" we write "plane angle" or "face" of trihedral angle, and for "angle of triangle" we substitute "angle between two faces" where the planes containing the solid angle are called its *faces*. We get, for instance, from I. 4, the theorem, *If two trihedral angles have the angles of two faces in the one equal to the angles of two faces in the other, and have likewise the angles included by these faces equal, then the angles in the remaining faces are equal, and the angles between the other faces are equal each to each, viz., those which are opposite equal faces.* The solid angles themselves are not necessarily equal, for they may be only symmetrical like the right hand and the left.

The connection indicated between triangles and trihedral angles will also be recognized in

Prop. 22. *If every two of three plane angles be greater than the third, and if the straight lines which contain them be all equal, a triangle may be made of the straight lines that join the extremities of those equal straight lines.*

And Prop. 23 solves the problem, *To construct a trihedral angle having the angles of its faces equal to three given plane angles, any two of them being greater than the third.* It is, of course, analogous to the problem of constructing a triangle having its sides of given length.

Two other theorems of this kind are added by Simson in his edition of Euclid's *Elements*.

§ 80. These are the principal properties of lines and planes in space, but, before we go on to their applications it will be well to define the word *distance*. In geometry distance means always "shortest distance;" viz., the distance of a point from a straight line, or from a plane, is the length of the perpendicular from the point to the line or plane. The distance between two non-intersecting lines is the length of their common perpendicular, there being but one. The distance between two parallel lines or between two parallel planes is the length of the common perpendicular between the lines or the planes.

§ 81. *Parallelepipeds.*—The rest of the book is devoted to the study of the parallelepiped. In Prop. 24 the possibility of such a solid is proved, viz.:—

Prop. 24. *If a solid be contained by six planes two and two of which are parallel, the opposite planes are similar and equal parallelograms.*

Euclid calls this solid henceforth a parallelepiped, though he never defines the word. Either face of it may be taken as *base*, and its distance from the opposite face as *altitude*.

Prop. 25. *If a solid parallelepiped be cut by a plane parallel to two of its opposite planes, it divides the whole into two solids, the base of one of which shall be to the base of the other as the one solid is to the other.*

This theorem corresponds to the theorem (VI. 1) that parallelograms between the same parallels are to one another as their bases. A similar analogy is to be observed among a number of the remaining propositions.

§ 82. After solving a few problems we come to

Prop. 28. *If a solid parallelepiped be cut by a plane passing through the diagonals of two of the opposite planes, it shall be cut in two equal parts.*

In the proof of this, as of several other propositions, Euclid neglects the difference between solids which are symmetrical like the right hand and the left.

Prop. 31. *Solid parallelepipeds, which are upon equal bases, and of the same altitude, are equal to one another.*

Props. 29 and 30 contain special cases of this theorem leading up to the proof of the general theorem.

As consequences of this fundamental theorem we get

Prop. 32. *Solid parallelepipeds, which have the same altitude, are to one another as their bases;* and Prop. 33, *Similar solid parallelepipeds are to one another in the triplicate ratio of their homologous sides.*

If we consider, as in § 67, the ratios of lines as numbers, we may also say—

The ratio of the volumes of similar parallelepipeds is equal to the ratio of the third powers of homologous sides.

Parallelepipeds which are not similar but equal are compared by aid of the theorem.

Prop. 34. *The bases and altitudes of equal solid parallelepipeds are reciprocally proportional; and if the bases and altitudes be reciprocally proportional, the solid parallelepipeds are equal.*

§ 83. Of the following propositions the 37th and 40th are of special interest.

Prop. 37. *If four straight lines be proportionals, the similar solid parallepipeds, similarly described from them, shall also be proportionals; and if the similar parallelepipeds similarly described from four straight lines be proportionals, the straight lines shall be proportionals.*

In symbols, it says—

$$\text{If } a : b = c : d, \text{ then } a^3 : b^3 = c^3 : d^3.$$

Prop. 40 teaches how to compare the volumes of triangular prisms with those of parallelepipeds, by proving *that a triangular prism is equal in volume to a parallelepiped, which has its altitude and its base equal to the altitude and the base of the triangular prism.*

§ 84. From these propositions follow all results relating to the mensuration of volumes. We shall state these as we did in the case of areas. The starting-point is the "rectangular" parallelepiped, which has every edge perpendicular to the planes it meets, and which takes the place of the rectangle in the plane. If this has all its edges equal we obtain the "cube."

If we take a certain line u as unit length, then the square on u is the unit of area, and the cube on u the unit of volume, that is to say, if we wish to measure a volume we have to determine how many unit cubes it contains.

A rectangular parallelepiped has, as a rule, the three edges unequal, which meet at a point. Every other edge is equal to one of them. If a, b, c be the three edges meeting at a point, then we may take the rectangle contained by two of them, say by b and c, as base and the third as altitude. Let V be its volume, V′ that of another rectangular parallelepiped which has the edges a', b, c, hence the same base as the first. It follows then easily, from Prop. 25 or 32, that $V : V' = a : a'$; or in words, *Rectangular parallelepipeds on equal bases are proportional to their altitudes.*

If we have two rectangular parallelepipeds, of which the first has the volume V and the edges a, b, c, and the second, the volume V′ and the edges a', b', c', we may compare them by aid of two new ones which have respectively the edges a', b, c, and a', b', c, and the volumes V_1 and V_2. We then have

$$V : V_1 = a : a'; \; V_1 : V_2 = b : b', \; V_2 : V' = c : c'.$$

Compounding these, we have

$$V : V' = (a : a')\,(b : b')\,(c : c'),$$

or

$$\frac{V}{V'} = \frac{a}{a'} \cdot \frac{b}{b'} \cdot \frac{c}{c'} .$$

Hence, as a special case, making V′ equal to the unit cube U on u we get

$$\frac{V}{U} = \frac{a}{u} \cdot \frac{b}{u} \cdot \frac{c}{u} = \alpha \cdot \beta \cdot \gamma,$$

where α, β, γ are the numerical values of a, b, c; that is, *The number of unit cubes in a rectangular parallelepiped* is equal to the product of the numerical values of its three edges. This is generally expressed by saying the volume of a rectangular parallelepiped is measured by the product of its sides, or by the product of its base into its altitude, which in this case is the same.

Prop. 31 allows us to extend this to any parallelepipeds, and Props. 28 or 40, to triangular prisms.

THEOREM.—*The volume of any parallelepiped, or of any triangular prism, is measured by the product of base and altitude.*

The consideration that any polygonal prism may be divided into a number of triangular prisms, which have the same altitude and the sum of their bases equal to the base of the polygonal prism, shows further that the same holds for any prism whatever.

BOOK XII.

§ 85. In the last part of Book XI. we have learnt how to compare the volumes of parallelepipeds and of prisms. In order to determine the volume of any solid bounded by plane faces we must determine the volume of pyramids, for every such solid may be decomposed into a number of pyramids.

As every pyramid may again be decomposed into triangular pyramids, it becomes only necessary to determine their volume. This is done by the

Theorem.—Every triangular pyramid is equal in volume to one-third of a triangular prism having the same base and the same altitude as the pyramid.

This is an immediate consequence of Euclid's

Prop. 7. *Every prism having a triangular base may be divided into three pyramids that have triangular bases, and are equal to one another.*

The proof of this theorem is difficult, because the three triangular pyramids into which the prism is divided are by no means equal in shape, and cannot be made to coincide. It has first to be proved that two triangular pyramids have equal volumes, if they have equal bases and equal altitudes. This Euclid does in the following manner. He first shows (Prop. 3) that a triangular pyramid may be divided into four parts, of which two are equal triangular pyramids similar to the whole pyramid, whilst the other two are equal triangular prisms, and further, that these two prisms together are greater than the two pyramids, hence more than half the given pyramid. He next shows (Prop. 4) that if two triangular pyramids are given, having equal bases and equal altitudes, and if each be divided as above, then the two triangular prisms in the one are equal to those in the other, and each of the remaining pyramids in the one has its base and altitude equal to the base and altitude of the remaining pyramids in the other. Hence to these pyramids the same process is again applicable. We are thus enabled to cut out of the two given pyramids equal parts, each greater than half the original pyramid. Of the remainder we can again cut out equal parts greater than half these remainders, and so on as far as we like. This process may be continued till the last remainder is smaller than any assignable quantity, however small. It follows, so we should conclude at present, that the two volumes must be equal, for they cannot differ by any assignable quantity.

To Greek mathematicians this conclusion offers far greater difficulties. They prove elaborately, by a *reductio ad absurdum*, that the volumes cannot be unequal. This proof must be read in the *Elements*. A further discussion of this method of exhaustion, as it is called, would belong to a treatise on the history of geometry. We refer readers to Hankel, *Geschichte der Mathematik* (p. 115 *sq.*). We must, however, state that we have in the above not proved Euclid's Prop. 5, but only a special case of it. Euclid does not suppose that the bases of the two pyramids to be compared are equal, and hence he proves that the volumes are as the bases. The reasoning of the proof becomes clearer in the special case, from which the general one may be easily deduced.

§ 86. Prop. 6 extends the result to pyramids with polygonal bases. From these results follow again the rules at present given for the mensuration of solids, viz., a pyramid is the third part of a triangular prism having the same base and the same altitude. But a triangular prism is equal in volume to a parallelepiped which has the same base and altitude. Hence if B is the base and h the altitude, we have

$$\text{Volume of prism} = Bh,$$

$$\text{Volume of pyramid} = \frac{1}{3}Bh,$$

statements which have to be taken in the sense that B means the number of square units in the base, h the number of units of length in the altitude, or that B and h denote the numerical values of base and altitude,

§ 87. A method similar to that used in proving Prop. 5 leads to the following results relating to solids bounded by simple curved surfaces:—

Prop. 10. *Every cone is the third part of a cylinder which has the same base, and is of an equal altitude with it.*

Prop. 11. *Cones and cylinders of the same altitude are to one another as their bases.*

Prop. 12. *Similar cones and cylinders have to one another the triplicate ratio of that which the diameters of their bases have.*

Prop. 13. *If a cylinder be cut by a plane parallel to its opposite planes or bases, it divides the cylinder into two cylinders, one of which is to the other as the axis of the first to the axis of the other;* which may also be stated thus:—

Cylinders on the same base are proportional to their altitudes.

Prop. 14. *Cones and cylinders upon equal bases are to one another as their altitudes.*

Prop. 15. *The bases and altitudes of equal cones and cylinders are reciprocally proportional, and if the bases and altitudes be reciprocally proportional, the cones and cylinders are equal to one another.*

These theorems again lead to formulæ in mensuration, if we compare a cylinder with a prism having its base and altitude equal to the base and altitude of the cylinder. This may be done by the method of exhaustion. We get, then, the result that their bases are equal, and have, if B denotes the numerical value of the base, and h that of the altitude,

$$\text{Volume of cylinder} = Bh,$$

$$\text{Volume of cone} = \frac{1}{3}Bh.$$

§ 88. The remaining propositions relate to circles and spheres. Of the sphere only one property is proved, viz.:—

Prop. 18. *Spheres have to one another the triplicate ratio of that which their diameters have.* The mensuration of the sphere, like that of the circle, the cylinder, and the cone, had not been settled in the time of Euclid. It was done by Archimedes.

Book XIII.

§ 89. The 13th and last book of Euclid's *Elements* is devoted to the regular solids. It is shown that there are five of them, viz.:—

1. The regular *tetrahedron*, with 4 triangular faces and 4 vertices;
2. The *cube*, with 8 vertices and 6 square faces;
3. The *octohedron*, with 6 vertices and 8 triangular faces;
4. The *dodecahedron*, with 12 pentagonal faces, 3 at each of the 20 vertices;
5. The *icosahedron*, with 20 triangular faces, 5 at each of the 12 vertices.

It is shown how to inscribe these solids in a given sphere, and how to determine the lengths of their edges.

These results are—if r denotes the radius of the circumscribed sphere, and a the side of the regular solid—

For tetrahedron $a^2 = \frac{8}{3}r^2,$

" octahedron $a^2 = 2r^2,$

" hexahedron or cube $a^2 = \frac{4}{3}r^2,$

" icosahedron $a^2 = 2\left(1 - \frac{\sqrt{5}}{5}\right)r^2,$

" dodecahedron $a^2 = 2\left(1 - \frac{\sqrt{5}}{3}\right)r^2.$

§ 90. The 13th book, and therefore the *Elements*, conclude with the scholium, "that no other regular solid exists besides the five ones enumerated."

The proof is very simple. Each face is a regular polygon, hence the angles of the faces at any vertex must be angles in equal regular polygons, must be together less than four right angles (XI. 21), and must be three or more in number. Each angle in a regular triangle equals two-thirds of one right angle. Hence it is possible to form a solid angle with three, four, or five regular triangles or faces. These give the solid angles of the tetrahedron, the octohedron, and the icosahedron. The angle in a square (the regular quadrilateral) equals one right angle. Hence three will form a solid angle, that of the cube, and four will not. The angle in the regular pentagon equals $\frac{6}{5}$ of a right angle. Hence three of them equal $\frac{18}{5}$ (*i.e.*, less than 4) right angles, and form the solid angle of the dodecahedron. Three regular polygons of six or more sides cannot form a solid angle. Therefore no other regular solids are possible.

Section II.—Higher or Projective Geometry.

It is difficult, at the outset, to characterize Projective Geometry as compared with Euclidian. But a few examples will at least indicate the difference between the two.

In Euclid's *Elements* almost all propositions refer to the *magnitude* of lines, angles, areas, or volumes, and therefore to measurement. The statement that an angle is right, or that two straight lines are parallel, refers to measurement. On the other hand, the fact that a straight line does or does not cut a circle is independent of measurement, it being dependent only upon the mutual "position" of the line and the circle. This difference becomes clearer if we project any figure from one plane to another. By this the length of lines, the magnitude of angles and areas, is altered, so that the projection, or shadow, of a square on a plane will not be a square; it will, however, be some quadrilateral. Again, the projection of a circle will not be a circle, but some other curve more or less resembling a circle. But one property may be stated at once,—no straight line can cut the projection of a circle in more than two points, because no straight line can cut a circle in more than two points. There are, then, some properties of figures which do not alter by projection, whilst others do. To the latter belong nearly all properties relating to measurement, at least in the form in which they are generally given. The others are said to be projective properties, and their investigation forms the subject of Projective Geometry.

Different as are the kinds of properties investigated in the old and the new sciences, the methods followed differ in a still greater degree. In Euclid each proposition stands by itself; its connection with others is never indicated; the leading ideas contained in its proof are not stated; general principles do not exist. In the modern methods, on the other hand, the greatest importance is attached to the leading thoughts which pervade the whole; and general principles, which bring whole groups of theorems under one aspect, are given rather than separate propositions. The whole tendency is towards generalization. A straight line is considered as given in its entirety, extending both ways to infinity, while Euclid is very careful never to admit anything but finite quantities. The treatment of the infinite is in fact another fundamental difference between the two methods. Euclid avoids it. In modern geometry it is systematically introduced, for only thus is generality obtained.

Of the different modern methods of geometry, we shall treat principally of the methods of projection and correspondence which have proved to be the most powerful. These have become independent of Euclidian Geometry, especially through the *Geometrie der Lage* of V. Staudt, and the *Ausdehnungslehre* of Grassmann.

For the sake of brevity we shall presuppose a knowledge of Euclid's *Elements*, although we shall use only a few of his propositions.

§ 1. We consider space as filled with points, lines, and planes, and these we call the elements out of which our figures are to be formed, calling any combination of these elements a "figure."

By a line we mean a straight line in its entirety, extending both ways to infinity; and by a plane, a plane surface, extending in all directions to infinity. We suppose

That through any two points in space one and only one line may be drawn (Eucl. I., Def. 4, Ax. 10, Post. 2);

That through any three points which are not in a line, one and only one plane may be placed (compare p. 344, § 73, above);

That the intersection of two planes is a line (Eucl. XI. 13);

That a line which has two points in common with a plane lies in the plane (Eucl. I., Def. 7), hence that the intersection of a line and a plane is a single point; and

That three planes which do not meet in a line have one single point in common.

These results may be stated differently in the following form:—

I. A plane is determined—
  1. By three points which do not lie in a line;
  2. By two intersecting lines;
  3. By a line and a point which does not lie in it.

A point is determined—
  1. By three planes which do not pass through a line;
  2. By two intersecting lines;
  3. By a line and a plane which does not pass through it.

II. A line is determined—
  1. By two points;
  2. By two planes.

The reader will observe that not only are planes determined by points, but also points by planes; that therefore we have a right to consider the planes as elements, like points; and also that in any one of the above statements we may interchange the words point and plane, and we obtain again a correct statement, provided that these statements themselves are true. As they stand, we ought, in several cases, to add "if they are not parallel," or some such words, parallel lines and planes being evidently left altogether out of consideration. To correct this we have to reconsider the theory of parallels.

§ 2. Let us take in a plane a line p (fig. 1), a point S not in this line, and a line q drawn through S. Then this line q will meet the line p in a point A. If we turn the line q about S towards q', its point of intersection with p will move along p towards B, passing, on continued turning, to a greater and greater distance, until it is moved out of our reach. If we turn q still farther, its continuation will meet p, but now at the other side of A. The point of intersection has disappeared to the right and reappeared to the left. There is one intermediate position where q is parallel to p—that is where it does not cut p. In every other position it cuts p in some finite point If, on the other hand, we move the point A to an infinite distance in p, then the line q which passes through A will be a line which does not cut p at any finite point. Thus we are led to say: *Every* line through S which joins it to any point at an infinite distance in p is parallel to p. But by Euclid's 12th axiom there is but one line parallel to p through S. The difficulty in which we are thus involved is due to the fact that we try to reason about infinity as if we, with our finite capabilities, could comprehend the infinite. To overcome this difficulty, we may say that all points at infinity in a line *appear* to us as one, and may be replaced by a single "ideal" point, just as all points in a fixed star—which is not at an infinite, only at a great distance—cannot be distinguished by us, and to beings on the earth count as one. We may therefore now give the following definitions and axiom:—

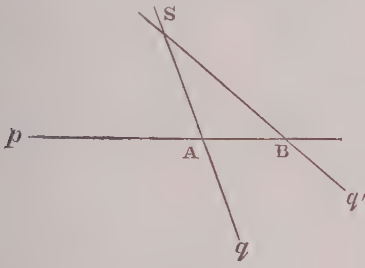


FIG. 1.

Definition.—Lines which meet at infinity are called parallel.

Axiom.—All points at an infinite distance in a line may be considered as one single point.

Definition.—This ideal point is called the point at infinity in the line.

The axiom is equivalent to Euclid's Axiom 12, for it follows from either that through any point only one line may be drawn parallel to a given line.

This point at infinity in a line is reached whether we move a point in the one or in the opposite direction of a line to infinity. A line thus appears closed by this point, and we speak as if we could move a point along the line from one position A to another B in two ways, either through the point at infinity or through finite points only.

It must never be forgotten that this point at infinity is ideal, that the results based on this assumption are true for that finite region of space which is within our reach, and that beyond this region they may or may not be true,—we do not know.

The advantage of this view of parallels will become apparent at every step as we go on.

§ 3. Having thus arrived at the notion of replacing all points at infinity in a line by one ideal point, there is no difficulty in replacing all points at infinity in a plane by one ideal line.

To make this clear, let us suppose that a line p, which cuts two fixed lines a and b in the points A and B, moves parallel to itself to a greater and greater distance. It will at last cut both a and b at their points at infinity, so that a line which joins the two points at infinity in two intersecting lines lies altogether at infinity. Every other line in the plane will meet it therefore at infinity, and thus it contains all points at infinity in the plane.

All points at infinity in a plane lie in a line, which is called the line at infinity in the plane.

It follows that parallel planes must be considered as planes having a common line at infinity, for any other plane cuts them in parallel lines (Eucl. XI. 16), which have a point at infinity in common.

If we next take two intersecting planes, then the point at infinity in their line of intersection lies in both planes, so that their lines at infinity meet. Hence every line at infinity meets every other line at infinity, and they are therefore all in one plane.

All points at infinity in space may be considered as lying in one ideal plane, which is called the plane at infinity.

§ 4. We have now the following definitions:—

Parallel lines are lines which meet at infinity;

Parallel planes are planes which meet at infinity;

A line is parallel to a plane if it meets it at infinity.

Theorems like this—Lines (or planes) which are parallel to a third are parallel to each other—follow at once.

This view of parallels leads therefore to no contradiction of Euclid's *Elements*.

As immediate consequences we get the propositions:—

Every line meets a plane in one point, or it lies in it;

Every plane meets every other plane in a line.

Any two lines in the same plane meet.

§ 5. We have called points, lines, and planes the elements of geometrical figures. We also say that an element of one kind *contains* one of the other if it lies in it or passes through it.

All the elements of one kind which are contained in one or two elements of a different kind form aggregates which have to be enumerated. They are the following:—

I. Of one dimension.
  1. The *row*, or range, *of points* formed by all points in a line, which is called its base.
  2. The *flat pencil* formed by all the lines through a point in a plane. Its base is the point in the plane.
  3. The *axial pencil* formed by all planes through a line which is called its base or axis.

II. Of two dimensions.
  1. The field of points and lines—that is, a plane with all its points and all its lines.
  2. The pencil of lines and planes—that is, a point in space with all lines and all planes through it.

III. Of three dimensions.
  The space of points—that is, all points in space.
  The space of planes—that is, all planes in space.

IV. Of four dimensions.
  The space of lines, or all lines in space.

§ 6. The word dimension in the above needs explanation.

If in a plane we take a row p and a pencil with centre Q, then through every point in p one line in the pencil will pass, and every ray in Q will cut p in one point, so that we are entitled to say a row contains as many points as a flat pencil lines, and, we may add, as an axial pencil planes, because an axial pencil is cut by a plane in a flat pencil.

The number of elements in the row, in the flat pencil, and in the axial pencil is, of course, infinite and indefinite too, but the same in all. For a moment we shall treat it as being a definite number which we denote by α. Then a plane contains α^2 points and as many lines. To see this, take a flat pencil in a plane. It contains α lines, and each line contains α points, whilst each point in the plane lies on one of these lines. Similarly, in a plane each line cuts a fixed line in a point. But this line is cut at each point by α lines and contains α points; hence there are α^2 lines in a plane.

A pencil in space contains as many lines as a plane contains points and as many planes as a plane contains lines, for any plane cuts the pencil in a field of points and lines. Hence a pencil contains α^2 lines and α^2 planes. *The field and the pencil are of two dimensions.*

To count the number of points in space, we observe that each point lies on some line in a pencil. But the pencil contains α^2 lines, and each line α points; hence space contains α^3 points. Each plane cuts any fixed plane in a line. But a plane contains α^2 lines, and through each pass α planes; therefore space contains α^3 planes.

Hence space contains as many planes as points, but it contains an infinite number of times more lines than points or planes. To count them, notice that every line cuts a fixed plane in one point. But α^2 lines pass through each point, and there are α^2 points in the plane. Hence there are α^4 lines in space. *The space of points and planes is of three dimensions, but the space of lines is of four dimensions.*

A field of points or lines contains an infinite number of rows and flat pencils; a pencil contains an infinite number of flat pencils and of axial pencils; space contains a triple infinite number of pencils and of fields, α^4 rows and axial pencils, and α^5 flat pencils—or, in other words, each point is a centre of α^3 flat pencils.

§ 7. The above enumeration allows a classification of figures. Figures in a row consist of groups of points only, and figures in the flat or axial pencil consist of groups of lines or planes. In the plane we may draw polygons; and in the pencil or in the point, solid angles, and so on.

We may also distinguish the different measurements. We have—

In the row, length of segment;
In the flat pencil, angles;
In the axial pencil, dihedral angles between two planes;
In the plane, areas;
In the pencil, solid angles;
In the space of points or planes, volumes.

SEGMENTS OF A LINE.

§ 8. Any two points A and B in space determine on the line through them a finite part, which may be considered as being described by a point moving from A to B. This we shall denote by AB, and distinguish it from BA, which is supposed as being described by a point moving from B to A, and hence in a direction or in a "sense" opposite to AB. Such a finite line, which has a definite sense, we shall call a "segment," so that AB and BA denote different segments, which are said to be equal in length but of opposite sense. The one sense is often called positive and the other negative.

In introducing the word "sense" for direction in a line, we have the word direction reserved for direction of the line itself, so that different lines have different directions, unless they be parallel, whilst in each line we have a positive and negative sense.

We may also say, with Professor Clifford, that AB denotes the "step" of going from A to B.

§ 9. If we now have three points A, B C in a line (fig. 2), the step A B will bring us from A to B, and the step BC from B to C. Hence both steps are equivalent to the one step AC. This is expressed by saying that AC is the "sum" of AB and BC; in symbols—

$$AB + BC = AC,$$

where account is to be taken of the sense.

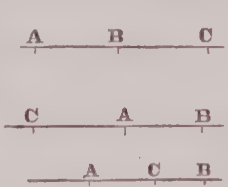


FIG. 2.

This equation is true whatever be the position of the three points on the line. As a special case we have

$$AB + BA = 0 \quad . \quad . \quad . \quad . \quad . \quad . \quad (1),$$

and similarly

$$AB + BC + CA = 0 \quad . \quad . \quad . \quad . \quad . \quad (2),$$

which again is true for any three points in a line.

We further write

$$AB = -BA,$$

where — denotes negative sense.

We can then, just as in algebra, change subtraction of segments into addition by changing the sense, so that AB — CB is the same as AB + (— CB) or AB + BC. A figure will at once show the truth of this. The sense is, in fact, in every respect equivalent to the "sign" of a number in algebra.

§ 10. Of the many formulæ which exist between points in a line we shall have to use only one more, which connects the segments between any four points A, B, C, D in a line. We have—

$$\begin{aligned} BC &= BD + DC, \\ CA &= CD + DA, \\ AB &= AD + DB; \end{aligned}$$

or multiplying these by AD, BD, CD respectively, we get—

$$\begin{aligned} BC.AD &= BD.AD + DC.AD = BD.AD - CD.AD \\ CA.BD &= CD.BD + DA.BD = CD.BD - AD.BD \\ AB.CD &= AD.CD + DB.CD = AD.CD - BD.CD. \end{aligned}$$

It will be seen that the sum of the right hand sides vanishes, hence that

$$BC.AD + CA.BD + AB.CD = 0 \quad . \quad . \quad . \quad (3)$$

for any four points on a line.

§ 11. If C is any point in the line AB, then we say that C divides the segment AB in the ratio $\frac{AC}{CB}$, account being taken of the sense of the two segments AC and CB. If C lies between A and C the ratio is positive, as AC and CB have the same sense. But if C lies without the segment AB, *i. e.*, if C divides AB externally, then the ratio is negative. To see how the value of this ratio changes with C, we will move C along the whole line (fig. 3), whilst A and B remain fixed. If C lies at the point A, then AC = 0, hence the ratio AC : CB vanishes. As C moves towards B, AC increases and CB decreases, so that our ratio increases. At the middle point M of AB it assumes the value + 1, and then increases till it reaches an infinitely large value, when C arrives at B. On passing beyond B the ratio becomes negative. If C is at P we have AC = AP = AB + BP, hence

$$\frac{AC}{CB} = \frac{AB}{PB} + \frac{BP}{PB} = -\frac{AB}{PB} - 1.$$

In the last expression the ratio AB : BP is positive, has its greatest value ∞ when C coincides with B, and vanishes when BC becomes infinite. Hence, as C moves from B to the right to the point at infinity, the ratio AC : CB varies from — ∞ to — 1.

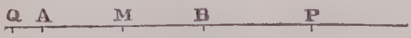


FIG. 3.

If, on the other hand, C is to the left of A, say at Q, we have AC = AQ = AB + BQ = AB — QB, hence, $\frac{AC}{CB} = \frac{AB}{QB} - 1.$

Here AB < QB, hence the ratio AB : QB is positive and always less than one, so that the whole is negative and < 1. If C is at the point at infinity it is — 1, and then increases as C moves to the right, till for C at A we get the ratio = 0. Hence—

"As C moves along the line from an infinite distance to the left to an infinite distance at the right, the ratio always increases; it starts with the value — 1, reaches 0 at A, + 1 at M, ∞ at B, changes now sign to — ∞, and increases till at an infinite distance it reaches again the value — 1. *It assumes therefore all possible values from — ∞ to + ∞, and each value only once, so that not only does every position of C determine a definite value of the ratio AC : CB, but also, conversely, to every positive or negative value of this ratio belongs one single point in the line AB.*"

PROJECTION AND CROSS-RATIOS.

§ 12. If we join a point A to a point S, then the point where the line SA cuts a fixed plane π is called the projection of A on the plane π from S as centre of projection. If we have two planes π and π′ and a point S, we may project every point A in π to the other plane. If A′ is the projection of A, then A is also the projection of A′, so that the relations are reciprocal. To every figure in π we get as its projection a corresponding figure in π′.

It will be our business to find such properties of figures as remain true for the projection, and which are called projective properties. For this purpose it will be sufficient to consider at first only constructions in one plane.

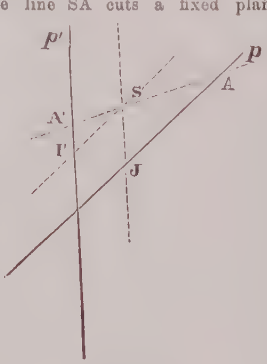


FIG. 4.

Let us suppose we have given in a plane two lines p and p' and a centre S (fig. 4); we may then project the points in p from S to p'. Let A′, B′ . . . be the projections of A, B . . ., the point at infinity in p which we shall denote by J will be projected into a finite point I′ in p', viz., into the point where the parallel to p through S cuts p'. Similarly one point J in p will be projected into the point I′ at infinity in p'. This point J is of course the point where the parallel to p' through S cuts p. We thus see that every point in p is projected into a single point in p'.

A glance at fig. 5 shows that a segment AB will be projected into a segment A′B′ which is not equal to it, at least not as a rule; and also that the ratio AC : CB is not equal to the ratio A′C′ : C′B′ formed by the projections. These ratios will become equal only if p and p' are parallel, for in this case the triangle SAB is similar to the triangle SA′B′. Between three points in a line and their projections there exists therefore in general no relation. But between four points a relation does exist.

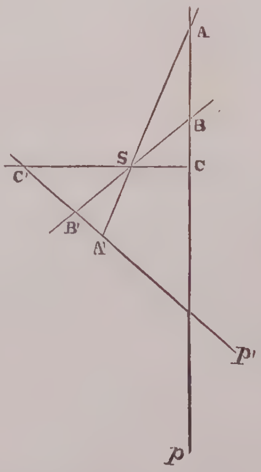


FIG. 5.

§ 13. Let A, B, C, D be four points in p, A′, B′, C′, D′ their projections in p', then the ratio of the two ratios AC : CB and AD : DB into which C and D divide the segment AB is equal to the corresponding expression between A′, B′, C′, D′. In symbols we have—

$$\frac{AC}{CB} : \frac{AD}{DB} = \frac{A'C'}{C'B'} : \frac{A'D'}{D'B'}$$

This is easily proved by aid of similar triangles.

Through the points A and B on p draw parallells to p', which cut the projecting rays in C_2, D_2, B_2 and A_1, C_1, D_1, as indicated in fig. 6. The two triangles ACC_2 and BCC_1 will be similar, as will also be the triangles ADD_2 and BDD_1.

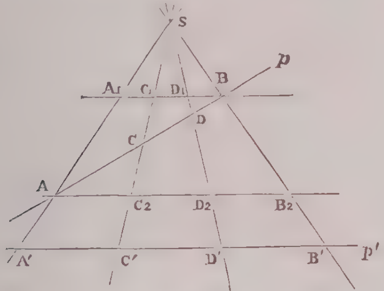


FIG. 6.

We have therefore—

$$\frac{AC}{CB} = \frac{AC_2}{C_1B}, \quad \frac{AD}{DB} = \frac{AD_2}{D_1B}$$

where account is taken of the sense.

Hence—

$$\frac{AC}{CB} : \frac{AD}{DB} = \frac{AC_2}{C_1B} : \frac{AD_2}{D_1B} = \frac{AC_2}{AD_2} : \frac{C_1B}{D_1B};$$

but

$$\frac{AC_2}{AD_2} = \frac{A'C'}{A'D'} \text{ and } \frac{C_1B}{D_1B} = \frac{C'B'}{D'B'};$$

so that the above expression becomes

$$\frac{A'C'}{A'D'} : \frac{C'B'}{D'B'},$$

which is equal to $\frac{A'C'}{C'B'} : \frac{A'D'}{D'B'}$ as required.

This result is of fundamental importance.

The expression formed has been called by Chasles the anharmonic ratio of the four points A, B, C, D. Instead of this Professor Clifford has proposed the shorter and more expressive name of "cross-ratio." We shall adopt the latter. We have then the

FUNDAMENTAL THEOREM.—*The cross-ratio of four points in a line is equal to the cross-ratio of their projections on any other line which lies in the same plane with it.*

§ 14. Before we draw conclusions from this result, we must investigate the meaning of a cross-ratio somewhat more fully.

If four points A, B, C, D, are given, and we wish to form their cross-ratio, we have first to divide them into two groups of two, the points in each group being taken in a definite order. Thus, let A, B be the first, C, D the second pair, A and C being the first points in each pair. The cross-ratio is then the ratio AC : CB divided by AD : DB. This will be denoted by (ABCD), so that

$$(ABCD) = \frac{AC}{CB} : \frac{AD}{DB}.$$

This is easily remembered. In order to write it out, make first the two lines for the fractions, and put above and below these the letters A and B in their places, thus, $\frac{A}{\quad B} : \frac{A}{\quad B}$; and then fill up, crosswise, the first by C and the other by D.

§ 15. If we take the points in a different order, the value of the cross-ratio will change. We can do this in twenty-four different ways by forming all permutations of the letters. But of these twenty-four cross-ratios groups of four are equal, so that there are really only six different ones.

We have the following rules:—

I. If in a cross-ratio the two groups be interchanged, its value remains unaltered.

$$(ABCD) = (CDAB).$$

II. If in a cross-ratio the two points belonging to one of the two groups be interchanged, the cross-ratio changes into its reciprocal.

$$(ABCD) = \frac{1}{(ABDC)}.$$

III. If in a cross-ratio the two middle letters be interchanged, the cross-ratio κ changes into its complement $1 - \kappa$.

$$(ABCD) = 1 - (ACBD).$$

The first two are easily proved by writing out their values. The third is proved by aid of the formula (3), § 10,

$$BC \cdot AD + CA \cdot BD + AB \cdot CD = 0.$$

If we divide this by CB . AD we get

$$-1 + \frac{CA \cdot BD}{CB \cdot AD} + \frac{AB \cdot CD}{CB \cdot AD} = 0,$$

or

$$\frac{AC}{CB} : \frac{AD}{DB} + \frac{AB}{BC} : \frac{AD}{DC} = 1;$$

that is,

$$(ABCD) + (ACBD) = 1,$$

which was to be proved.

IV. From II. it follows at once that if we interchange the elements in each pair, the cross-ratio remains unaltered; and thus we see that

$$(ABCD) = (CDAB) \quad \text{by I.}$$
$$= (BADC) = (DCBA) \quad \text{by II.}$$

§ 16. By aid of these rules we get the following results:—

$$(ABCD) = (BADC) = (CDAB) = (DCBA) = \kappa.$$

$$(ABDC) = (BACD) = (CDBA) = (DCAB) = \frac{1}{\kappa}.$$

$$(ACBD) = (BDAC) = (CADB) = (DBCA) = 1 - \kappa.$$

$$(ACDB) = (BDCA) = (CABD) = (DBAC) = \frac{1}{1 - \kappa}.$$

$$(ADBC) = (BCAD) = (CBDA) = (DACB) = \frac{\kappa - 1}{\kappa}.$$

$$(ADCB) = (BCDA) = (CBAD) = (DABC) = \frac{\kappa}{\kappa - 1}.$$

In the theorem that the cross-ratio of four points equals that of the projections, the points have, of course, to be taken in the same order.

§ 17. If one of the points of which a cross-ratio is formed is the point at infinity in the line, the cross-ratio changes into a simple ratio. It is convenient to let the point at infinity occupy the last place in the symbolic expression for the cross-ratio. Thus if I is a point at infinity, we have

$$(ABCI) = -\frac{AC}{CB},$$

because

$$AI : IB = -1.$$

Every common ratio of three points in a line may thus be expressed as a cross-ratio, by adding the point at infinity to the group of points.

§ 18. If the points have special positions, the cross-ratios κ may have such a value that, of the six different ones, two and two become equal. If the first two shall be equal, we get $\kappa = \frac{1}{\kappa}$, or $\kappa^2 = 1$, $\kappa = \pm 1$.

If we take $\kappa = +1$, we have (ABCD) = 1, or $\frac{AC}{CB} = \frac{AD}{DB}$; that is the points C and D coincide, provided that A and B are different. This is too special a case to be of much interest.

If, however, we take $\kappa = -1$, so that (ABCD) = − 1, we have $\frac{AC}{CB} = -\frac{AD}{DB}$. *Hence* C *and* D *divide* AB *internally and externally in the same ratio.*

The four points are in this case said to be *harmonic points*, and C *and* D *are said to be harmonic conjugates with regard to* A *and* B.

But we have also (CDAB) = − 1, so that A and B are harmonic conjugates with regard to C and D.

The principal property of harmonic points upon which almost all applications depend, is this, that their cross-ratio remains unaltered if we interchange the two points belonging to one pair, viz:

$$(ABCD) = (ABDC) = (BACD).$$

For four harmonic points the six cross-ratios which are generally different become two and two equal:

$$\kappa = -1, \; 1 - \kappa = 2, \; \frac{\kappa}{\kappa - 1} = \tfrac{1}{2}$$

$$\frac{1}{\kappa} = -1, \; \frac{1}{1 - \kappa} = \tfrac{1}{2}, \; \frac{\kappa - 1}{\kappa} = 2.$$

Hence if we get four points whose cross-ratio is 2 or ½, then they are harmonic, but not arranged so that conjugates are paired. If this is the case the cross-ratio = − 1.

§ 19. If we equate any two of the above six values of the cross-ratios, we get either $\kappa = 1, 0, \infty$, or $\kappa = -1, 2, \frac{1}{2}$, or else κ becomes a root of the equation $\kappa^2 - \kappa + 1 = 0$, that is, an imaginary cube root of -1. In this case the six values become three and three equal, so that only two different values remain. This case, though important in the theory of cubic curves, is for our purposes of no interest, whilst harmonic points are all-important.

§ 20. From the definition of harmonic points, and by aid of § 11, the following properties are easily deduced.

If C and D are harmonic conjugates with regard to A and B, then one of them lies in, the other without AB; it is impossible to move from A to B without passing either through C or through D; the one blocks the finite way, the other the way through infinity. This is expressed by saying A and B are "separated" by C and D.

For every position of C there will be one and only one point D which is its harmonic conjugate with regard to any point pair A, B.

If A and B are different points, and if C coincides with A or B, D does. But if A and B coincide, one of the points C or D, lying between them, coincides with them, and the other may be anywhere in the line. It follows that "*if of four harmonic conjugates two coincide, then a third coincides with them, and the fourth may be any point in the line.*"

If C is the middle point between A and B, then D is the point at infinity for AC : CB = + 1, hence AD : DB must be equal to − 1. *The harmonic conjugate of the point at infinity in a line with regard to two points* A, B *is the middle point of* AB.

This important property gives a first example how metric properties are connected with projective ones.

§ 21. *Complete Quadrilateral.*—A figure formed by four lines in a plane is called a complete quadrilateral or, shorter, a four-side (fig. 7). The figure has six *vertices*, that is points where the sides meet, and three diagonals AB, EF, GH, which join *opposite* vertices.

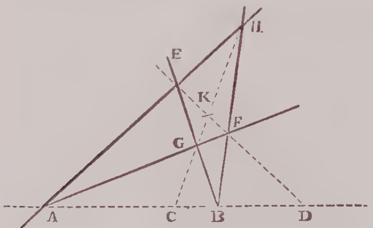


FIG. 7.

Similarly a figure formed by four points in a plane is called a four-point. It has six sides, which join the points or vertices, and three diagonal points, where the sides meet.

The three diagonals of a four-side cut each other harmonically.

If we project the points E, F, K, D from H to AB, we get

$$(EFKD) = (ABCD),$$

and if we project them from G, we get

$$(EFKD) = (BACD);$$

so that

$$(ABCD) = (BACD),$$

that is the cross-ratio (ABCD) is equal to its reciprocal, hence $= -1$, as the four points are all different. This gives the important theorem:—

THEOREM.—*In every four-side any diagonal is cut harmonically by the other two.*

This allows the solution of the problem:—

PROBLEM.—*To construct the harmonic conjugate* D *to a point* C *with regard to two given points* A *and* B.

Solution.—Through A draw any two lines, and through C one cutting the former two in G and H. Join these points to B, cutting the former two lines in E and F. The point D where EF cuts AB will be the harmonic conjugate required.

This remarkable construction requires nothing but the drawing of lines, and is therefore independent of measurement. It follows, also, that *all four-sides which have two vertices at* A *and* B, *and one diagonal passing through* C, *will each have the third diagonal passing through* D.

§ 22. The theory of cross-ratios may be extended from points in a row to lines in a flat pencil, and to planes in an axial pencil. We have seen (§ 13) that if the lines which join four points A, B, C, D to any point S be cut by any other line in A′, B′, C′, D′, then (ABCD) = (A′B′C′D′). In other words, four lines in a flat pencil are cut by every other line in four points whose cross-ratio is constant.

Definition.—By the cross-ratio of four rays in a flat pencil is meant the cross-ratio of the four points in which the rays are cut by any line. If a, b, c, d be the lines, then this cross-ratio is denoted by $(abcd)$.

Definition.—By the cross-ratio of four planes in an axial pencil is understood the cross-ratio of the four points in which any line cuts the planes, or what is the same thing, the cross-ratio of the four rays in which any plane cuts the four planes.

In order that this definition may have a meaning, it has to be proved that all lines cut the pencil in points which have the same cross-ratio. This is seen at once for two intersecting lines, as their plane cuts the axial pencil in a flat pencil, which is itself cut by the two lines. The cross-ratio of the four points on one line is therefore equal to that on the other, and equal to that of the four rays in the flat pencil.

If two non-intersecting lines p and q cut the four planes in A, B, C, D and A′, B′, C′, D′, draw a line r to meet both p and q, and let this line cut the planes in A″, B″, C″, D″. Then (ABCD) = (A′B′C′D′), for each is equal to (A″B″C″D″).

§ 23. We may now also extend the notion of harmonic elements, viz.:—

Definition.—Four rays in a flat pencil and four planes in an axial pencil are said to be harmonic if their cross-ratio equals − 1, that is, if they are cut by a line in four harmonic points.

Harmonic pencils are constructed by aid of the theorem in § 21, which may now be stated thus:—

In a four-side two sides are harmonic conjugates with regard to the diagonal through their intersection and the line from this point to the point where the other diagonals meet. Or thus: *In a four-point the lines joining one diagonal point to the other two are harmonic conjugates with regard to the sides passing through the first.*

If we understand by a "median line" of a triangle a line which joins a vertex to the middle point of the opposite side, and by a "median line" of a parallelogram a line joining middle points of opposite sides, we get as special cases of the last theorem:—

The diagonals and median lines of a parallelogram form an harmonic pencil; and

At a vertex of any triangle, the two sides, the median line, and the line parallel to the base form an harmonic pencil.

Taking the parallelogram a rectangle, or the triangle isosceles, we get:—

THEOREM.—*Any two lines and the bisections of their angles form an harmonic pencil.* Or:—

In an harmonic pencil, if two conjugate rays are perpendicular, then the other two are equally inclined to them; and, conversely, *if one ray bisects the angle between conjugate rays, it is perpendicular to its conjugate.*

This connects perpendicularity and bisection of angles with projective properties.

§ 24. We add a few theorems and problems which are easily proved or solved by aid of harmonics.

An harmonic pencil is cut by a line parallel to one of its rays in three equidistant points.

Through a given point to draw a line such that the segment determined on it by a given angle is bisected at that point.

Having given two parallel lines to bisect on either any given segment without using a pair of compasses.

Having given in a line a segment and its middle point, to draw through any given point in the plane a line parallel to the given line.

To draw a line which joins a given point to the intersection of two given lines which meet off the drawing paper (by aid of § 21).

CORRESPONDENCE.

§ 25. Two rows, p and p', which are one the projection of the other (as in fig. 5), stand in a definite relation to each other, characterized by the following properties.

1. *To each point in either corresponds one point in the other;* that is, those points are said to correspond which are projections of one another.

2. *The cross-ratio of any four points in one equals that of the corresponding points in the other.*

3. *The lines joining corresponding points all pass through the same point.*

If we suppose corresponding points marked, and the rows brought into any other position, then the lines joining corresponding points will no longer meet in a common point, and hence the third of the above properties will not hold any longer; but we have still a correspondence between the points in the two rows possessing the first two properties. Such a correspondence has been called a *one-one correspondence*, whilst the two rows between which such correspondence has been established are said to be *projective* or *homologous*. Two rows which are each the projection of the other are therefore *projective*. We shall presently see, also, that any two projective rows may always be placed in such a position that one appears as the projection of the other. If they are in such a position the rows are said to be in *perspective position*, or simply to be *perspective*.

§ 26. The notion of a one-one correspondence between rows may be extended to flat and axial pencils, viz., a flat pencil will be said to be projective to a flat pencil if to each ray in the first corresponds one ray in the second, and if the cross-ratio of four rays in one equals that of the corresponding rays in the second.

Similarly an axial pencil may be projective to an axial pencil. But a flat pencil may also be projective to an axial pencil, or either pencil may be projective to a row. The definition is the same in each case: there is a one-one correspondence between the elements, and four elements have the same cross-ratio as the corresponding ones.

§ 27. There is also in each case a special position which is called *perspective*, viz.:—

1. Two projective rows are perspective if they lie in the same plane, and if the one row is a projection of the other.

2. Two projective flat pencils are perspective—(α) if they lie in the same plane, and have a row as a common section; (β) if they lie in the same pencil (in space), and are both sections of the same axial pencil; (γ) if they are in space and have a row as common section, or are both sections of the same axial pencil, one of the conditions involving the other.

3. Two projective axial pencils, if their axes meet, and if they have a flat pencil as a common section.

4. A row and a projective flat pencil, if the row is a section of the pencil, each point lying in its corresponding line.

5. A row and a projective axial pencil, if the row is a section of the pencil, each point lying in its corresponding line.

6. A flat and a projective axial pencil, if the former is a section of the other, each ray lying in its corresponding plane.

That in each case the correspondence established by the position indicated is such as has been called projective follows at once from the definition. It is not so evident that the perspective position may always be obtained. We shall show in § 30 this for the first three cases. First, however, we shall give a few theorems which relate to the general correspondence, not to the perspective position.

§ 28. Theorem.—*Two rows or pencils, flat or axial, which are projective to a third are projective to each other*, as follows at once from the definitions.

§ 29. Fundamental Theorem.—*If two rows, or two pencils, either flat or axial, or a row and a pencil, shall be projective, we may assume to any three elements in the one the three corresponding elements in the other, and then the correspondence is uniquely determined.*

Proof.—If in two projective rows we assume that the points A, B, C in the first correspond to the given points A', B', C' in the second, then to any fourth point D in the first will correspond a point D' in the second, so that

$$(ABCD) = (A'B'C'D').$$

But there is only one point, D', which makes the cross-ratio $(A'B'C'D')$ equal to the given number (ABCD).

The same reasoning holds in the other cases.

§ 30. *Theorem.*—If two rows are perspective, then the lines joining corresponding points all meet in a point, the centre of projection; and the point in which the two bases of the rows intersect as a point in the first row coincides with its corresponding point in the second.

This follows from the definition. The converse also holds, viz.:—

Theorem.—*If two projective rows have such a position that one point in the one coincides with its corresponding point in the other, then they are perspective, that is, the lines joining corresponding points all pass through a common point, and form a flat pencil.*

Proof.—Let A, B, C, D . . . be points in the one, and A', B', C', D' . . . the corresponding points in the other row, and let A be made to coincide with its corresponding point A'. Let S be the point where the lines BB' and CC' meet and let us join S to the point D in the first row. This line will cut the second row in a point D'', so that A,B,C,D are projected from S into the points A,B',C',D''. The cross-ratio (ABCD) is therefore equal to $(AB'C'D'')$ and by hypothesis it is equal to $(A'B'C'D')$. Hence $(A'B'C'D'') = (A'B'C'D')$, that is, D'' is the same point as D'.

§ 31. *Theorem.*—If two projected flat pencils in the same plane are perspective, then the intersections of corresponding lines form a row, and the line joining the two centres as a line in the first pencil corresponds to the same line as a line in the second. And conversely.

Theorem.—*If two projective pencils in the same plane, but with different centres, have one line in the one coincident with its corresponding line in the other, then the two pencils are perspective, that is, the intersection of corresponding lines lie in a line.*

The proof is the same as in § 30.

§ 32. *Theorem.*—If two projective flat pencils in the same point (pencil in space), but not in the same plane, are perspective, then the planes joining corresponding rays all pass through a line (they form an axial pencil), and the line common to the two pencils (in which their planes intersect) corresponds to itself. And conversely,

Theorem.—If two flat pencils which have a common centre, but do not lie in a common plane, are placed so that one ray in the one coincides with its corresponding ray in the other, then they are perspective, that is, the planes joining corresponding lines all pass through a line.

§ 33. *Theorem.*—If two projective axial pencils are perspective, then the intersection of corresponding planes lie in a plane, and the plane common to the two pencils (in which the two axes lie) corresponds to itself. And conversely,

Theorem.—If two projective axial pencils are placed in such a position that a plane in the one coincides with its corresponding plane, then the two pencils are perspective, that is, corresponding planes meet in lines which lie in a plane.

The proof again is the same as in § 30.

§ 34. These theorems relating to perspective position become illusory if the projective rows of pencils have a common base. We then have:—

Theorem.—In two projective rows on the same line—and also in two projective and concentric flat pencils in the same plane, or in two projective axial pencils with a common axis—every element in the one coincides with its corresponding element in the other as soon as three elements in the one coincide with their corresponding elements in the other.

Proof (in case of two rows).—Between four elements A, B, C, D and their corresponding elements A', B', C', D' exists the relation $(ABCD) = (A'B'C'D')$. If now A',B',C' coincide respectively with A,B,C, we get $(ABCD) = (ABCD')$; hence D and D' coincide.

The last theorem may also be stated thus:—

Theorem.—In two projective rows or pencils, which have a common base but are not identical, not more than two elements in the one can coincide with their corresponding elements in the other.

Thus two projective rows on the same line cannot have more than two pairs of coincident points unless every point coincides with its corresponding point.

It is easy to construct two projective rows on the same line, which have two pairs of corresponding points coincident. Let the points A, B, C as points belonging to the one row correspond to A, B, and C' as points in the second. Then A and B coincide with their corresponding points, but C does not. It is, however, not necessary that two such rows have twice a point coincident with its corresponding point; it is possible that this happens only once or not at all. Of this we shall see plenty of examples as we go on.

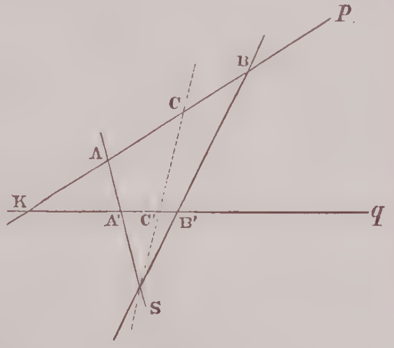


Fig. 8.

§ 35. If two projective rows or pencils are in perspective position, we know at once which element in one corresponds to any given element in the other. If p and q (fig. 8) are two projective rows, so that K corresponds to itself, and if we know that to A and B in p correspond A' and B' in q, then the point S, where AA' meets BB', is the centre of projection, and hence,

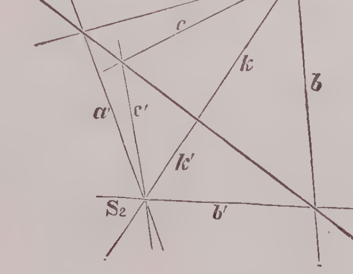


Fig. 9.

in order to find the point C' corresponding to C, we have only to join C to S; the point C', where this line cuts q, is the point required.

If two flat pencils, S_1 and S_2, in a plane are perspective (fig. 9), we need only to know two pairs, a, a' and b, b', of corresponding rays in order to find the axis s of projection. This being known, a ray c' in S_2, corresponding to a given ray c in S_1, is found by joining S_2 to the point where c cuts the axis s.

A similar construction holds in the other cases of perspective figures.

On this depends the solution of the following general problem.

§ 36. *Problem.* — Three pairs of corresponding elements in two projective rows or pencils being given, to determine for any element in one the corresponding element in the other.

We solve this in the two cases of two projective rows and of two projective flat pencils in a plane.

Problem I.—Let A, B, C be three points in a row s, A', B', C' the corresponding points in a projective row s', both being in a plane; it is required to find for any point D in s the corresponding point D' in s'.

Problem II. — Let a, b, c be three rays in a pencil S, a', b', c' the corresponding rays in a projective pencil S', both being in the same plane; it is required to find for any ray d in S the corresponding ray d' in S'.

The solution is made to depend on the construction of an auxiliary row or pencil which is perspective to both the given ones. This is found as follows: —

Solution of Problem I. — On the line joining two corresponding points, say AA' (fig. 10), take any two points, S and S', as centres of auxiliary pencils. Join the intersection B_1 of SB and $S'B'$ to the intersection C_1 of SC and $S'C'$ by the line s_1. Then a row on s_1 will be perspective to s with S as centre of projection, and to s' with S' as centre. To find now the point D' on s' corresponding to a point D on s we have only to determine the point D_1, where the line SD cuts s_1, and to draw $S'D_1$; the point where this line cuts s' will be the required point D'.

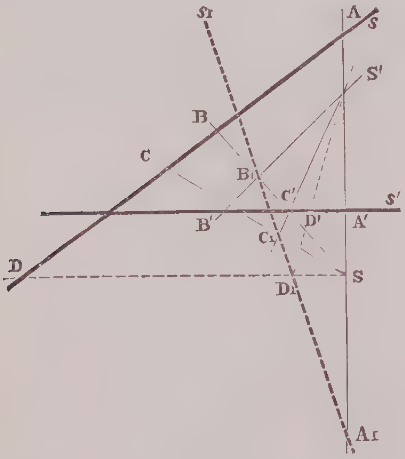


FIG. 10.

Proof. — The rows s and s' are both perspective to the row s_1, hence they are projective to one another. To A, B, C, D on s correspond A_1, B_1, C_1, D_1 on s_1, and to these correspond A', B', C', D', on s'; so that D and D' are corresponding points as required.

Solution of Problem II. — Through the intersection A of two corresponding rays a and a' (fig. 11), take two lines, s and s', as bases of auxiliary rows. Let S_1 be the point where the line b_1, which joins B and B', cuts the line c_1, which joins C and C'. Then a pencil S_1 will be perspective to S with s as axis of projection. To find the ray d' in S' corresponding to a given ray d in S cut d by s at D; project this point from S_1 to D' on s' and join D' to S'. This will be the required ray.

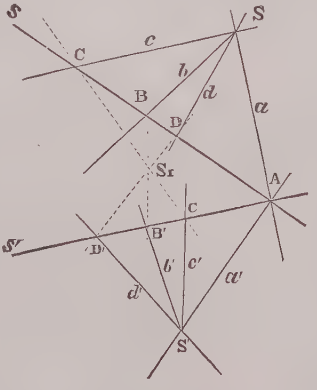


Fig. 11.

Proof.—That the pencil S_1 is perspective to S and also to S' follows from construction. To the lines a_1, b_1, c_1, d_1 in S_1 correspond the lines a, b, c, d in S and the lines a', b', c', d' in S', so that d and d' are corresponding rays.

In the first solution the two centres, S, S', are *any* two points on a line joining any two corresponding points, so that the solution of the problem allows of a great many different constructions. *But whatever construction be used, the point D', corresponding to D, must be always the same,* according to the theorem in § 29. This gives rise to a number of theorems, into which, however, we shall not enter. The same remarks hold for the second problem.

§ 37. As a further application of the theorems about perspective rows and pencils we shall prove the following important theorem.

Theorem. — If ABC and $A'B'C'$ (fig. 12) be two triangles, such that the lines AA', BB', CC' meet in a point S, then the intersections of BC and $B'C'$, of CA and $C'A'$, and of AB and $A'B'$ will lie in a line.

Proof. — Let a, b, c denote the lines AA', BB', CC', which meet at S. Then these may be taken as bases of projective rows, so that A, A', S on a correspond to B, B', S on b, and to C, C', S on c. As the point S is common to all, any two of these rows will be perspective.

If S_1 be the centre of projection of rows b and c,
S_2 " " " c and a,
S_3 " " " a and b,

and if the line S_1S_2 cuts a in A_1, and b in B_1, and c in C_1, then A_1, B_1 will be corresponding points in a and b, both corresponding to C_1 in c. But a and b are perspective, therefore the line A_1B_1, that is S_1S_2, joining corresponding points must pass through the centre of projection S_3 of a and b. In other words, S_1, S_2, S_3 lie in a line. This is Desargues's celebrated theorem if we state it thus: —

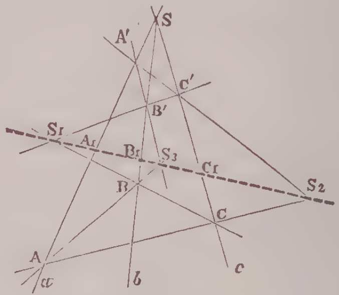


FIG. 12.

Theorem of Desargues. — If each of two triangles has one vertex on each of three concurrent lines, then the intersections of corresponding sides lie in a line, those sides being called corresponding which are opposite to vertices on the same line.

The converse theorem holds also, viz: —

Theorem. —If the sides of one triangle meet those of another in three points which lie in a line, then the vertices lie on three lines which meet in a point.

The proof is almost the same as before.

§ 38. *Metrical relations between projective rows.* — Every row contains one point which is distinguished from all others, viz., the point at infinity. In two projective rows, to the point I at infinity in one corresponds a point I' in the other, and to the point J' at infinity in the second corresponds a point J in the first. The points I' and J are in general finite. If now A and B are any two points in the one, A', B' the corresponding points in the other row, then

$$(ABJI) = (A'B'J'I').$$

Or,

$$\frac{AJ}{JB} : \frac{AI}{IB} = \frac{A'J'}{J'B'} : \frac{A'I'}{I'B'};$$

but, by § 17,

$$\frac{AI}{IB} = \frac{A'J'}{J'B'} = -1,$$

therefore the last equation changes into

$$\frac{AJ}{JB} \cdot \frac{A'I'}{I'B'} = 1,$$

or into

$$AJ \cdot A'I' = BJ \cdot B'I',$$

that is to say —

Theorem. — The product of the distances of any two corresponding points in two projective rows from the points which correspond to the points at infinity in the other is constant, viz., $AJ \cdot A'I' = k$. Steiner has called this number k the *Power of the correspondence.*

§ 39. *Similar Rows.* — If the points at infinity in two projective rows correspond so that I' and J are at infinity, this result loses its meaning. But if A, B, C be any three points in one A′, B′, C′ the corresponding ones on the other row, we have

$$(ABCI) = (A'B'C'I'),$$

which reduces to

$$\frac{AC}{CB} = \frac{A'C'}{C'B'}; \text{ or } \frac{AC}{A'C'} = \frac{BC}{B'C'},$$

that is, corresponding segments are proportional. Conversely, if corresponding segments are proportional, then to the point at infinity in one corresponds the point at infinity in the other. If we call such rows *similar*, we may state the result thus—

Theorem.—Two projective rows are similar if to the point at infinity in one corresponds the point at infinity in the other, and conversely, if two rows are similar then they are projective, and the points at infinity are corresponding points.

From this the well-known propositions follow:—

Two lines are cut proportionally (in similar rows) by a series of parallels. The rows are perspective, with centre of projection at infinity.

If two similar rows are placed parallel, then the lines joining homologous points pass through a common point.

§ 40. *Theorem.*—If two flat pencils be projective, then there exists in either one single pair of lines at right angles to one another, such that the corresponding lines in the other pencil are again at right angles.

To prove this, we place the pencils in perspective position (fig. 13) by making one ray coincident with its corresponding ray. Corresponding rays meet then on a line p. And now we draw the circle which has its centre O on p, and which passes through the centres S and S′ of the two pencils. This circle cuts p in two points H and K. The two pairs of rays, h, k and h', k', joining these points to S and S′ will be pairs of corresponding rays at right angles. The construction gives in general but one circle, but if the line p is the perpendicular bisector of SS′ there exists an infinite number, and *to every right angle in the one pencil corresponds a right angle in the other.*

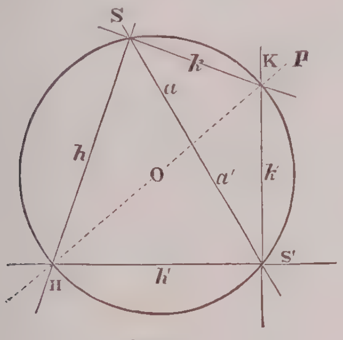


Fig. 13.

Principle of Duality.

§ 41. It has been stated in § 1 that not only points, but also planes and lines, are taken as elements out of which figures are built up. We shall now see that the construction of one figure which possesses certain properties gives rise in many cases to the construction of another figure, by replacing, according to definite rules, elements of one kind by those of another. The new figure thus obtained will then possess properties which may be stated as soon as those of the original figure are known.

We obtain thus a principle, known as the *principle of duality* or of *reciprocity*, which enables us to construct to any figure not containing any measurement in its construction a *reciprocal* figure, as it is called, and to deduce from any theorem a *reciprocal* theorem, for which no further proof is needed.

It is convenient to print reciprocal propositions on opposite sides of a page broken into two columns, and this plan will occasionally be adopted.

We begin by repeating in this form a few of our former statements:—

Two points determine a line.	Two planes determine a line.
Three points which are not in a line determine a plane.	Three planes which do not pass through a line determine a point.
A line and a point without it determine a plane.	A line and a plane not through it determine a point.
Two lines in a plane determine a point.	Two lines through a point determine a plane.

These propositions show that it will be possible, when any figure is given, to construct a second figure by taking planes instead of points, and points instead of planes, but lines where we had lines.

For instance, if in the first figure we take a plane and three points in it, we have to take in the second figure a point and three planes through it. The three points in the first, together with the three lines joining them two and two, form a triangle; the three planes in the second and their three lines of intersection form a trihedral angle. A triangle and a trihedral angle are therefore reciprocal figures.

Similarly, to any figure in a plane consisting of points and lines will correspond a figure consisting of planes and lines passing through a point S, and hence belonging to the pencil which has S as centre.

The figure reciprocal to four points in space which do not lie in a plane will consist of four planes which do not meet in a point. In this case each figure forms a tetrahedron.

§ 42. As other examples we have the following:—

To a row	is reciprocal	an axial pencil,
" a flat pencil	"	a flat pencil,
" a field of points and lines	"	a pencil of planes and lines.
" the space of points	"	the space of planes.

For the row consists of a line and all the points in it, reciprocal to it therefore will be a line with all planes through it, that is, an axial pencil; and so for the other cases.

This correspondence of reciprocity breaks down, however, if we take figures which contain measurement in their construction. For instance, there is no figure reciprocal to two planes at *right angles*, because there is no segment in a row which has a magnitude as definite as a right angle.

We add a few examples of reciprocal propositions which are easily proved.

Theorem.—If A, B, C, D are any four points in space, and if the lines AB and CD meet, then all four points lie in a plane, hence also AC and BD, as well as AD and BC, meet.	*Theorem.*—If α, β, γ, δ are four planes in space, and if the lines $\alpha\beta$ and $\gamma\delta$ meet, then all four planes lie in a point (pencil), hence also $\alpha\beta$ and $\gamma\delta$, as well as $\alpha\delta$ and $\beta\gamma$, meet.

THEOREM.—*If of any number of lines every one meets every other, whilst all do not*

lie in a point, then all lie in a plane.	*lie in a plane, then all lie in a point (pencil).*

§ 43. Reciprocal figures as explained lie both in space of three dimensions. If the one is confined to a plane (is formed of elements which lie in a plane), then the reciprocal figure is confined to a pencil (is formed of elements which pass through a point).

But there is also a more special principle of duality, according to which figures are reciprocal which lie both in a plane or both in a pencil. In the plane we take points and lines as reciprocal elements, for they have this fundamental property in common, that two elements of one kind determine one of the other. In the pencil, on the other hand, lines and planes have to be taken as reciprocal, and here it holds again that two lines or planes determine one plane or line.

Thus, to one plane figure we can construct one reciprocal figure in the plane, and to each one reciprocal figure in a pencil. We mention a few of these. At first we explain a few names:—

A figure consisting of n points in a plane will be called an n-point.	A figure consisting of n lines in a plane will be called an n-side.
A figure consisting of n planes in a pencil will be called an n-flat.	A figure consisting of n lines in a pencil will be called an n-edge.

It will be understood that an n-side is different from a polygon of n sides. The latter has sides of finite length and n vertices, the former has sides all of infinite extension, and every point where two of the sides meet will be a vertex: A similar difference exists between a solid angle and an n-edge or an n-flat. We notice particularly—

A four-point has six sides, of which two and two are opposite, and three diagonal points, which are intersections of opposite sides.	A four-side has six vertices, of which two and two are opposite, and three diagonals, which join opposite vertices.
A four-flat has six edges, of which two and two are opposite, and three diagonal planes, which pass through opposite edges.	A four-edge has six faces of which two and two are opposite, and three diagonal edges, which are intersections of opposite faces.

A four-side is usually called a complete quadrilateral. The above notation, however, seems better adapted for the statement of reciprocal propositions.

§ 44.

If a point moves in a plane it describes a plane curve.	If a line moves in a plane it envelopes a plane curve (fig. 14).
If a plane moves in a pencil it envelopes a cone.	If a line moves in a pencil it describes a cone.

A curve thus appears as generated either by points, and then, we call it a "locus," or by lines, and then we call it an "envelope." In the same manner a cone, which means here a surface, appears either as the locus of lines passing through a fixed point, the "vertex" of the cone, or as the envelope of planes passing through the same point.

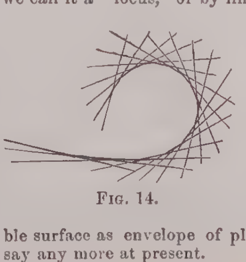


Fig. 14.

To a surface as locus of points corresponds, in the same manner, a surface as envelope of planes; and to a curve in space as locus of points corresponds a developable surface as envelope of planes. Of the latter we shall not say any more at present.

It will be seen from the above that we may, by aid of the principle of duality, construct for every figure a reciprocal figure, and that to any property of the one a reciprocal property of the other will exist, as long as we consider only properties which depend upon nothing but the positions and intersections of the different elements and not upon measurement.

For such propositions it will therefore be unnecessary to prove more than one of two reciprocal theorems.

CURVES AND CONES OF SECOND ORDER OR SECOND CLASS.

§ 45. If we have two projective pencils in a plane, corresponding rays will meet, and their point of intersection will constitute some locus which we have to investigate. Reciprocally, if two projective rows in a plane are given, then the lines which join corresponding points will envelope some curve. We prove first :—

Theorem.—If two projective flat pencils lie in a plane, but are neither perspective nor concentric, then the locus of intersections of corresponding rays is a curve of the *second order*, that is, no line contains more than two points of the locus.

Proof.—We draw any line t. This cuts each of the pencils in a row, so that we have on t two rows, and these are projective because the pencils are projective. If corresponding rays of the two pencils meet on the line t, their intersection will be a point in the one row which coincides with its corresponding point in the other. But two projective rows on the same base cannot have more than two points of one coincident with their corresponding points in the other (§ 34).

Theorem.—If two projective rows lie in a plane, but are neither perspective nor on a common base, then the envelope of lines joining corresponding points is a curve of the *second class*, that is, through no point pass more than two of the enveloping lines.

Proof.—We take any point T and join it to all points in each row. This gives two concentric pencils, which are projective because the rows are projective. If a line joining corresponding points in the two rows passes through T, it will be a line in the one pencil which coincides with its corresponding line in the other. But two projective concentric flat pencils in the same plane cannot have more than two lines of one coincident with their corresponding line in the other (§ 34).

It will be seen that the proofs are reciprocal, so that the one may be copied from the other by simply interchanging the words point and line, locus and envelope, row and pencil, and so on. We shall therefore in future prove seldom more than one of two reciprocal theorems, and often state one theorem only, the reader being recommended to go through the reciprocal proof by himself, and to supply the reciprocal theorems when not given.

§ 46. We state the theorems in the pencil reciprocal to the last without proving them :—

Theorem.—If two projective flat pencils are concentric, but are neither perspective nor coplanor, then the envelope of the planes joining corresponding rays is a cone of the second class; that is, no line through the common centre contains more than two of the enveloping planes.

Theorem.—If two projective axial pencils lie in the same pencil (their axes meet in a point), but are neither perspective nor co-axial, then the locus of lines joining corresponding planes is a cone of the second order; that is, no plane in the pencil contains more than two of these lines.

§ 47. Of theorems about cones of second order and cones of second class we shall state only very few. We point out, however, the following connection between the curves and cones under consideration :—

The lines which join any point in space to the points on a curve of the second order form a cone of the second order.

Every plane section of a cone of the second order is a curve of the second order.

The planes which join any point in space to the lines enveloping a curve of the second class envelope themselves a cone of the second class.

Every plane section of a cone of the second class is a curve of the second class.

By its aid, or by the principle of duality, it will be easy to obtain theorems about them from the theorems about the.curves.

We prove the first. A curve of the second order is generated by two projective pencils. These pencils, when joined to the point in space, give rise to two projective axial pencils, which generate the cone in question as locus of the lines where corresponding planes meet.

§ 48.

Theorem.—The curve of second order which is generated by two projective flat pencils passes through the centres of the two pencils.

Proof.—If S and S′ are the two pencils, then to the ray SS′ or p' in the pencil S′ corresponds in the pencil S a ray p, which is different from p', for the pencils are not perspective. But p and p' meet at S, so that S is a point on the curve, and similarly S′.

Theorem.—The envelope of second class which is generated by two projective rows contains the bases of these rows as enveloping lines or tangents.

Proof.—If s and s' are the two rows, then to the point ss' or P′ as a point in s' corresponds in s a point P, which is not coincident with P′, for the rows are not perspective. But P and P′ are joined by s, so that s is one of the enveloping lines, and similarly s'.

It follows that every line in one of the two pencils cuts the curve in two points, viz., once at the centre S of the pencil, and once where it cuts its corresponding ray in the other pencil. These two points, however, coincide, if the line is cut by its corresponding line at S itself. The line p in S, which corresponds to the line SS′ in S′ is therefore the only line through S which has but one point in common with the curve, or which cuts the curve in two *coincident* points. Such a line is called a tangent to the curve, touching the latter at the point S, which is called the point of contact.

In the same manner we get in the reciprocal investigation the result that through every point in one of the rows, say in s, two tangents may be drawn to the curve, the one being s, the other the line joining the point to its corresponding point in s'. There is, however, one point P in s for which these two lines coincide. Such a point in one of the tangents is called the "point of contact" of the tangent. We thus get—

Theorem.—To the line joining the centres of the projective pencils as a line in one pencil corresponds in the other the tangent at its centre.

Theorem.—To the point of intersection of the bases of two projective rows as a point in one row corresponds in the other the *point of contact* of its base.

§ 49. Two projective pencils are determined if three pairs of corresponding lines are given. Hence if a_1, b_1, c_1 are three lines in a pencil S_1, and a_2, b_2, c_2 the corresponding lines in a projective pencil S_2, the correspondence and therefore the curve of the second order generated by the points of intersection of corresponding rays is determined. Of this curve we know the two centres S_1 and S_2, and the three points a_1a_2, b_1b_2, c_1c_2, hence five points in all. This and the reciprocal considerations enable us to solve the following two problems :—

Problem.—To construct a curve of the second order, of which five points S_1, S_2, A, B, C are given.

Problem.—To construct a curve of the second class, of which five tangents u_1, u_2, a, b, c are given.

In order to solve the left-hand problem, we take two of the given points, say S_1 and S_2, as centres of pencils. These we make projective by taking the rays a_1, b_1, c_1, which join S_1 to A, B, C respectively, as corresponding to the rays a_2, b_2, c_2, which join S_2 to A, B, C, respectively, so that three rays meet their corresponding rays at the given points A, B, C. This determines the correspondence of the pencils which will generate a curve of the second order passing through A, B, C and through the centres S_1 and S_2. hence through the five given points. To find more points on the curve we have to construct for any ray in S_1, the corresponding ray in S_2. This has been done in § 36. But we repeat the construction in order to deduce further properties from it. We also solve the right-hand problem. Here we select two, viz., u_1, u_2 of the five given lines, u_1, u_2, a, b, c, as bases of two rows, and the points A_1, B_1, C_1, where a, b, c cut u_1 as corresponding to the points A_2, B_2, C_2 where a, b, c cut u_2.

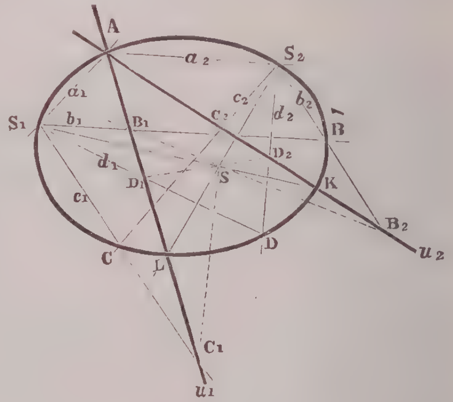


FIG. 15.

We get then the following solutions of the two problems :—

Solution.—Through the point A draw any two lines, u_1, and u_2 (fig. 15), the first u_1, to cut the pencil S_1, in a row AB_1C_1, the other u_2, to cut the pencil S_2, in a row AB_2C_2. These two rows will be perspective, as the point A corresponds to itself, and the centre of projection will be the point S, where the lines B_1B_2 and C_1C_2 meet. To find now for any ray d_1 in S_1 its corresponding ray d_2 in S_2, we determine the point D_1 where d_1 cuts u_1, project this point from S to D_2 on u_2 and join S_2 to D_2. This will be the required ray d_2 which cuts d_1 at some point D on the curve.

Solution.—In the line a take any two points S_1 and S_2, as centres of pencils (fig. 16), the first S_1 $(A_1B_1C_1)$ to project the row u_1, the other S_2 $(A_2B_2C_2)$ to project the row u_2. These two pencils will be perspective, the line S_1A_1 being the same as the corresponding line S_2A_2, and the axis of projection will be the line u, which joins the intersection B of S_1B_1 and S_2B_2 to the intersection C of S_1C_1 and S_2C_2. To find now for any point D_1 in u_1 the corresponding point D_2 in u_2, we draw S_1D_1 and project the point D where this line cuts u from S_2 to u_2. This will give the required point D_2, and the line d joining D_1 to D_2, will be a new tangent to the curve.

§ 50. These constructions prove, when rightly interpreted, very important properties of the curves in question.

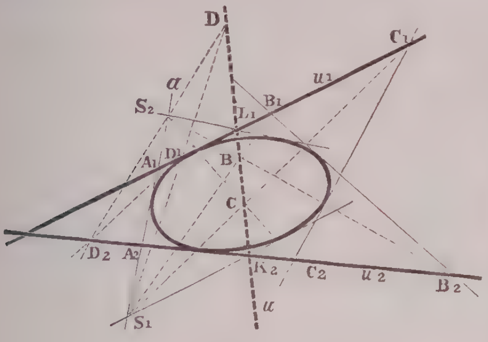


FIG. 16.

If in fig. 15 we draw in the pencil S_1 the ray k_1, which passes through the auxiliary centre S, it will be found that the corresponding ray k_2 cuts it on u_2. Hence—

Theorem.—In the above construction the bases of the auxiliary rows u_1 and u_2 cut the curve where they cut the rays S_2S and S_1S respectively.	*Theorem.*—In the above construction (fig. 16) the tangents to the curve from the centres of the auxiliary pencils S_1 and S_2 are the lines which pass through u_2u and u_1u respectively.

As A is any given point on the curve, and u_1 any line through it, we have solved the problems:—

Problem.—To find the second point in which any line through a known point on the curve cuts the curve.	*Problem.*—To find the second tangent which can be drawn from any point in a given tangent to the curve.

If we determine in S_1 (fig. 15) the ray corresponding to the ray S_2S_1 in S_2, we get the tangent at S_1. Similarly we can determine the point of contact of the tangents u_1 or u_2 in fig. 16.

§ 51. If five points are given, of which not three are in a line, then we can, as has just been shown, always draw a curve of the second order through them, we select two of the points as centres of projective pencils, and then one such curve is determined. It will be presently shown that we get always the same curve if two other points are taken as centres of pencils, that therefore five points *determine* one curve of the second order, and reciprocally, that five tangents determine one curve of the second class. Six points taken at random will therefore not lie on a curve of the second order. In order that this may be the case a certain condition has to be satisfied, and this condition is easily obtained from the construction in § 49, fig. 15. If we consider the conic determined by the five points A, S_1, S_2, K, L, then the point D will be on the curve if, and only if, the points on D_1, S, D_2 be in a line.

This may be stated differently if we take AKS_1DS_2L (figs. 15 and 17) as a hexagon inscribed in the conic, then AK and DS_2 will be opposite sides, so will be KS_1 and S_2L, as well as S_1D and LA. The first two meet in D_2, the others in S and D_1 respectively. We may therefore state the required condition, together with the reciprocal one, as follows:—

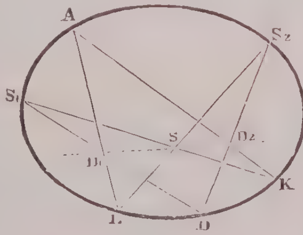


FIG. 17.

Pascal's Theorem.—If a hexagon be inscribed in a curve of the second order, then the intersections of opposite sides are three points in a line.	*Brianchon's Theorem.*—If a hexagon be circumscribed about a curve of the second class, then the lines joining opposite vertices are three lines meeting in a point.

These celebrated theorems, which are known by the names of their discoverers, are perhaps the most fruitful in the whole theory of conics. Before we go over to their applications we have to show that we obtain the same curve if we take, instead of S_1, S_2, any two other points on the curve as centres of projective pencils.

§ 52. We know that the curve depends only upon the correspondence between the pencils S_1 and S_2, and not upon the special construction used for finding new points on the curve. The point A (fig. 15 or fig. 17), through which the two auxiliary rows u_1, u_2 were drawn, may therefore be changed to any other point on the curve. Let us now suppose the curve drawn, and keep the points S_1, S_2, K, L, and D, and hence also the point S fixed, whilst we move A along the curve. Then the line AL will describe a pencil about L as centre, and the point D_1 a row on S_1D perspective to the pencil L. At the same time AK describes a pencil about K and D_2 a row perspective to it on S_2D. But by Pascal's Theorem D_1 and D_2 will always lie in a line with S, so that the rows described by D_1 and D_2 are perspective. It follows that the pencils K and L will themselves be projective, corresponding rays meeting on the curve. This proves that we get the same curve whatever pair of the five given points we take as centres of projective pencils. Hence—

Theorem.—Only one curve of the second order can be drawn which passes through five given points.	*Theorem.*—Only one curve of the second class can be drawn which touches five given lines.

We have seen that if on a curve of the second order two points coincide at A, the line joining them becomes the tangent at A. If, therefore, a point on the curve and its tangent are given, this will be equivalent to having given two points on the curve. Similarly, if on the curve of second class a tangent and its point of contact are given, this will be equivalent to two given tangents.

We may therefore extend the last theorem:—

Theorem.—Only one curve of the second order can be drawn, of which four points and the tangent at one of them, or three points and the tangents at two of them, are given.	*Theorem.*—Only one curve of the second class can be drawn, of which four tangents and the point of contact at one of them, or three tangents and the points of contact at two of them, are given.

§ 53. At the same time it has been proved:—

Theorem.—If all points on a curve of the second order be joined to any two of them, then the two pencils thus formed are projective, those rays being corresponding which meet on the curve. Hence— The cross-ratio of four rays joining a point S on a curve of second order to four fixed points A, B, C, D in the curve is independent of the position of S, and is called the cross-ratio of the four points A, B, C, D. If this cross-ratio is = — 1, the four points are said to be four harmonic points.	*Theorem.*—All tangents to a curve of second class are cut by any two of them in projective rows, those being corresponding points which lie on the same tangent. Hence— The cross-ratio of the four points in which any tangent u is cut by four fixed tangents a, b, c, d is independent of the position of u, and is called the cross-ratio of the four tangents a, b, c, d. If this cross-ratio equals — 1, the four tangents are said to be four harmonic tangents.

We have seen that a curve of second order, as generated by projective pencils, has at the centre of each pencil one tangent; and further, that any point on the curve may be taken as centre of such pencil. Hence—

Theorem.—A curve of second order has at every point one tangent.	*Theorem.*—A curve of second class has on every tangent a point of contact.

§ 54. We return to Pascal's and Brianchon's theorems and their applications, and shall, as before, state the results both for curves of the second order and curves of the second class, but prove them only for the former.

Pascal's theorem may be used when five points are given to find more points on the curve, viz., it enables us to find the point where any line through one of the given points cuts the curve again. It is convenient, in making use of Pascal's theorem, to number the points, to indicate the order in which they are to be taken in forming a hexagon, which, by the way, may be done in 60 different ways. It will seen that 1 2 and (leaving out 3) 4 5 are opposite sides, so are 2 3 and (leaving out 4) 5 6, and also 3 4 and (leaving out 5) 6 1.

If the points 1 2 3 4 5 are given, and we want a sixth point on a line drawn through 1, we know all the sides of the hexagon with the exception of 5 6, and this is found by Pascal's theorem.

If this line should happen to pass through 1, then 6 and 1 coincide, or the line 6 1 is the tangent at 1. And always if two consecutive vertices of the hexagon approach nearer and nearer, then the side joining them will ultimately become a tangent.

We may therefore consider a pentagon inscribed in a curve of second order and the tangent at one of its vertices as a hexagon, and thus get the theorem:—

Theorem.—Every pentagon inscribed in a curve of second order has the property that the intersections of two pair of non-consecutive sides lie in a line with the point where the fifth side cuts the tangent at the opposite vertex.	*Theorem.*—Every pentagon circumscribed about a curve of the second class has the property that the lines which join two pairs of non-consecutive vertices meet on that line which joins the fifth vertex to the point of contact of the opposite side.

This enables us also to solve the following problems.

Problem.—Given five points on a curve of second order to construct the tangent at any one of them.	*Problem.*—Given five tangents to a curve of second class to construct the point of contact of any one of them.

If twice two adjacent vertices coincide, the hexagon becomes a quadrilateral, with tangents at two vertices. These we take to be opposite, and get the following theorems:—

Theorem.—If a quadrilateral be inscribed in a curve of second order, the intersections of opposite sides, and also the intersections of the tangents at opposite vertices, lie in a line (fig. 18).

Theorem.—If a quadrilateral be circumscribed about a curve of second class, the lines joining opposite vertices, and also the lines joining points of contact of opposite sides, meet in a point.

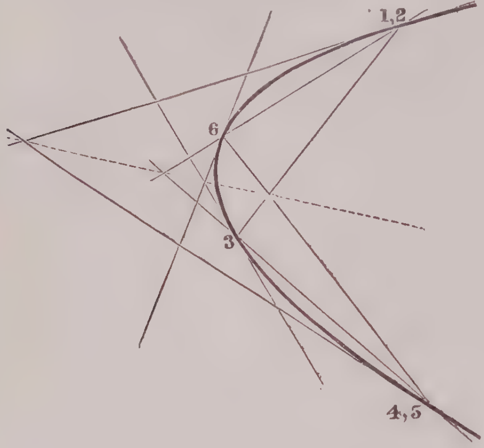


FIG. 18.

If we consider the hexagon made up of a triangle and the tangents at its vertices, we get—

Theorem.—If a triangle is inscribed in a curve of second order, the points in which the sides are cut by the tangents at the opposite vertices meet in a point.

Theorem.—If a triangle be circumscribed about a curve of second class, the lines which join the vertices to the points of contact of the opposite sides meet in a point (fig. 19).

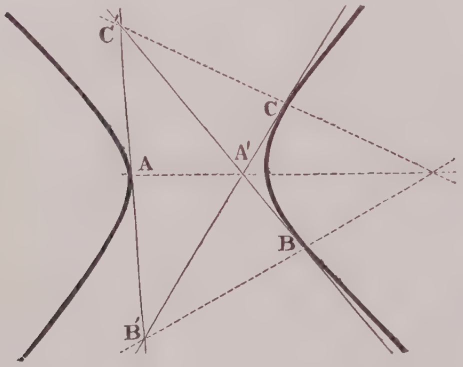


FIG. 19.

§ 55. Of these theorems, those about the quadilateral give rise to a number of others. Four points A, B, C, D may in three different ways be formed into a quadrilateral, for we may take them in the order ABCD, or ACBD, or ACDB, so that either of the points B, C, D may be taken as the vertex opposite to A. Accordingly we may apply the theorem in three different ways.

Let A, B, C, D be four points on a curve of second order (fig. 20), and let us take them as forming a quadilateral by taking the points in the order ABCD, so that A, C and also B, D are pairs of opposite vertices. Then P, Q will be the points where opposite sides meet, and E, F the intersections of tangents at opposite vertices. The four points P, Q, E, F lie therefore in a line. The quadrilateral ACBD gives us in the same way the four points Q, R, G, H in a line, and the quadrilateral ABDC a line containing the four points R, P, I, K. These three lines form a triangle PQR.

The relation between the points and lines in this figure may be expressed more clearly if we consider ABCD as a four-point inscribed in a conic, and the tangent at these points as a four-side circumscribed about it,—viz., it will be seen that P, Q, R are the diagonal points of the four-point ABCD, whilst the sides of the triangle PQR are the diagonals of the circumscribing four-side. Hence the theorem—

THEOREM.—*Any four-point on a curve of the second order and the four-side formed by the tangents at these points stand in this relation that the diagonal points of the four-point lie in the diagonals of the four-side.* And conversely,

If a four-point and a circumscribed four-side stand in the above relation, then a curve of the second order may be described which passes through the four points and touches there the four sides of these figures.

That the last part of the theorem is true follows from the fact that the four points A, B, C, D and the line *a*, as tangent at A,

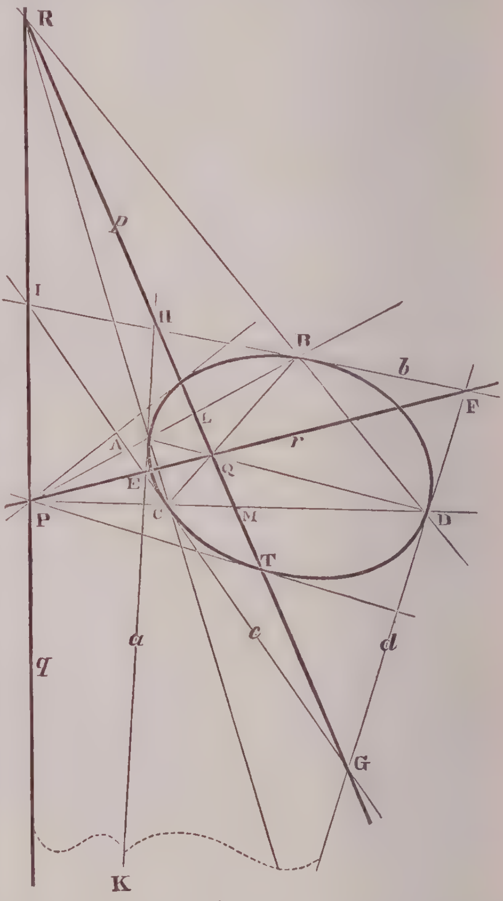


FIG. 20.

determine a curve of the second order, and the tangents to this curve at the other points B, C, D are given by the construction which leads to fig. 20.

The theorem reciprocal to the last is—

THEOREM.—*Any four-side circumscribed about a curve of second class and the four-point formed by the points of contact stand in this relation that the diagonals of the four-side pass through the diagonal points of the four-point.* And conversely,

If a four-side and an inscribed four-point stand in the above relation, then a curve of the second class may be described which touches the sides of the four-side at the points of the four-points.

§ 56. The four-point and the four-side in the two reciprocal theorems are alike. Hence if we have a four-point ABCD and a four-side *abcd* related in the manner described, then not only may a curve of the second order be drawn, but also a curve of the second class, which both touch the lines *a*, *b*, *c*, *d* at the points A, B, C, D.

The curve of second order is already more than determined by the points A, B, C and the tangents *a*, *b*, *c* at A, B, and C. The point D may therefore be *any* point on this curve, and *d* any tangent to the curve. On the other hand the curve of the second class is more than determined by the three tangents *a*, *b*, *c* and their points of contact A, B, C, so that *d* is any tangent to this curve. It follows that every tangent to the curve of second order is a tangent of a curve of the second class having the same point of contact. In other words, the curve of second order is a curve of second class, and *vice versa*. Hence the important theorems:—

THEOREM.—*Every curve of second order is a curve of second class.*

THEOREM.—*Every curve of second class is a curve of second order.*

The curves of second order and of second class having thus been proved to be identical shall henceforth be called by the common name of *Conics*.

For these curves hold, therefore, all properties which have been proved for curves of second order or of second class. We may therefore now state Pascal's and Brianchon's theorem thus—

Pascal's Theorem.—If a hexagon be inscribed in a conic, then the intersections of opposite sides lie in a line.

Brianchon's Theorem.—If a hexagon be circumscribed about a conic, then the diagonals forming opposite centres meet in a point.

§ 57. If we suppose in fig. 20 that the point D together with the tangent *d* moves along the curve, whilst A, B, C and their tangents *a*, *b*, *c* remain fixed, then the ray DA will describe a pencil about A, the point Q a projective row on the fixed line BC, the point F the row *b*, and the ray EF a pencil about E. But EF passes always through Q. Hence the pencil described by AD is projective to the pencil described by EF, and therefore to the row described by F on *b*. At the same time the line BD describes a pencil about B projective to that described by AD (§ 53). Therefore the pencil BD and the row F on *b* are projective. Hence—

THEOREM.—*If on a conic a point A be taken and the tangent a at this point then the cross-ratio of the four rays which join A to any four points on the curve is equal to the cross-ratio of the points in which the tangents at these points cut the tangent at A.*

§ 58. There are theorems about cones of second order and second class in a pencil which are reciprocal to the above, according to § 43. We mention only a few of the more important ones.

Theorem.—The locus of intersections of corresponding planes in two projective axial pencils whose axes meet is a cone of the second order.

Theorem.—The envelope of planes which join corresponding lines in two projective flat pencils, not in the same plane, is a cone of the second class.

Theorem.—Cones of second order and cones of second class are identical.

Theorem.—Every plane cuts a cone of the second order in a conic.

THEOREM.—*A cone of second order is uniquely determined by five of its edges or by five of its tangent planes, or by four edges and the tangent plane at one of them, etc., etc.*

Theorem (Pascal's).—If a solid angle of six faces be inscribed in a cone of the second order, then the intersections of opposite faces are three lines in a plane.

Theorem (Brianchon's).—If a solid angle of six edges be circumscribed about a cone of the second order, then the planes through opposite edges meet in a line.

Each of the other theorems about conics may be stated for cones of the second order.

§ 59. We have not yet considered the shape of the conics. We know that any line in the plane of the conic, and hence that the line at infinity, either has no point in common with the curve, or one (counting for two coincident points), or two distinct points. If the line at infinity has no point on the curve the latter is altogether finite, and is called an *Ellipse* (fig. 20). If the line at infinity has only one point in common with the conic, the latter extends to infinity, and has the line at infinity a tangent. It is called a *Parabola* (fig. 21). If, lastly, the line at infinity cuts the curve in two points, it consists of two separate parts which each extend in two branches to the points at infinity where they meet. The curve is in this case called an *Hyperbola* (see fig. 19, 24, or 25). The tangents at the two points at infinity are finite because the line at infinity is not a tangent. They are called *Asymptotes*. The branches of the hyperbola approach these lines indefinitely as a point on the curves moves to infinity.

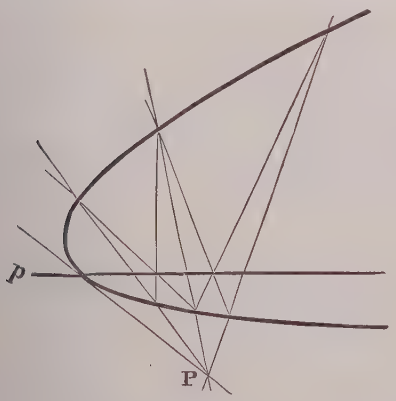


FIG. 21.

§ 60. That the circle belongs to the curves of the second order is seen at once if we state in a slightly different form the theorem that in a circle all angles at the circumference standing upon the same arc are equal. If two points, S_1, S_2 on a circle be joined to any other two points A and B on the circle, then the angle included by the rays S_1A and S_1B is equal to that between the rays S_2A and S_2B, so that as A moves along the circumference the rays S_1A and S_2A describe equal and therefore projective pencils. The circle can thus be generated by two projective pencils, and is a curve of the second order.

If we join a point in space to all points on a circle, we get a (circular) cone of the second order (§ 43). Every plane section of this cone is a conic. This conic will be an ellipse, a parabola, or an hyperbola, according as the line at infinity in the plane has no, one, or two points in common with the conic in which the plane at infinity cuts the cone. It follows that our curves of second order may be obtained as sections of a circular cone, and that they are identical with the "Conic Sections" of the Greek mathematicians.

§ 61. Any two tangents to a parabola are cut by all others in projective rows; but the line at infinity being one of the tangents, the points at infinity on the rows are corresponding points, and the rows therefore similar. Hence—

THEOREM.—*The tangents to a parabola cut each other proportionally.*

POLE AND POLAR.

§ 62. We return once again to the remarkable figure (fig. 20) which we obtained in § 55.

If a four-side be circumscribed about and a four-point inscribed in a conic, so that the vertices of the second are the points of contact of the sides of the first, then the triangle formed by the diagonals of the first is the same as that formed by the diagonal points of the other.

Such a triangle will be called a *polar triangle* of the conic, so that PQR in fig. 20 is a polar triangle. It has the property that on the side *p* opposite P meet the tangents at A and B, and also those at C and D. From the harmonic properties of four-points and four-sides it follows further that the points L, M, where it cuts the lines AB and CD, are harmonic conjugates with regard to AB and CD respectively.

If the point P is given, and we draw a line through it, cutting the conic in A and B, then the point Q harmonic conjugate to P with regard to AB, and the point H where the tangents at A and B meet, are determined. But they lie both on *p*, and therefore this line is determined. If we now draw a second line through P, cutting the conic in C and D, then the point M harmonic conjugate to P with regard to CD, and the point G where the tangents at C and D meet, must also lie on *p*. As the first line through P already determines *p*, the second may be any line through P. Now every two lines through P determine a four-point ABCD on the conic, and therefore a polar-triangle which has one vertex at P and its opposite side at *p*. This result, together with its reciprocal, give the theorem :—

THEOREM.—*All polar-triangles which have one vertex in common have also the opposite side in common.*

All polar-triangles which have one side in common have also the opposite vertex in common.

§ 63. To any point P in the plane of but not on a conic corresponds thus one line *p* as the side opposite to P in all polar triangles which have one vertex at P, and reciprocally to every line *p* corresponds one point P as the vertex opposite to *p* in all triangles which have *p* as one side.

We call the line *p* the *polar* of P, and the point P the *pole* of the line *p* with regard to the conic.

If a point lies on the conic, we call the tangent at that point its polar; and reciprocally we call the point of contact the pole of tangent.

§ 64. From these definitions and former results follow—

Theorem.—The polar of any point P not on the conic is a line *p*, which has the following properties :—	*Theorem.*—The pole of any line *p* not a tangent to the conic is a point P, which has the following properties :—
1. On every line through P which cuts the conic, it contains the harmonic conjugate of P with regard to those points on the conic.	1. Of all lines through a point on *p* from which two tangents may be drawn to the conic, it contains the line which is harmonic conjugate to *p*, with regard to the two tangents.
2. If tangents can be drawn from P, their points of contact lie on *p*.	2. If *p* cuts the conic, the tangents at the intersections meet at P.
3. Tangents drawn at the points where any line through P cuts the conic, meet on it; and conversely,	3. The point of contact of tangents drawn from any point on *p* to the conic lie in a line with P; and conversely,
4. If from any point on it tangents be drawn, their points of contact will lie in a line with P.	4. Tangents drawn at points where any line through P cuts the conic meet on *p*.
5. Any four-point on the conic which has one diagonal point at P has the other two lying on *p*.	5. Any four-side circumscribed about a conic which has one diagonal on *p* has the other two meeting at P.

The truth of 2 follows from I. If T be a point where p cuts the conic, then one of the points where PT cuts the conic, and which are harmonic conjugates with regard to PT, coincides with T; hence the other does—that is, PT touches the curve at T.

That 4 is true follows thus: If we draw from a point H on the polar one tangent a to the conic, join its point of contact A to the pole P, determine the second point of intersection B of this line with the conic, and draw the tangent at B, it will pass through H, and will therefore be the second tangent which may be drawn from H to the curve.

§ 65. The second property of the polar or pole gives rise to the theorem—

Theorem.—From a point in the plane of a conic, two, one, or no tangents may be drawn to the conic, according as its polar has two, one, or no points in common with the curve.

Theorem.—A line in the plane of a conic, has two, one, or no points in common with the conic, according as two, one, or no tangents can be drawn from its pole to the conic.

Of any point in the plane of a conic we say that it was *without*, *on*, or *within* the curve according as two, one, or no tangents to the curve pass through it. The points on the conic separate those within the conic from those without. That this is true for a circle is known from elementary geometry. That it also holds for other conics follows from the fact that every conic may be considered as the projection of a circle, which will be proved later on.

The fifth property of pole and polar stated in § 64 shows how to find the polar of any point and the pole of any line by aid of the straight-edge only. Practically it is often convenient to draw three secants through the pole, and to determine only one of the diagonal points for two of the four-points formed by pairs of these lines and the conic (fig. 21).

These constructions also solve the problem :—

Problem.—From a point without a conic, to draw the two tangents to the conic by aid of the straight-edge only.

For we need only draw the polar of the point in order to find the points of contact.

§ 66. The property of a polar-triangle may now be stated thus—

Theorem.—In a polar-triangle each side is the polar of the opposite vertex, and each vertex is the pole of the opposite side.

If P is one vertex of a polar-triangle, then the other vertices, Q and R, lie on the polar p of P. One of these vertices we may choose arbitrarily. For if from any point Q on the polar a secant be drawn cutting the conic in A and D (fig. 22), and if the lines joining these points to P cut the conic again at B and C, then the line BC will pass through Q. Hence P and Q are two of the vertices on the polar-triangle which is determined by the four-point ABCD. The third vertex R lies also on the line p. It follows, therefore, also—

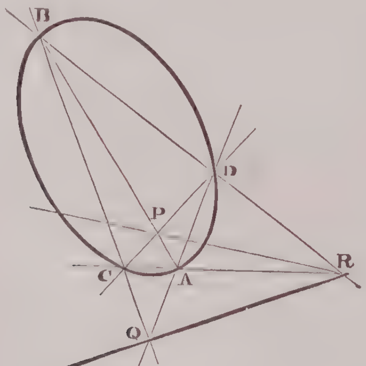


FIG. 22.

THEOREM.—*If* Q *is a point on the polar of* P, *then* P *is a point on the polar of* Q; and reciprocally,

If q *is a line through the pole of* p, *then* p *is a line through the pole of* q.

This is a very important theorem. It may also be stated thus—

THEOREM.—*If a point moves along a line describing a row, its polar turns about the pole of the line describing a pencil.*

This pencil is projective to the row, so that the cross-ratio of four poles in a row equals the cross-ratio of its four polars, which pass through the pole of the row.

To prove the last part, let us suppose that P, A, and B in fig. 22 remain fixed, whilst Q moves along the polar p of P. This will make CD turn about P and move R along p, whilst QD and RD describe projective pencils about A and B. Hence Q and R describe projective rows, and hence PR, which is the polar of Q, describes a pencil projective to either.

§ 67. Two points, of which one, and therefore each, lies on the polar of the other, are said to be *conjugate with regard to the conic*; and two lines, of which one, and therefore each, passes through the pole of the other, are said to be *conjugate with regard to the conic.* Hence all points conjugate to a point P lie on the polar of P; all lines conjugate to a line p pass through the pole of p.

If the line joining two conjugate poles cuts the conic, then the poles are harmonic conjugates with regard to the points of intersection; hence one lies within the other without the conic, and all points conjugate to a point within a conic lie without it.

Of a polar-triangle any two vertices are conjugate poles, any two sides conjugate lines. If, therefore, one side cuts a conic, then one of the two vertices which lie on this side is within and the other without the conic. The vertex opposite this side lies also without, for it is the pole of a line which cuts the curve. In this case therefore one vertex lies within, the other two without. If, on the other hand, we begin with a side which does not cut the conic, then its pole lies within and the other vertices without. Hence—

Theorem.—Every polar triangle has one and only one vertex within the conic.

We add, without a proof, the theorem—

Theorem.—The four points in which a conic is cut by two conjugate polars are four harmonic points in the conic.

§ 68. If two conics intersect in four points (they cannot have more points in common, § 52), there exists one and only one four-point which is inscribed in both, and therefore one polar triangle common to both.

Theorem.—Two conics which intersect in four points have always one and only one common polar-triangle; and reciprocally,

Two conics which have four common tangents have always one and only one common polar-triangle.

The proof that these polar-triangles are identical in case of a conic which have four points and also four tangents in common is left to the reader.

DIAMETERS AND AXES OF CONICS.

§ 69. *Diameters.*—The theorems about the harmonic properties of poles and polars contain, as special cases, a number of important metrical properties of conics. These are obtained if either the pole or the polar is moved to infinity,—it being remembered that the harmonic conjugate to a point at infinity, with regard to two points A, B, is the middle point of the segment AB. The most important properties are stated in the following theorems :—

The middle points of parallel chords of a conic lie in a line —viz., on the polar to the point at infinity on the parallel chords. This line is called a *diameter.*

The polar of every point at infinity is a diameter.

The tangents at the end points of a diameter are parallel, and are parallel to the chords bisected by the diameter.

All diameters pass through a common point, the pole of the line at infinity.

All diameters of a parabola are parallel, the pole to the line at infinity being the point where the curve touches the line at infinity.

In case of the ellipse and hyperbola, the pole to the line at infinity is a finite point called the *centre* of the curve.

A centre of a conic bisects every chord through it.

The centre of an ellipse is within the curve, for the line at infinity does not cut the ellipse.

The centre of an hyperbola is without the curve, because the line at infinity cuts the curve. Hence also

From the centre of an hyperbola two tangents can be drawn to the curve which have their point of contact at infinity. These are called *Asymptotes* (§ 59.)

To construct a diameter of a conic, draw two parallel chords and join their middle points.

To find the centre of a conic, draw two diameters; their intersection will be the centre.

§ 70. *Conjugate Diameters.*—A polar-triangle with one vertex at the centre will have the opposite side at infinity. The other two sides pass through the centre, and are called *conjugate diameters*, each being the polar of the point at infinity on the other.

Of two conjugate diameters each bisects the chords parallel to the other, and if one cuts the curve, the tangents at its ends are parallel to the other diameter.

Further—

Every parallelogram inscribed in a conic has its sides parallel to two conjugate diameters; and

Every parallelogram circumscribed about a conic has as diagonals two conjugate diameters.

This will be seen by considering the parallelogram in the first case as an inscribed four-point, in the other as a circumscribed four-side, and determining in each case the corresponding polar-triangle. The first may also be enunciated thus—

The lines which join any point on an ellipse or an hyperbola to the ends of a diameter are parallel to two conjugate diameters.

§ 71. THE CIRCLE.—*If every diameter is perpendicular to its conjugate the conic is a circle.*

For the line which joins the ends of a diameter to any point on the curve include a right angle.

A conic which has more than one pair of conjugate diameters at right angles to each other is a circle.

Let AA′ and BB′ (fig. 23) be one pair of conjugate diameters at right angles to each other, CC′ and DD′ a second pair. If we draw through the end point A of one diameter a chord AP parallel to DD′, and join P to A′, then PA and PA′ are, according to § 70, parallel to two conjugate diameters. But PA is parallel to DD′, hence PA′ is parallel to CC′, and therefore PA and PA′ are perpendicular. If we further draw the tangents to the conic at A and A′, these will be perpendicular to AA′, they being parallel to the conjugate diameter BB′. We know thus five points on the conic, viz., the points A and A′ with their tangents, and the point P. Through these a circle may be drawn having AA′ as diameter; and as through five points one conic only can be drawn, this circle must coincide with the given conic.

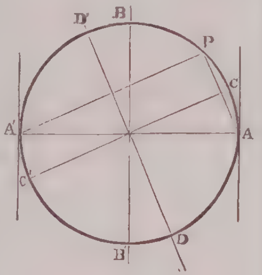


FIG. 23.

§ 72. *Axes.*—Conjugate diameters perpendicular to each other are called *axes*, and the points where they cut the curve *vertices* of the conic.

In a circle every diameter is an axis, every point on it is a vertex; and any two lines at right angles to each other may be taken as a pair of axes of any circle which has its centre at their intersection.

If we describe on a diameter AB of an ellipse or hyperbola a circle concentric to the conic, it will cut the latter in A and B (fig. 24). Each of the semicircles in which it is divided by AB will be partly within, partly without the curve, and must cut the latter therefore again in a point. The circle and the conic have thus four points A, B, C, D, and therefore one polar-triangle, in common (§ 68). Of this the centre is one vertex, for the line at infinity is the polar to this point, both with regard to the circle and the other conic. The other two sides are conjugate diameters of both, hence perpendicular to each other. This gives—

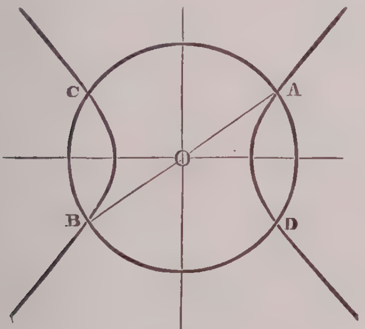


FIG. 24.

Theorem.—An ellipse as well as an hyperbola has one pair of axes.

This reasoning shows at the same time *how to construct the axis of an ellipse or of an hyperbola.*

A parabola has one axis, if we define an axis as a diameter perpendicular to the chords which it bisects. It is easily constructed. The line which bisects any two parallel chords is a diameter. Chords perpendicular to it will be bisected by a parallel diameter, and this is the axis.

§ 73. The first part of the right hand theorem in § 64 may be stated thus: any two conjugate lines through a point P without a conic are harmonic conjugates with regard to the two tangents that may be drawn from P to the conic.

If we take instead of P the centre C of an hyperbola, then the conjugate lines become conjugate diameters, and the tangents asymptotes. Hence—

Theorem.—Any two conjugate diameters of an hyperbola are harmonic conjugates with regard to the asymptotes.

As the axes are conjugate diameters at right angles to one another, it follows (§ 23)—

Theorem.—The axes of an hyperbola bisect the angles between the asymptotes.

Let O be the centre of the hyperbola (fig. 25), *t* any secant which cuts the hyperbola in C, D and the asymptotes in E, F, then the line OH which bisects the chord CD is a diameter conjugate to the diameter OK which is parallel to the secant *t*, so that OK and OM are harmonic with regard to the asymptotes. The point M therefore bisects EF. But by construction M bisects CD. It follows that DF = EC, and ED = CF; or

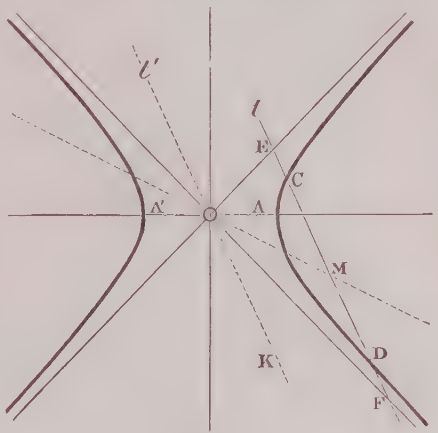


FIG. 25.

THEOREM.—*On any secant of an hyperbola the segments between the curve and the asymptotes are equal.*

If the chord is changed into a tangent, this gives

The segment between the asymptotes on any tangent to an hyperbola is bisected by the point of contact.

The first part allows a simple solution of the problem to find any number of points on an hyperbola, of which the asymptotes and one point are given. This is equivalent to three points and the tangents at two of them. This construction requires measurement.

§ 74. For the parabola, too, follows some metrical properties. A diameter PM (fig. 26) bisects every chord conjugate to it, and the pole P of such a chord BC lies on the diameter. But a diameter cuts the parabola once at infinity. Hence—

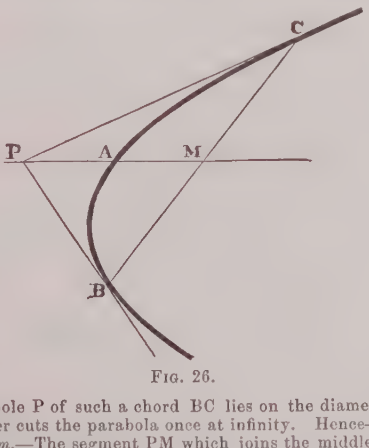


FIG. 26.

Theorem.—The segment PM which joins the middle point M of a chord of a parabola to the pole P of the chord is bisected by the parabola at A.

§ 75. Two asymptotes and any two tangents to an hyperbola may be considered as a quadrilateral circumscribed about the hyperbola. But in such a quadrilateral the intersections of the diagonals and the points of contact of opposite sides lie in a line (§ 54). If therefore DEFG (fig. 27) is such a quadrilateral, then the diagonals DF and GE will meet on the line which joins the points of contact of the asymptotes, that is, on the line at infinity; hence they are parallel. From this the following theorem is a simple deduction:—

Theorem.—All triangles formed by a tangent and the asymptotes of an hyperbola are equal in area.

If we draw at a point P (fig. 27) on an hyperbola a tangent, the part HK between the asymptotes is bisected at P. The parallelogram PQOQ′ formed by the asymptotes and lines parallel to them through P will be half the triangle OHK, and will therefore be constant. If we now take the asymptotes

OX and OY as oblique axes of co-ordinates, the lines OQ and QP will be the co-ordinates of P, and will satisfy the equation $xy = \text{const.} = a^2$.

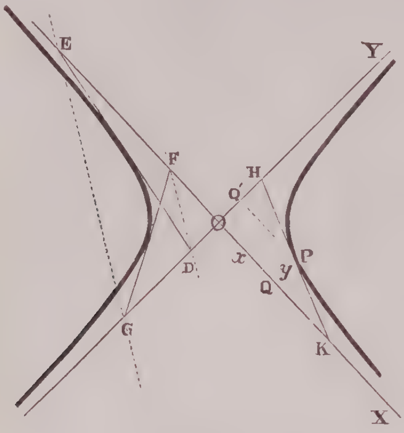


Fig. 27.

Theorem.—For the asymptotes as axes of co-ordinates the equation of the hyperbola is

$$xy = \text{const.}$$

It is not difficult to get the equations to the ellipse and hyperbola referred to their axes as axes of co-ordinates. We are satisfied to have shown in one case that the curves of the second order as generated by projective pencils are the same as those which are in co-ordinate geometry defined by equations of the second degree.

INVOLUTION.

§ 76. If we have two projective rows, ABC on u and A′B′C′ on u', and place their bases on the same line, then each point in this line counts twice, once as a point in the row u and once as a point in the row u'. In fig. 28 we denote the points as points in the one row by letters above the line A, B, C . . ., and as points in the second row by A′, B′, C′ . . . below the line. Let now A and B′ be the same point, then to A will correspond a point A′ in the second, and to B′ a point B in the first row. In general these points A′ and B will be different. It may, however, happen that they coincide. Then the correspondence is a peculiar one, as the following theorem shows:—

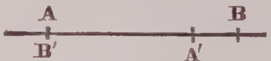


Fig. 28.

Theorem.—*If two projective rows lie on the same base, and if it happens that to one point in the base the same point corresponds, whether we consider the point as belonging to the first or to the second row, then the same will happen for every point in the base—that is to say, to every point in the line corresponds the same point in the first as in the second row.*

Proof. In order to determine the correspondence, we may assume three pairs of corresponding points in two projective rows. Let then A′, B′, C′, in fig. 29, correspond to A, B, C, so that A and B′, and also B and A′, denote the same point. Let us further denote the point C′ when considered as a point in the first row by D; then it is to be proved that the point D′, which corresponds to D, is the same point as C. We know that the cross-ratio of four points is equal to that of the corresponding row. Hence

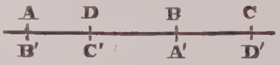


Fig. 29.

$$(ABCD) = (A'B'C'D')$$

but replacing the dashed letters by those undashed ones which denote the same points, the second cross-ratio equals (BADD′), which, according to § 15, iv., equals (ABD′D); so that the equation becomes

$$(ABCD) = (ABD'D).$$

This requires that C and D′ coincide.

§ 77. Two projective rows on the same base, which have the above property, that to every point, whether it be considered as a point in the one or in the other row, corresponds the same point, are said to be in *involution*, or to form an *involution* of points on the line.

We mention, but without proving it, that any two projective rows may be placed so as to form an involution.

An involution may be said to consist of a row of pairs of points, to every point A corresponding a point A′, and to A′ again the point A. These points are said to be conjugate.

From the definition, according to which an involution may be considered as made up of two projective rows, follow at once the following important properties:—

(1.) The cross-ratio of four points equals that of the four conjugate points.

(2.) If we call a point which coincides with its conjugate point a "focus" of the involution, we may say: An involution has either two foci, or one, or none, and is called respectively a hyperbolic, parabolic, or elliptic involution (§ 34).

(3.) In a hyperbolic involution any two conjugate points are harmonic conjugates with regard to the two foci.

For if A, A′ be two conjugate points, F_1, F_2 the two foci, then to the points F_1, F_2, A, A′ in the one row correspond the points F_1, F_2, A′, A in the other, each focus corresponding to itself. Hence $(F_1F_2AA') = (F_1F_2A'A)$—that is, we may interchange the two points AA′ without altering the value of the cross-ratio, which is the characteristic property of harmonic conjugates (§ 18).

(4.) The point conjugate to the point at infinity is called the "centre" of the involution. Every involution has a centre, unless the point at infinity be a focus, in which case we may say that the centre is at infinity.

In a hyperbolic involution the centre is the middle point between the foci.

(5.) The product of the distances of two conjugate points, A, A′ from the centre O is constant:—

$$OA \, . \, OA' = c.$$

Proof.—Let A, A′, and B, B′ be two pairs of conjugate points, O the centre, I the point at infinity, then

$$(ABOI) = (A'B'IO),$$

or

$$OA \, . \, OA' = OB \, . \, OB'.$$

In order to determine the distances of the foci from the centre, we write F for A and A′ and get

$$\overline{OF}^2 = c; \; OF = \pm\sqrt{c}.$$

Hence if c is positive OF is real, and has two values, equal and opposite. The involution is hyperbolic.

If $c = 0$, $OF = 0$, and the two foci both coincide with the centre.

If c is negative, $\sqrt{c}$ becomes imaginary, and there are no foci. Hence we may write—

In a hyperbolic involution, $OA \, . \, OA' = k^2$,
In a parabolic involution, $OA \, . \, OA' = 0$,
In an elliptic involution, $OA \, . \, OA' = -k^2$.

From these expressions it follows that conjugate points A, A′ in a hyperbolic involution lie on the same side of the centre, and in an elliptic involution on opposite sides of the centre, and that in a parabolic involution one coincides with the centre.

In the first case, for instance, OA . OA′ is positive; hence OA and OA′ have the same sign.

It also follows that two segments, AA′ and BB′, between pairs of conjugate points have the following positions:—in a hyperbolic involution they lie either one altogether within or altogether without each other; in a parabolic involution they have one point in common; and in an elliptic involution they overlap, each being partly within and partly without the other.

Proof.—We have $OA \, . \, OA' = OB \, . \, OB' = k^2$ in case of a hyperbolic involution. Let A and B be the points in each pair which are nearer to the centre O. If now A, A′ and B, B′ lie on the same side of O, and if B is nearer to O than A, so that $OB < OA$, then $OB' > OA'$; hence B′ lies further away from O than A′, or the segment AA′ lies within BB′. And so on for the other cases.

(6.) An involution is determined—

(α) By two pairs of conjugate points. Hence also
(β) By one pair of conjugate points and the centre;
(γ) By the two foci;
(δ) By one focus and one pair of conjugate points;
(ε) By one focus and the centre.

(7.) The condition that A, B, C and A′, B′, C′ may form an involution may be written in one of the forms—

$$(ABCC') = (A'B'C'C),$$

or

$$(ABCA') = (A'B'C'A),$$

or

$$(ABC'A') = (A'B'CA),$$

for each expresses that in the two projective rows in which A, B, C and A′, B′, C′ are conjugate points two conjugate elements may be interchanged.

(8.) Any three pairs, A, A′, B, B′, C, C′, of conjugate points are connected by the relation—

$$\frac{BA'}{A'C} \cdot \frac{CB'}{B'A} \cdot \frac{AC'}{C'B} = -1.$$

Proof.—We have by (7) (ABC′A′) = (A′B′CA), which, when worked out, gives the above relation.

The latter is easily remembered by aid of the following rule of writing the first side. First write

$$\frac{\mathrm{B}\quad}{\quad\mathrm{C}}\;\frac{\mathrm{C}\quad}{\quad\mathrm{A}}\;\frac{\mathrm{A}\quad}{\quad\mathrm{B}},$$

and then fill up the gaps in numerator and denominator by A′, B′, C′ respectively.

§ 78. THEOREM.—*The sides of any four-point are cut by any line in six points in involution, opposite sides being cut in conjugate points.*

Let $A_1B_1C_1D_1$ (fig. 30) be the four-point. If its sides be cut by the line p in the points A, A′, B, B′, C, C′, if further, C_1D_1 cuts the line A_1B_1 in C_2, and if we project the row $A_1B_1C_2C$ to p once from D_1 and once from C_1, we get

$$(\mathrm{A'B'C'C}) = (\mathrm{BAC'C}).$$

Interchanging in the last cross-ratio the letters in each pair we get

$$(\mathrm{A'B'C'C}) = (\mathrm{ABCC'}).$$

Hence by § 77 (7) the points are in involution.

The theorem may also be stated thus:—

Theorem.—The three points in which any line cuts the sides of a triangle and the projections, from any point in the plane, of the vertices of the triangle on to the same line are six points in involution.

Or again—

The projections from any point on to any line of the six vertices of a four-side are six points in involution, the projections of opposite vertices being conjugate points.

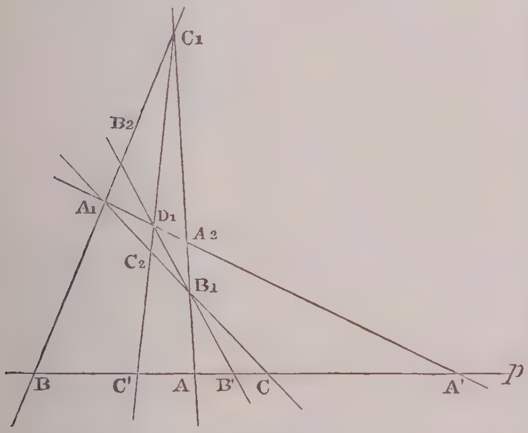


FIG. 30.

This property gives a simple means to construct, by aid of the straight edge only, in an involution of which two pairs of conjugate points are given, to any point its conjugate.

§ 79. The theory of involution may at once be extended from the row to the flat and the axial pencil—viz., we say that there is an involution in a flat or in an axial pencil if any line cuts the pencil in an involution of points. An involution in a pencil consists of pairs of conjugate rays or planes; it has two, one, or no *focal rays* or *planes*, but nothing corresponding to a centre.

An involution in a flat pencil contains always one, and in general only one, pair of conjugate rays which are perpendicular to one another. For in two projective flat pencils exist always two corresponding right angles (§ 40).

Each involution in an axial pencil contains in the same manner one pair of conjugate planes at right angles to one another.

As a rule, there exists but one pair of conjugate lines or planes at right angles to each other. But it is possible that there are more, and then there is an infinite number of such pairs. An involution in a flat pencil, in which every ray is perpendicular to its conjugate ray, is said to be *circular*. That such involution is possible is easily seen thus:—if in two concentric flat pencils each ray on one is made to correspond to that ray on the other which is perpendicular to it, then the two pencils are projective, for if we turn the one pencil through a right angle each ray in one coincides with its corresponding ray in the other. But these two projective pencils are in involution.

A circular involution has no focal rays, because no ray in a pencil coincides with the ray perpendicular to it.

§ 80. THEOREM.—*Every elliptical involution in a row may be considered as a section of a circular involution.*

Proof.—In an elliptical involution any two segments AA′ and BB′ lie partly within partly without each other (fig. 31). Hence two circles described on AA′ and BB′ as diameters will intersect in two points E and E′. The line EE′ cuts the base of the involution at a point O, which, from a well known proposition (Eucl. III. 35), has the property that OA . OA′ = OB . OB′, for each is equal to OE . OE′. The point O is therefore the centre of the involution. If we wish to construct to any point C the conjugate point C′, we may draw the circle through CEE′. This will cut the base in the required point C′ for OC . OC′ = OA . OA′. But EC and EC′ are at right angles. Hence the involution which is obtained by joining E or E′ to the points in the given involution is circular. This may also be expressed thus:—

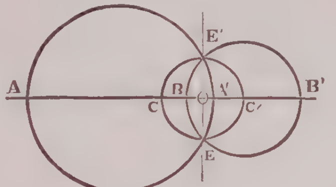


FIG. 31.

Every elliptical involution has the property that there are two definite points in the plane, from which any two conjugate points are seen under a right angle.

At the same time the following problem has been solved:—

Problem.—To determine the centre and also the point corresponding to any given point in an elliptical involution of which two pairs of conjugate points are given.

§ 81. By the aid of § 53, the points on a conic may be made to correspond to those on a line, so that the row of points on the conic is projective to a row of points on a line. We may also have two projective rows on the same conic, and these will be in involution as soon as one point on the conic has the same point corresponding to it all the same to whatever row it belongs. An involution of points on a conic will have the property (as follows from its definition, and from § 53) that the lines which join conjugate points of the involution to any point on the conic are conjugate lines of an involution in a pencil, and that a fixed tangent is cut by the tangents at conjugate points on the conic in points which are again conjugate points of an involution on the fixed tangent. For such involution on a conic the following theorem holds:—

THEOREM.—*The lines which join corresponding points in an involution on a conic all pass through a fixed point;* and reciprocally, *the points of intersection of conjugate lines in an involution among tangents to a conic lie on a line.*

We prove the first part only. The involution is determined by two pairs of conjugate points, say by A, A′ and B, B′ (fig. 32). Let AA′ and BB′ meet in P. If we join the points in involution to any point on the conic, and the conjugate points to another point on the conic, we obtain two projective pencils. We take A and A′ as centres of these pencils, so that the pencils A(A′BB′) and A′(AB′B) are projective, and in perspective position, because AA′ corresponds to A′A. Hence corresponding rays meet in a line, of which two points are found by joining AB′ to A′B and AB to A′B′. It follows that the *axis* of perspective is the polar of the point P, where AA′ and BB′ meet. If we now wish to construct to any other point C on the conic the corresponding point C′, we join C to A′ and the point where this line cuts p to A. The latter line cuts the conic again in C′. But we know from the theory of pole and polar that the line CC′ passes through P.

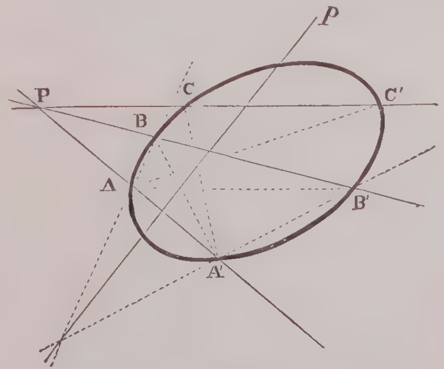


FIG. 32.

Involution Determined by a Conic on a Line.—Foci.

§ 82. The polars, with regard to a conic, of points in a row p form a pencil P projective to the row (§ 66). This pencil cuts the base of the row p in a projective row.

If A is a point in the given row, A' the point where the polar of A cuts p, then A and A' will be corresponding points. If we take A' a point in the first row, then the polar of A' will pass through A, so that A corresponds to A'—in other words, the rows are in involution. The conjugate points in this involution are conjugate points with regard to the conic. Conjugate points coincide only if the polar of a point A passes through A—that is, if A lies on the conic. Hence—

Theorem.—*A conic determines on every line in its plane an involution, in which those points are conjugate which are also conjugate with regard to the conic.*

If the line cuts the conic the involution is hyperbolic, the points of intersection being the foci.

If the line touches the conic the involution is parabolic, the two foci coinciding at the point of contact.

If the line does not cut the conic the involution is elliptic, having no foci.

If, on the other hand, we take a point P in the plane of a conic, we get to each line a through P one conjugate line which joins P to the pole of a. These pairs of conjugate lines through P form an involution in the pencil at P. The focal rays of this involution are the tangents drawn from P to the conic. This gives the theorem reciprocal to the last, viz.:—

Theorem.—*A conic determines in every pencil in its plane an involution, corresponding lines being conjugate lines with regard to the conic.*

If the point is without the conic the involution is hyperbolic, the tangents from the points being the focal rays.

If the point lies on the conic the involution is parabolic, the tangent at the point counting for coincident focal rays.

If the point is within the conic the involution is elliptic, having no focal rays.

It will further be seen that the involution determined by a conic on any line p is a section of the involution, which is determined by the conic at the pole P of p.

§ 83. *Definition.*—The centre of a pencil in which the conic determines a circular involution is called a focus of the conic.

In other words—

A focus is such a point that every line through it is perpendicular to its conjugate line.

The polar to a focus is called a *directrix* of the conic.

From the definition it follows that:—

Every focus lies on an axis, for the line joining a focus to the centre of the conic is a diameter to which the conjugate lines are perpendicular; and

Every line joining two foci is an axis, for the perpendiculars to this line through the foci are conjugate to it. These conjugate lines pass through the pole of the line, the pole lies therefore at infinity, and the line is a diameter, hence by the last property an axis.

It follows that all *foci lie on one axis*, for no line joining a point in one axis to a point in the other can be an axis.

As the conic determines in the pencil which has its centre at a focus a circular involution, no tangents can be drawn from the focus to the conic. Hence *each focus lies within a conic;* and *a directrix does not cut the conic.*

Further properties are found by the following considerations:—

§ 84. Through a point P one line p can be drawn, which is with regard to a given conic conjugate to a given line q, viz., that line which joins the point P to the pole of the line q. If the line q is made to describe a pencil about a point Q, then the line p will describe a pencil about P. These two pencils will be projective, for the line p passes through the pole of q, and whilst q describes the pencil Q, its pole describes a projective row, and this row is perspective to the pencil P.

We now take the point P on an axis of the conic, draw any line p through it, and from the pole of p draw a perpendicular q to p. Let q cut the axis in Q. Then in the pencils of conjugate lines, which have their centres at P and Q, the lines p and q are conjugate lines at right angles to one another. Besides, to the axis as a ray in either pencil will correspond in the other the perpendicular to the axis (§ 72). The conic generated by the intersection of corresponding lines in the two pencils is therefore the circle on PQ as diameter, *so that every line in P is perpendicular to its corresponding line in Q.*

To every point P on an axis of a conic corresponds thus a point Q, such that conjugate lines through P and Q are perpendicular.

We shall show that these *point-pairs, P, Q form an involution.* To do this let us move P along the axis, and with it the line p, keeping the latter parallel to itself. Then P describes a row, p a perspective pencil (of parallels), and the pole of p a projective row. At the same time the line q describes a pencil of parallels perpendicular to p, and perspective to the row formed by the pole of p. The point Q, therefore, where q cuts the axis, describes a row projective to the row of points P. The two points P and Q describe thus two projective rows on the axis; and not only does P as a point in the first now correspond to Q, but also Q as a point in the first corresponds to P. The two rows therefore form an involution. *The centre of this involution, it is easily seen, is the centre of the conic.*

A focus of this involution has the property that any two conjugate lines through it are perpendicular; hence, it is a focus to the conic.

Such involution exists on each axis. But only one of these can have foci, because all foci lie on the same axis. The involution on one of the axes is elliptic, and appears (§ 80) therefore as the section of two circular involutions in two pencils whose centres lie in the other axis. These centres are foci, hence the one axis contains two foci, the other axis none; *or every central conic has two foci which lie on one axis equidistant from the centre.*

The axis which contains the foci is called the *principal axis;* in case of an hyperbola it is the axis which cuts the curve, because the foci lie within the conic.

In case of the parabola there is but one axis. The involution on this axis has its centre at infinity. One focus is therefore at infinity, the one focus only is finite. *A parabola has only one focus.*

§ 85. If through any point P (fig. 33) on a conic the tangent PT and the normal PN (*i. e.*, the perpendicular to the tangent through the point of contact) be drawn these will be conjugate lines with regard to the conic, and at right angles to each other. They will therefore cut the principal axis in two points, which are conjugate in the involution considered in § 84; hence they are harmonic conjugates with regard to the foci. If therefore the two foci F_1 and F_2 be joined to P, these lines will be harmonic with regard to the tangent and normal. As the latter are perpendicular, they will bisect the angles between the other pair. Hence—

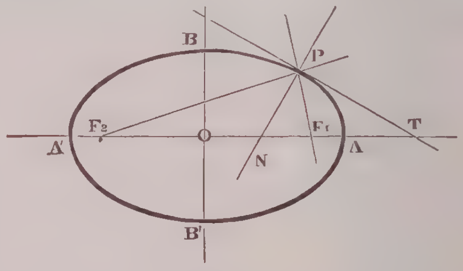


Fig. 33.

The line joining any point on a conic to the two foci are equally inclined to the tangent and normal at that point.

In case of the parabola this becomes—

The line joining any point on a parabola to the focus and the diameter through the point, are equally inclined to the tangent and normal at that point.

From the definition of a focus it follows that—

The segment of a tangent between the directrix and the point of contact is seen from the focus belonging to the directrix under a right angle, because the lines joining the focus to the ends of this segment are conjugate with regard to the conic, and therefore perpendicular.

With equal ease the following theorem is proved:—

The two lines which join the points of contact of two tangents each to one focus, but not both to the same, are seen from the intersection of the tangents under equal angles.

§ 86. Other focal properties of a conic are obtained by the following considerations:

Let F (fig. 34) be a focus to a conic, f the corresponding directrix, A and B the points of contact of two tangents meeting at T, and P the point where the line AB cuts the directrix. Then TF will be the polar of P (because polars of F and T meet at P). Hence TF and PF are conjugate lines through a focus, and therefore perpendicular. They are further harmonic conjugates with regard to FA and FB (§§ 64 and 13), so that they bisect the angles formed by these lines. This by the way proves—

The segments between the point of intersection of two tangents to a conic and their points of contact are seen from a focus under equal angles.

If we next draw through A and B lines parallel to TF, then the points A_1, B_1 where these cut the directrix will be harmonic conjugates with regard to P and the point where FT cuts the directrix. The lines FT and FP bisect therefore also the angles between FA_1 and FB_1. From this it follows easily that the triangles FAA_1 and FBB_1 are equiangular, and therefore similar, so that

$$FA : AA_1 = FB : BB_1.$$

The triangles AA_1A_2 and BB_1B_2 formed by drawing perpendiculars from A and B to the directrix are also similar, so that $AA_1 : AA_2 = BB_1 : BB_2$.

This, combined with the above proportion, gives

$$FA : AA_2 = FB : BB_2.$$

Hence the theorem :

The ratio of the distances of any point on a conic from a focus and the corresponding directrix is constant.

To determine this ratio we consider its value for a vertex on the principal axis. In an ellipse the focus lies between the two vertices on this axis, hence the focus is nearer to a vertex than to the corresponding directrix. Similarly in an hyperbola a vertex is nearer to the directrix than to the focus. In a parabola the vertex lies halfway between directrix and focus.

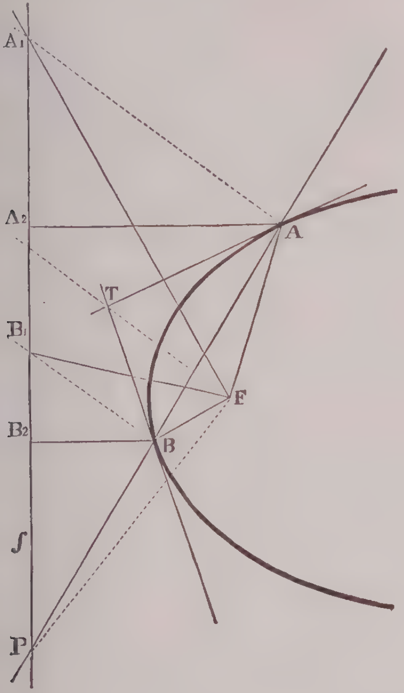


FIG. 34.

It follows in an ellipse the ratio between the distance of a point from the focus to that from the directrix is less than unity, in the parabola it equals unity, and in the hyperbola it is greater than unity.

It is here the same which focus we take, because the two foci lie symmetrical to the axis of the conic. If now P is any point on the conic having the distances r_1 and r_2 from the foci and the distances d_1 and d_2 from the corresponding directrices, then

$$\frac{r_1}{d_1} = \frac{r_2}{d_2} = e,$$

where e is constant. Hence also $\frac{r_1 \pm r_2}{d_1 \pm d_2} = e$.

In the ellipse, which lies between the directrices, $d_1 + d_2$ is constant, therefore also $r_1 + r_2$. In the hyperbola, on the other hand, $d_1 - d_2$ is constant, equal to the distance between the directrices, therefore in this case $r_1 - r_2$ is constant.

If we call the distances of a point on a conic from the focus its focal distances we have the theorem :

In an ellipse the sum of the focal distances is constant ; and in an hyperbola the difference of the focal distances is constant.

This constant sum or difference equals in both cases the length of the principal axis.

PENCIL OF CONICS.

§ 87. Through four points A, B, C, D in a plane, of which no three lie in a line, an infinite number of conics may be drawn, viz., through these four points and any fifth one single conic. *This system of conics is called a pencil of conics.* Similarly all conics touching four fixed lines form a system such that any fifth tangent determines one and only one conic. We have here the theorems :—

Theorem.—The pairs of points in which any line is cut by a system of conics through four fixed points are in involution.

Theorem.—The pairs of tangents which can be drawn from a point to a system of conics touching four fixed lines are in involution.

We prove the first theorem only. Let ABCD (fig. 35) be the four-point, then any line t will cut two opposite sides AC, BD in the points E, E′, the pair AD, BC in points F, F′, and any conic of the system in M, N, and we have

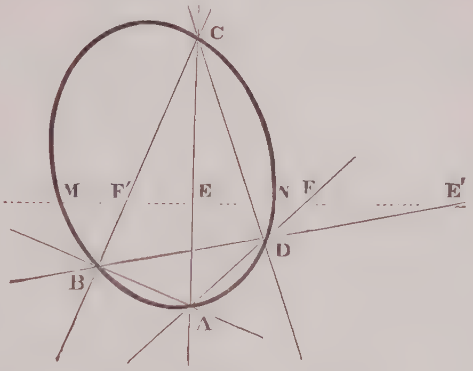


FIG. 35.

$$A(CDMN) = B(CDMN).$$

If we cut these pencils by t we get

$$(EFMN) = (F'E'MN)$$

or

$$(EFMN) = (E'F'NM).$$

But this is, according to § 77 (7), the condition that M, N are corresponding points in the involution determined by the point pairs E, E′, F, F′ in which the line t cuts pairs of opposite sides of the four-point ABCD. This involution is independent of the particular conic chosen.

§ 88. There follow several important consequences :—

THEOREM.—*Through four points two, one, or no conic may be drawn which touch any given line, according as the involution determined by the given four-point on the line has real, coincident, or imaginary foci.*

THEOREM.—*Two, one, or no conics may be drawn which touch four given lines and pass through a given point, according as the involution determined by the given four-side at the point has real, coincident, or imaginary focal rays.*

For the conic through four points which touches a given line has its point of contact at a focus of the involution determined by the four-point on the line.

As a special case we get, by taking the line at infinity :—

THEOREM.—*Through four points of which none is at infinity either two or no parabolas may be drawn,*

The problem of drawing a conic through four points and touching a given line is solved by determining the points of contact on the line, that is, by determining the foci of the involution in which the line cuts the sides of the four-point. The corresponding remark holds for the problem of drawing the conics which touch four lines and pass through a given point.

RULED QUADRIC SURFACES.

§ 89. Formerly we have considered projective rows which lie in the same plane. In that case, lines joining corresponding points envelope a conic. We shall now consider projective rows whose bases do not meet. In this case, corresponding points will be joined by lines which do not lie in a plane, but on some surface, which like every surface generated by lines is called a *ruled* surface. This surface clearly contains the bases of the two rows.

If the points in either row be joined to the base of the other, we obtain two axial pencils which are also projective, those planes being corresponding which pass through corresponding points in the given rows. If A, A′ be two corresponding points, α, α' the planes in the axial pencils passing through them, then AA′ will be the line of intersection of the corresponding planes α, α', and also the line joining corresponding points in the rows.

If we cut the whole figure by a plane this will cut the axial pencils in two projective flat pencils, and the curve of the second order generated by these will be the curve in which the plane cuts the surface. Hence

THEOREM.—*The locus of lines joining corresponding points in two projective rows which do not lie in the same plane is a surface which contains the bases of the rows, and which can also be generated by the lines of intersection of corresponding planes in two projective axial pencils. This surface is cut by every plane in a curve of the second order, hence either in a conic or in a line-pair.*

No line which does not lie altogether on the surface can have more than two points in common with the surface, which is therefore said to be of the second order, or is called a ruled quadric surface.

That no line which does not lie on the surface can cut the surface in more than two points is seen at once if a plane be drawn through the line, for this will cut the surface in a conic. It follows also that

A line which contains more than two points of the surface lies altogether on the surface.

§ 90. Through any point in space one line can always be drawn cutting two given lines which do not themselves meet.

If therefore three lines in space be given of which no two meet, then through every point in either one line may be drawn cutting the other two.

THEOREM.—*If a line moves so that it always cuts three given lines of which no two meet, then it generates a ruled quadric surface.*

Proof.—Let a, b, c be the given lines, and p, q, r . . . . lines cutting them in the points A, A′, A″ . . . ; B, B′, B″ . . . ; C, C′, C″ . . . respectively; then the planes through a containing p, q, r, and the planes through b containing the same lines, may be taken as corresponding planes in two axial pencils which are projective, because both pencils cut the line c in the same row C, C′, C″ . . . ; the surface can therefore be generated by projective axial pencils.

Of the lines p, q, r . . . no two can meet, for otherwise the lines a, b, c which cut them would also lie in their plane. There is a single infinite number of them, for one passes through each point of a. These lines are said to form a *set* of lines on the surface.

If now three of the lines p, q, r be taken, then every line d cutting them will have three points in common with the surface, and will therefore lie altogether on it. This gives rise to a second set of lines on the surface. From what has been said the theorem follows:—

THEOREM.—*A ruled quadric surface contains two sets of straight lines. Every line of one set cuts every line of the other, but no two lines of the same set meet.*

Any two lines of the same set may be taken as bases of two projective rows, or of two projective pencils which generate the surface. They are cut by the lines of the other set in two projective rows.

The plane at infinity like every other plane cuts the surface either in a conic proper or in a line-pair. In the first case the surface is called an *Hyperboloid of one sheet*, in the second an *Hyperbolic Paraboloid.*

The latter may be generated by a line cutting three lines of which one lies at infinity, that is, cutting two lines and remaining parallel to a given plane.

QUADRIC SURFACES.

§ 91. The conics, the cones of the second order, and the ruled quadric surfaces complete the figures which can be generated by projective rows or flat and axial pencils, that is, by those aggregates of elements which are of one dimension (§§ 5, 6). We shall now consider the simpler figures which are generated by aggregates of two dimensions. The space at our disposal will not, however, allow us to do more than indicate a few of the results.

§ 92. We establish a correspondence between the lines and planes in pencils in space, or reciprocally between the points and lines in two or more planes, but consider principally pencils.

In two pencils we may either make planes correspond to planes and lines to lines, or else planes to lines and lines to planes. If hereby the condition be satisfied that to a flat, or axial, pencil, corresponds in the first case a projective flat, or axial, pencil, and in the second a projective axial, or flat, pencil, the pencils are said to be *projective* in the first case and *reciprocal* in the second.

For instance, two pencils which join two points S_1 and S_2 to the different points and lines in a given plane π are projective (and in perspective position), if those lines and planes be taken as corresponding which meet the plane π in the same point or in the same line. In this case every plane through both centres S_1 and S_2 of the two pencils will correspond to itself. If these pencils are brought into any other position they will be projective (but not perspective).

The correspondence between two projective pencils is uniquely determined, if to four rays (or planes) in the one the corresponding rays (or planes) in the other are given, provided that no three rays of either set lie in a plane.

Proof.—Let a, b, c, d be four rays in the one, a', b', c', d' the corresponding rays in the other pencil. We shall show that we can find for every ray e in the first a single corresponding ray e' in the second. To the axial pencil a (b, c, d . . .) formed by the planes which join a to b, c, d . . . , respectively corresponds the axial pencil a' (b', c', d' . . .), and this correspondence is determined. Hence, the plane $a'e'$ which corresponds to the plane ae is determined. Similarly the plane $b'e'$ may be found and both together determine the ray e'.

Similarly the correspondence between two reciprocal pencils is determined if for four rays in the one the corresponding planes in the other are given.

§ 93. We may now combine—

1. Two reciprocal pencils.
   Each ray cuts its corresponding plane in a point, the locus of these points is a quadric surface.
2. Two projective pencils.
   Each plane cuts its corresponding plane in a line, but a ray as a rule does not cut its corresponding ray. The locus of points where a ray cuts its corresponding ray is a twisted cubic. The lines where a plane cuts its corresponding plane are secants.
3. Three projective pencils.
   The locus of intersection of corresponding planes is a cubic surface.

Of these we consider only the first two cases.

§ 94. If two pencils are reciprocal, then to a plane in either corresponds a line in the other, to a flat pencil an axial pencil, and so on. Every line cuts its corresponding plane in a point. If S_1 and S_2 be the centres of the two pencils, and P be a point where a line a_1 in the first cuts its corresponding plane α_2, *then the line b_2 in the pencil S_2 which passes through P will meet its corresponding plane β_1 in P.* For b_2 is a line in the plane α_2. The corresponding plane β_1 must therefore pass through the line a_1, hence through P.

The points in which the lines in S_1 cut the planes corresponding to them in S_2 are therefore the same as the points in which the lines in S_2 cut the planes corresponding to them in S_1.

The locus of these points is a surface which is cut by a plane in a conic or in a line-pair and by a line in not more than two points unless it lies altogether on the surface. The surface itself is therefore called a quadric surface, or a surface of the second order.

To prove this we consider any line p in space.

The flat pencil in S_1 which lies in the plane drawn through p and the corresponding axial pencil in S_2 determine on p two projective rows, and those points in these which coincide with their corresponding points lie on the surface. But there exist only two, or one, or no such points, unless every point coincides with its corresponding point. In the latter case the line lies altogether on the surface.

This proves also that a plane cuts the surface in a curve of the second order, as no line can have more than two points in common with it. To show that this is a curve of the same kind as those considered before, we have to show that it can be generated by projective flat pencils. We prove first that this is true for any plane through the centre of one of the pencils, and afterwards that every point on the surface may be taken as the centre of such pencil. Let then α_1 be a plane through S_1. To the flat pencil in S_1 which it contains corresponds in S_2 a projective axial pencil with axis a_2, and this cuts α_1 in a second flat pencil. These two flat pencils in α_1 are projective, and, in general, neither concentric nor perspective. They generate therefore a conic. But if the line a_2 passes through S_1 the pencils will have S_1 as common centre, and may therefore have two, or one, or no lines united with their corresponding lines. The section of the surface by the plane α_1 will be accordingly a line-pair or a single line, or else the plane α_1 will have only the point S_1 in common with the surface.

Every line l_1 through S_1 cuts the surface in two points, viz., first in S_1 and then at the point where it cuts its corresponding plane. If now the corresponding plane passes through S_1, as in the case just considered, then the two points where l_1 cuts the surface coincide at S_1, and the line is called a *tangent* to the surface with S_1 as *point of contact.* Hence if l_1 be a tangent, it lies in that plane τ_1 which corresponds to the line S_2S_1 as a line in the pencil S_2. The section of this plane has just been considered. It follows that—

All tangents to quadric surface at the centre of one of the reciprocal pencils lie in a plane which is called the tangent plane to the surface at that point as point of contact.

To the line joining the centres of the two pencils as a line in one corresponds in the other the tangent plane at its centre.

The tangent plane to a quadric surface either cuts the surface in two lines, or it has only a single line, or else only a single point in common with the surface.

In the first case the point of contact is said to be hyperbolic, in the second parabolic, in the third elliptic.

§ 95. It remains to be proved that every point S on the surface may be taken as centre of one of the pencils which generate the surface. Let S be any point on the surface Φ′ generated by the reciprocal pencils S_1 and S_2. We have to establish a reciprocal correspondence between the pencils S and S_1, so that the surface generated by them is identical with Φ. To do this we draw two planes α_1 and β_1 through S_1, cutting the surface Φ in two conics which we also donate by α_1 and β_1. These conics meet at S_1, and at some other point T where the line of intersection of α_1 and β_1 cuts the surface.

In the pencil S we draw some plane σ which passes through T, but not through S_1 or S_2. It will cut the two conics first at T, and therefore each at some other point which we call A and B respectively. These we join to S by lines a and b, and now establish the required correspondence between the pencils S_1 and S as follows:—To S_1T shall correspond the plane σ, to the plane α_1 the line a, and to β_1 the line b, hence to the flat pencil in α_1 the axial pencil a. These pencils are made projective by aid of the conic in α_1.

In the same manner the flat pencil in β_1 is made projective to the axial pencil b by aid of the conic in β_1, corresponding elements being those which meet on the conic. This determines the correspondence, for we know for more than four rays in S_1 the corresponding planes in S. The two pencils S and S_1 thus made reciprocal generate a quadric surface Φ', which passes through the point S and through the two conics α_1 and β_1.

The two surfaces Φ and Φ' have therefore the points S and S_1 and the conics α_1 and β_1 in common. To show that they are identical, we draw a plane through S and S_2, cutting each of the conics α_1 and β_1 in two points, which will always be possible. This plane cuts Φ and Φ' in two conics which have the point S and the points where it cuts α_1 and β_1 in common, that is five points in all. The conics therefore coincide.

This proves that all those points P on Φ' lie on Φ which have the property that the plane SS_2P cuts the conics α_1, β_1 in two points each. If the plane SS_2P has not this property, then we draw a plane SS_1P. This cuts each surface in a conic, and these conics have in common the points S, S_1, one point on each of the conics α_1, β_1, and one point on one of the conics through S and S_2 which lie on both surfaces, hence five points. They are therefore coincident, and our theorem is proved.

§ 96. The following propositions follow:—

A quadric surface has at every point a tangent plane.

Every plane section of a quadric surface is a conic or a line-pair.

Every line which has three points in common with a quadric surface lies on the surface.

Every conic which has five points in common with a quadric surface lies on the surface.

Through two conics which lie in different planes, but have two points in common, and through one external point always one quadric surface may be drawn.

§ 97. *Every plane which cuts a quadric surface in a line-pair is a tangent plane.* For every line in this plane through the centre of the line-pair (the point of intersection of the two lines) cuts the surface in two coincident points and is therefore a tangent to the surface, *the centre of the line-pair being the point of contact.*

If a quadric surface contains a line, then every plane through this line cuts the surface in a line-pair (or in two coincident lines). For this plane cannot cut the surface in a conic. Hence

If a quadric surface contains one line p *then it contains an infinite number of lines, and through every point Q on the surface, one line* q *can be drawn which cuts* p. For the plane through the point Q and the line p cuts the surface in a line-pair which must pass through Q and of which p is one line.

No two such lines q *on the surface can meet.* For as both meet p their plane would contain p and therefore cut the surface in a triangle.

Every line which cuts three lines q *will be on the surface;* for it has three points in common with it.

Hence the quadric surfaces which contain lines are the same as the ruled quadric surfaces considered in §§ 89–93, but with one important exception. In the last investigation we have left out of consideration the possibility of a plane having only one line (two coincident lines) in common with a quadric surface.

§ 98. To investigate this case we suppose first that there is one point A on the surface through which two different lines a, b can be drawn, which lie altogether on the surface.

If P is any other point on the surface which lies neither on a nor b, then the plane through P and a will cut the surface in a second line a' which passes through P and which cuts a. Similarly there is a line b' through P which cuts b. These two lines a' and b' *may* coincide, but then they must coincide with PA.

If this happens for one point P, it happens for every other point Q. For if two different lines could be drawn through Q, then by the same reasoning the line PQ would be altogether on the surface, hence two lines would be drawn through P against the assumption. From this follows:—

If there is one point on a quadric surface through which one, but only one, line can be drawn on the surface, then through every point one line can be drawn, and all these lines meet in a point. The surface is a cone of the second order.

If through one point on a quadric surface, two and only two, lines can be drawn on the surface, then through every point two lines may be drawn, and the surface is a ruled quadric surface.

If through one point on a quadric surface no line on the surface can be drawn, then the surface contains no lines.

Using the definitions at the end of § 95, we may also say:—

On a quadric surface the points are all hyperbolic, or all parabolic, or all elliptic.

As an example of a quadric surface with elliptical points, we mention the sphere which may be generated by two reciprocal pencils, where to each line in one corresponds the plane perpendicular to it in the other.

§ 99. *Poles and Polar Planes.*—The theory of poles and polars with regard to a conic is easily extended to quadric surfaces.

Let P be a point in space not on the surface, which we suppose not to be a cone. On every line through P which cuts the surface in two points we determine the harmonic conjugate Q of P with regard to the points of intersection. Through one of these lines we draw two planes α and β. The locus of the points Q in α is a line a, the polar of P with regard to the conic in which α cuts the surface. Similarly the locus of points Q in β is a line b. This cuts a, because the line of intersection of α and β contains but one point Q. The locus of all points Q therefore is a plane. *This plane is called the polar plane of the point* P, *with regard to the quadric surface. If* P *lies on the surface we take the tangent plane of* P *as its polar.*

The following propositions hold:—

1. *Every point has a polar plane,* which is constructed by drawing the polars of the point with regard to the conics in which two planes through the point cut the surface.

2. *If* Q *is a point in the polar of* P, *then* P *is a point in the polar of* Q, because this is true with regard to the conic in which a plane through PQ cuts the surface.

3. *Every plane is the polar plane of one point which is called the pole of the plane.*

The pole to a plane is found by constructing the polar planes of three points in the plane. Their intersection will be the pole.

4. *The points in which the polar plane of* P *cuts the surface are points of contact of tangents drawn from* P *to the surface,* as is easily seen. Hence:—

5. *The tangents drawn from a point* P *to a quadric surface form a cone of the second order,* for the polar plane of P cuts it in a conic.

6. *If the pole describes a line* a, *its polar plane will turn about another line* a′, as follows from 2. *These lines* a *and* a′ *are said to be conjugate with regard to the surface.*

§ 100. The pole of the line at infinity is called the *centre* of the surface. If it lies at the infinity, the plane at infinity is a tangent plane, and the surface is called a *paraboloid.*

The polar plane to any point at infinity passes through the centre, and is called a diametrical plane.

A line through the centre is called a diameter. It is bisected at the centre. The line conjugate to it lies at infinity.

If a point moves along a diameter its polar plane turns about the conjugate line at infinity; that is, *it moves parallel to itself, its centre moving on the first line.*

The middle points of parallel chords lie in a plane, viz., in the polar plane of the point at infinity through which the chords are drawn.

The centres of parallel sections lie in a diameter which is a line conjugate to the line at infinity in which the planes meet.

Twisted Cubics.

§ 101. If two pencils with centres S_1 and S_2 are made projective, then to a ray in one corresponds a ray in the other, to a plane a plane, to a flat or axial pencil a projective flat or axial pencil, and so on.

There is a double infinite number of lines in a pencil. We shall see that a single infinite number of lines in one pencil meets its corresponding ray, and that the points of intersection form a curve in space.

Of the double infinite number of planes in the pencils each will meet its corresponding plane. This gives a system of a double infinite number of lines in space. We know (§ 5) that there is a quadruple infinite number of lines in space. From among these we may select those which satisfy one or more given conditions. The systems of lines thus obtained were first systematically investigated and classified by Plücker, in his *Geometrie des Raumes.* He uses the following names:—

A *treble infinite* number of lines, that is, all lines which satisfy one condition, are said to form a *complex of lines, e.g.,* all lines cutting a given line, or all lines touching a surface.

A *double infinite* number of lines, that is, all lines which satisfy two conditions, or which are common to two complexes, are said to form a *congruence of lines; e.g.,* all lines in a plane, or all lines cutting two curves, or all lines cutting a given curve twice.

A *single infinite* number of lines, that is all lines which satisfy three conditions, or which belong to three complexes, form a *ruled surface, e.g.,* one set of lines on a ruled quadric surface, or developable surfaces which are formed by the tangents to a curve.

It follows that all lines in which corresponding planes in two projective pencils meet form a congruence. We shall see this congruence consists of all lines which cut a twisted cubic twice, or of all *secants* to a twisted cubic.

§ 102. Let l_1 be the line S_1S_2 as a line in the pencil S_1. To it corresponds a line l_2 in S_2. *At each of the centres two corresponding lines meet.* The two axial pencils with l_1 and l_2 as axes are projective, and, as their axes meet at S_2, the intersections of corresponding planes form a cone of the second order (§ 58), with S_2 as centre. If π_1 and π_2 be corresponding planes, then their intersection will be a line p_2 which passes through S_2.

Corresponding to it in S_1 will be a line p_1 which lies in the plane π_1, and which therefore meets p_2 at some point P. Conversely, if p_2 be any line in S_2 which meets its corresponding line p_1 at a point P, then to the plane l_2p_2 will correspond the plane l_1p_1, that is, the plane S_1S_2P. These planes intersect in p_2, so that p_2 is a line on the quadric cone generated by the axial pencils l_1 and l_2. Hence:—

All lines in one pencil which meet their corresponding lines in the other form a cone of the second order which has its centre at the centre of the first pencil, and passes through the centre of the second.

From this follows that the points in which corresponding rays meet lie on two cones of the second order which have the ray joining their centres in common, and form therefore, together with the line S_1S_2 or l_1, the intersection of these cones. Any plane cuts each of the cones in a conic. These two conics have necessarily that point in common in which it cuts the line l_1, and therefore besides either one or three other points. It follows that the curve is of the *third order* as a plane may cut it in three, but not in more than three points. Hence:—

The locus of points in which corresponding lines on two projective pencils meet is a curve of the third order or a "twisted cubic" k*, which passes through the centres of the pencils, and which appears as the intersection of two cones of the second order, which have one line in common.*

A line belonging to the congruence determined by the pencils is a secant of the cubic; it has two, or one, or no points in common with this cubic, and is called accordingly a secant proper, a tangent, or a secant improper of the cubic. A secant improper may be considered, to use the language of co-ordinate geometry, as a secant with imaginary points of intersection.

§ 103. If a_1 and a_2 be any two corresponding lines in the two pencils, then corresponding planes in the axial pencils having a_1 and a_2 as axes generate a ruled quadric surface. If P be any point on the cubic k, and if p_1, p_2, be the corresponding rays in S_1 and S_2 which meet at P, then to the plane a_1p_1 in S_1 corresponds a_2, p_2 in S_2. These therefore meet in a line through P.

This may be stated thus:—

Those secants of the cubic which cut a ray a_1, *drawn through the centre* S_1 *of one pencil, form a ruled quadric surface which passes through both centres, and which contains the twisted cubic* k. *Of such surfaces an infinite number exists. Every ray through* S_1 *or* S_2 *which is not a secant determines one of them.*

If, however, the rays a_1 and a_2 are secants meeting at A, then the ruled quadric surface becomes a cone of the second order, having A as centre. Or *all lines of the congruence which pass through a point on the twisted cubic* k *form a cone of the second order.* In other words, the projection of a twisted cubic from any point in the curve on to any plane is a conic.

If a_1, is not a secant, but made to pass through any point Q in space, the ruled quadric surface determined by a_1 will pass through Q. *There will therefore be one line of the congruence passing through* Q, *and only one.* For if two such lines pass through Q, then the lines S_1Q and S_2Q will be corresponding lines; hence Q will be a point on the cubic k, and an infinite number of secants will pass through it. Hence:—

Through every point in space not on the twisted cubic one and only one secant to the cubic can be drawn.

§ 104. The fact that all the secants through a point on the cubic form a quadric cone shows that the centres of the projective pencils generating the cubic are not distinguished from any other points on the cubic. If we take any two points S, S′ on the cubic, and draw the secants through each of them we obtain two quadric cones, which have the line SS′ in common, and which intersect besides along the cubic. If we make these two pencils having S and S′ as centres projective by taking four rays on the one cone as corresponding to the four rays on the other which meet the first on the cubic, the correspondence is determined. These two pencils will generate a cubic, and the two cones of secants having S and S′ as centres will be identical with the above cones, for each has five rays in common with one of the first, viz., the line SS′ and the four lines determined for the correspondence; therefore these two cones intersect in the original cubic. This gives the theorem:—

On a twisted cubic any two points may be taken as centres of projective pencils which generate the cubic, corresponding planes being those which meet on the same secant.

Of the two projective pencils at S and S′ we may keep the first fixed, and move the centre of the other along the curve. The pencils will hereby remain projective, and a plane α in S will be cut by its corresponding plane α' always in the same secant a. Whilst S′ moves along the curve the plane α' will turn about a, describing an axial pencil.

In this article we have given a purely geometrical theory of conics, cones of the second order, quadric surfaces, etc. In doing so we have followed, to a great extent, Reye's *Geometrie der Lage*, and to this excellent work those readers are referred who wish for a more exhaustive treatment of the subject.

It will have been observed that scarcely any use has been made of algebra, and it would have been even possible to avoid this little, as is done by Reye. There are, however, other systems of geometry which start more or less from theorems known to the Greeks, and using more or less algebra.

We cannot do more here than enumerate a few of the more prominent works on the subject, which, however, are almost all Continental. These are the following:—

Monge, *Géométrie Descriptive;* Carnot, *Géométrie de Position* (1803), containing a theory of transversals; Poncelet's great work, *Traité des Propriétés Projectives des Figures* (1822); Möbins, *Barycentrischer Calcul* (1826); Steiner, *Abhängigkeit Geometrischer Gestalten* (1832), containing the first full discussion of the projective relations between rows, pencils, etc.; Von Staudt, *Geometrie der Lage* (1847) and *Beiträge zur Geometrie der Lage* (1856–60), in which a system of geometry is built up from the beginning without any reference to number, so that ultimately a number itself gets a geometrical definition, and in which imaginary elements are systematically introduced into pure geometry; Chasles, *Aperçu Historique* (1837), in which the author gives a brilliant account of the progress of modern geometrical methods, pointing out the advantages of the different purely geometrical methods as compared with the analytical ones, but without taking as much account of the German as of the French authors; Id., *Rapport sur les Progrès de la Géométrie* (1870), a continuation of the *Aperçu;* Id., *Traité de Géométrie Supérieure* (1852); Cremona, *Introduzione ad una Teoria Geometrica della Curve Piane* (1862) and its continuation *Preliminari di una Teoria Geometrica delle Superficie*, which at present are most easily procurable in their German translations by Curtze. As more elementary books, we mention Steiner, *Vorlesungen über Synthetische Geometrie*, edited by Geiser and Schröder (1867); Cremona, *Éléments de Géométrie Projective* (1875), translated from the Italian by Dewulf; Townsend, *Modern Geometry of the Point, Line, and Circle* (1863), which contains a variety of modern methods, but, unfortunately, is confined to circles, without entering into conics. A great many of the propositions are, however, easily extended to conics. (O. H.)

PART II.—ANALYTICAL GEOMETRY.

This will be here treated as a method. The science is Geometry; and it would be possible, analytically, or by the method of co-ordinates, to develop the truths of geometry in a systematic course. But it is proposed not in any way to attempt this, but simply to explain the method, giving such examples, interesting (it may be) in themselves, as are suitable for showing how the method is employed in the demonstration and solution of theorems or problems.

Geometry is one-, two-, or three-dimensional, or, what is the same thing, it is lineal, plane, or solid, according as the space dealt with is the line, the plane, or ordinary (three-dimensional) space. No more general view of the subject need here be taken:—but in a certain sense one-dimensional geometry does not exist, inasmuch as the geometrical constructions for points in a line can only be performed by travelling out of the line into other parts of a plane which contains it, and conformably to the usual practice Analytical Geometry will be treated under the two divisions, Plane and Solid.

It is proposed to consider Cartesian co-ordinates almost exclusively; for the proper development of the science homogeneous co-ordinates (three and four in plane and solid geometry respectively) are required; and it is moreover necessary to have the correlative line- and plane-co-ordinates; and in solid geometry to have the *six* co-ordinates of the line. The most comprehensive English works are those of Dr. Salmon, *The Conics* (5th edition, 1869), *Higher Plane Curves* (2d edition, 1873), and *Geometry of Three Dimensions* (3d edition, 1874); we have also on plane geometry Clebsch's *Vorlesungen über Geometrie*, posthumous, edited by Dr. F. Lindemann, Leipsic, 1875, not yet complete.

1. PLANE ANALYTICAL GEOMETRY (§§ 1–25).

1. It is assumed that the points, lines, and figures considered exist in one and the same plane, which plane, therefore, need not be in any way referred to. The position of a point is determined by means of its (Cartesian) co-ordinates; *i.e.*, as explained under the article CURVE, we take the two lines $x'Ox$ and $y'Oy$, called the axes of x and y respectively, intersecting in a point O called the origin, and determine the position of any other point P by means of its co-ordinates $x = \text{OM}$ (or NP), and $y = \text{MP}$ (or ON). The two axes are usually (as in fig. 1) at right angles to each other, and the lines PM, PN are then at right angles to the axes of x and y respectively. Assuming a scale

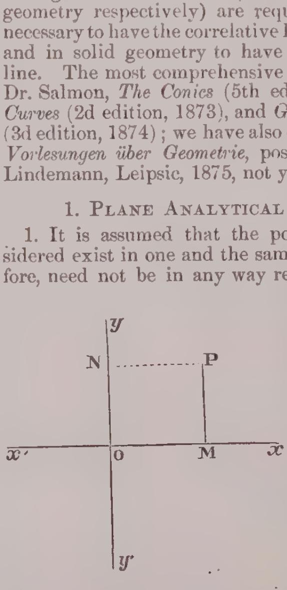


FIG. 1.

at pleasure, the co-ordinates x, y of a point have numerical values.

It is necessary to attend to the signs: x has opposite signs according as the point is on one side or the other of the axis of y, and similarly y has opposite signs according as the point is on the one side or the other of the axis of x. Using the letters N, E, S, W as in a map, and considering the plane as divided into four quadrants by the axes, the signs are usually taken to be—

x	y	for quadt.
+	+	N E
+	−	S E
−	+	N W
−	−	S W

A point is said to have the co-ordinates (a, b), and is referred to as the point (a, b), when its co-ordinates are $x=a$, $y=b$; the co-ordinates x, y of a variable point, or of a point which is for the time being regarded as variable, are said to be current co-ordinates.

2. It is sometimes convenient to use oblique co-ordinates; the only difference is that the axes are not at right angles to each other; the lines PM, PN are drawn parallel to the axes of y and x respectively, and the figure OMPN is thus a parallelogram. But in all that follows the Cartesian co-ordinates are taken to be rectangular; polar co-ordinates and other systems will be briefly referred to in the sequel.

3. If the co-ordinates (x, y) of a point are not given, but only a relation between them $f(x, y)=0$, then we have a curve. For if we consider x as a real quantity varying continuously from $-\infty$ to $+\infty$, then, for any given value of x, y has a value or values. If these are all imaginary, there is not any real point; but if one or more of them be real, we have a real point or points, which (as the assumed value of x varies continuously) varies or vary continuously therewith; and the locus of all these real points is a curve. The equation completely defines the curve; to trace the curve directly from the equation, nothing else being known, we obtain as above a series of points sufficiently near to each other, and draw the curve through them. For instance, let this be done in a simple case. Suppose $y=2x-1$; it is quite easy to obtain and lay down a series of points as near to each other as we please, and the application of a ruler would show that these were in a line; that the curve is a line depends upon something more than the equation itself, viz., the theorem that every equation of the form $y=ax+b$ represents a line; supposing this known, it will be at once understood how the process of tracing the curve may be abbreviated; we have $x=0$, $y=-1$, and $x=\frac{1}{2}$, $y=0$; the curve is thus the line passing through these two points. But in the foregoing example the notion of a line is taken to be a known one, and such notion of a line does in fact precede the consideration of any equation of a curve whatever, since the notion of the co-ordinates themselves rests upon that of a line. In other cases it may very well be that the equation is the definition of the curve; the points laid down, although (as finite in number) they do not actually determine the curve, determine it to any degree of accuracy; and the equation thus enables us to construct the curve.

A curve may be determined in another way; viz., the co-ordinates x, y may be given each of them as a function of the same variable parameter θ; $x, y=f(\theta), \phi(\theta)$ respectively. Here, giving to θ any number of values in succession, these equations determine the values of x, y, that is, the positions of a series of points on the curve. The ordinary form $y=\phi(x)$, where y is given explicitly as a function of x, is a particular case of each of the other two forms: we have $f(x, y), =y-\phi(x), =0$; and $x=\theta$, $y=\phi(\theta)$.

4. As remarked under CURVE, it is a useful exercise to trace a considerable number of curves, first taking equations which are purely numerical, and then equations which contain literal constants (representing numbers); the equations most easily dealt with are those wherein one co-ordinate is given as an explicit function of the other, say $y=\phi(x)$ as above. A few examples are here given, with such explanations as seem proper.

(1.) $y=2x-1$, as before; it is at once seen that this is a line; and taking it to be so, any two points, for instance, $(0, -1)$ and $(\frac{1}{2}, 0)$ determine the line.

(2.) $y=x^2$. The equation shows that x may be positive or negative, but that y is always positive, and has the same values for equal positive and negative values of x: the curve passes through the origin, and through the points, $(\pm 1, 1)$. It is already known that the curve lies wholly above the axis of x. To find its form in the neighborhood of the origin, give x a small value, $x=\pm 0{\cdot}1$ or $\pm 0{\cdot}01$, then y is very much smaller, $=0{\cdot}01$ and $0{\cdot}0001$ in the two cases respectively; this shows that the curve touches the axis of x at the origin. Moreover, x may be as large as we please, but when it is large, y is much larger; for instance, $x=10$, $y=100$. The curve is a parabola (fig. 2).

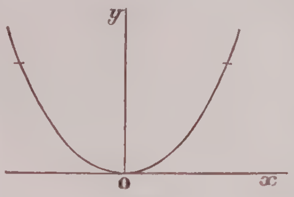


FIG. 2.

(3.) $y=x^3$. Here x being positive y is positive, but x being negative y is also negative: the curve passes through the origin, and also through the points $(1, 1)$ and $(-1, -1)$. Moreover, when x is small, $=0{\cdot}1$ for example, then not only is y, $=0{\cdot}001$, very much smaller than x, but it is also very much smaller than y was for the last-mentioned curve $y=x^2$, that is, in the neighborhood of the origin the present curve approaches more closely the axis of x. The axis of x is a tangent at the origin, but it is a tangent of a peculiar kind (a stationary or inflexional tangent), cutting the curve at the origin, which is an inflexion. The curve is the cubical parabola (fig. 3).

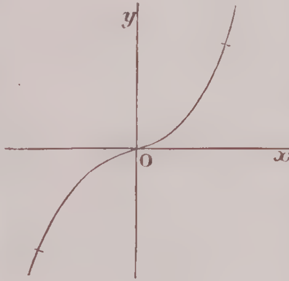


FIG. 3.

(4.) $y^2=x-1.x-3.x-4$. Here $y=0$ for $x=1, =3, =4$. Whenever $x-1.x-3.x-4$ is positive, y has two equal and opposite values; but when $x-1.x-3.x-4$, is negative, then y is imaginary. In particular, for x less than 1, or between 3 and 4, y is imaginary, but for x between 1 and 3, or greater than 4, y has two values. It is clear that for x somewhere between 1 and 3, y will attain a maximum, the values of x and y may be found approximately by trial. The curve will consist of an oval and infinite branch, and it is easy to see that, as shown in fig. 4, the curve where it cuts the axis of x cuts it at right angles. It may be further remarked that, as x increases from 4, the value of y will increase more and more rapidly; for instance, $x=5$, $y^2=8$, $x=10$, $y^2=378$, etc., and it is easy to see that this implies that the curve has on the infinite branch two inflexions as shown.

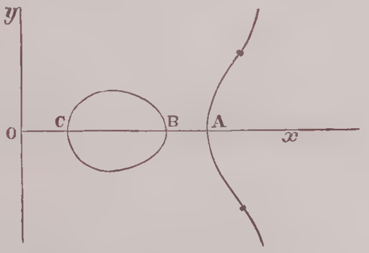


FIG. 4.

(5.) $y^2=x-c.x-b.x-a$, where $a>b>c$ (that is, a nearer to $+\infty$, c to $-\infty$). The curve has the same general form as in the last figure, the oval extending between the limits $x=c$, $x=b$, the infinite branch commencing at the point $x=a$.

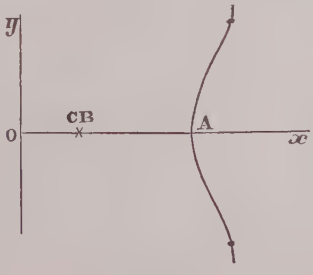


FIG. 5.

(6.) $y^2=(x-c)^2(x-a)$. Suppose that in the last-mentioned curve, $y^2=x-c.x-b.x-a$, b gradually diminishes, and becomes ultimately $=c$. The infinite branch (see fig. 5) changes its form, but not in a very marked manner, and it retains the two inflexions. The oval lies always between the values $x = c$, $x = b$, and therefore its length continually diminishes; it is easy to see that its breadth will also continually diminish; ultimately it shrinks up into a mere point. The curve has thus a conjugate or isolated point, or acnode. For a direct verification observe that $x = c$, $y = 0$, so that $(c, 0)$ is a point of the curve, but if x is either less than c, or between c and a, y^2 is negative, and y is imaginary.

(7.) $y^2 = (x - c)(x - a)^2$. If in the same curve b gradually increases and becomes ultimately $= a$, the oval and the infinite branch change each of them its form, the oval extending always between the values $x = c$, $x = b$, and thus continually approaching the infinite branch, which begins at $x = a$. The consideration of a few numerical examples, *with careful drawing*, would show that the oval and the infinite branch as they approach sharpen out each towards the other (the two inflexions on the infinite branch coming always nearer to the point $(a, 0)$),—so that finally, when b becomes $= a$, the curve has the form shown in fig. 6, there being now a double point or node (crunode) at A, and the inflexions on the infinite branch having disappeared.

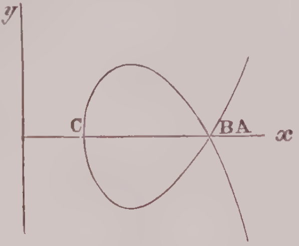


FIG. 6.

In the last four examples the curve is one of the cubical curves called the divergent parabolas: 4 is a mere numerical example of 5, and 6, 7, 8 are in Newton's language the parabola *cum ovali*, *punctata*, and *nodata* respectively. When a, b, c are all equal, or the form is $y^2 = (x - c)^3$, we have a cuspidal form, Newton's parabola *cuspidata*, otherwise the semicubical parabola.

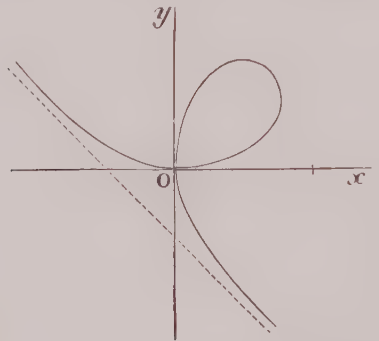


FIG. 7.

(8.) As an example of a curve given by an implicit equation, suppose the equation is

$$x^3 + y^3 - 3xy = 0\,;$$

this is a nodal cubic curve, the node at the origin, and the axes touching the two branches respectively (fig. 7). An easy mode of tracing it is to express x, y each of them in terms of a variable θ, $x = \frac{3\theta}{1+\theta^3}$, $y = \frac{3\theta^2}{1+\theta^3}$; but it is instructive to trace the curve directly from its equation.

5. It may be remarked that the purely algebraical process, which is in fact that employed in finding a differential coefficient $\frac{dy}{dx}$, if applied directly to the equation of the curve, determines the point consecutive to any given point of the curve, that is, the direction of the curve at such given point, or, what is the same thing, the direction of the tangent at that point. In fact, if α, β are the co-ordinates of any point on a curve $f(x, y) = 0$, then writing in the equation of the curve $x = \alpha + h$, $y = \beta + k$, and in the resulting equation $f(\alpha + h, \beta + k) = 0$ (developed in powers of h and k), omitting the term $f(\alpha, \beta)$, which vanishes, and the terms containing the second and higher powers of h, k, we have a linear equation $Ah + Bk = 0$, which determines the ratio of the increments h, k. Of course, in the analytical development of the theory, we translate this into the notation of the differential calculus; but the question presents itself, and is thus seen to be solvable, as soon as it is attempted to trace a curve from its equation.

Geometry is Descriptive, or Metrical.

6. A geometrical proposition is either *descriptive* or *metrical:* in the former case it is altogether independent of the idea of magnitude (length, inclination, etc.); in the latter case it has reference to this idea. It is to be noticed that, although the method of co-ordinates seems to be by its inception essentially metrical, and we can hardly, except by metrical considerations, connect an equation with the curve which it represents (for instance, even assuming it to be known that an equation $Ax + By + C = 0$ represents a line, yet if it be asked what line, the only form of answer is, that it is the line cutting the axes at *distances* from the origin $-C \div A$, $-C \div B$ respectively), yet in dealing by this method with descriptive propositions, we are, in fact, eminently free from all metrical considerations.

7. It is worth while to illustrate this by the instance of the well-known theorem of the radical centre of three circles. The theorem is that, given any three circles, A, B, C (fig. 8), the common chords $\alpha\alpha'$, $\beta\beta'$, $\gamma\gamma'$ of the three pairs of circles meet in a point.

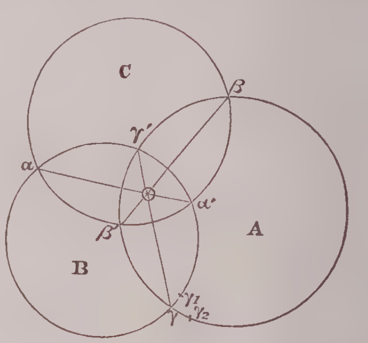


FIG. 8.

The geometrical proof is metrical throughout:—

Take O the point of intersection of $\alpha\alpha'$, $\beta\beta'$, and joining this with γ', suppose that $\gamma'O$ does not pass through γ, but that it meets the circles A, B in two distinct points γ_1, γ_2, respectively. We have then the known metrical property of intersecting chords of a circle; viz., in circle C where $\alpha\alpha'$, $\beta\beta'$ are chords meeting at a point O,

$$O\alpha . O\alpha' = O\beta . O\beta',$$

where, as well as in what immediate follows, $O\alpha$, etc., denote, of course, *lengths* or *distances*.

Similarly in circle A,

$$O\beta . O\beta' = O\gamma_1 . O\gamma',$$

and in circle B,

$$O\alpha . O\alpha' = O\gamma_2 . O\gamma'.$$

Consequently $O\gamma_1 . O\gamma' = O\gamma_2 . O\gamma'$, that is, $O\gamma_1 = O\gamma_2$, or the points γ_1 and γ_2 coincide; that is, they each coincide with γ.

We contrast this with the analytical method:—

Here it only requires to be known that an equation $Ax + By + C = 0$ represents a line, and an equation $x^2 + y^2 + Ax + By + C = 0$ represents a circle. A, B, C have, in the two cases respectively, metrical significations; but these we are not concerned with. Using S to denote the function $x^2 + y^2 + Ax + By + C$, the equation of a circle is $S = 0$, where S stands for its value; more briefly, we say the equation is $S, = x^2 + y^2 + Ax + By + C, = 0$. Let the equation of any other circle be $S', = x^2 + y^2 + A'x + B'y + C' = 0$; the equation $S - S' = 0$ is a linear equation ($S - S'$ is in fact $= (A - A')x + (B - B')y + C - C'$), and it thus represents a line; this equation is satisfied by the co-ordinates of each of the points of intersection of the two circles (for at each of these points $S = 0$ and $S' = 0$, therefore also $S - S' = 0$); hence the equation $S - S' = 0$ is that of the line joining the two points of intersection of the two circles, or say it is the equation of the common chord of the two circles. Considering then a third circle $S'', = x^2 + y^2 + A''x + B''y + C'' = 0$, the equations of the common chords are $S - S' = 0$, $S - S'' = 0$, $S' - S'' = 0$ (each of these a linear equation); at the intersection of the first and second of these lines $S = S'$ and $S = S''$, therefore also $S' = S''$, or the equation of the third line is satisfied by the co-ordinates of the point in question; that is, the three chords intersect in a point O, the co-ordinates of which are determined by the equations $S = S' = S''$.

It further appears that if the two circles $S = 0$, $S = 0'$ do not intersect in any real points, they must be regarded as intersecting in two imaginary points, such that the line joining them is the real line represented by the equation

$S-S'=0$; or that two circles, whether their intersections be real or imaginary, have always a real common chord (or radical axis), and that for *any* three circles the common chords intersect in a point (of course real) which is the radical centre. And by this very theorem, given two circles with imaginary intersections, we can, by drawing circles which meet each of them in real points, construct the radical axis of the first-mentioned two circles.

8. The principle employed in showing that the equation of the common chord of two circles is $S-S'=0$ is one of very extensive application, and some more illustrations of it may be given.

Suppose $S=0$, $S'=0$ are lines (that is, let S, S′ now denote linear functions $Ax+By+C$, $A'x+B'y+C'$), then $S-kS'=0$ (k an arbitrary constant) is the equation of *any* line passing through the point of intersection of the two given lines. Such a line may be made to pass through any given point, say the point (x_0, y_0); *i. e.*, if S_0, S'_0 are what S, S′ respectively become on writing for (x, y) the values (x_0, y_0), then the value of k is $k=S_0\div S'_0$. The equation in fact is $SS'_0-S_0S'=0$; and starting from this equation we at once verify it *a posteriori;* the equation is a linear equation satisfied by the values of (x, y) which make $S=0$, $S'=0$; and satisfied also by the values (x_0, y_0); and it is thus the equation of the line in question.

If, as before, $S=0$, $S'=0$ represent circles, then (k being arbitrary) $S-k\,S'=0$ is the equation of any circle passing through the two points of intersection of the two circles; and to make this pass through a given point (x_0, y_0) we have again $k=S_0\div S'_0$. In the particular case $k=1$, the circle becomes the common chord (more accurately, it becomes the common chord together with the line infinity, but this is a question which is not here gone into).

If S denote the general quadric function,

$$S=ax^2+2hxy+by^2+2fy+2gx+c,=(a, b, c, f, g, h)(x, y, 1)^2,$$

then the equation $S=0$ represents a conic; assuming this, then, if $S'=0$ represents another conic, the equation $S-kS'=0$ represents *any* conic through the four points of intersection of the two conics.

Returning to the equation $Ax+By+C=0$ of a line, if this pass through two given points (x_1, y_1), (x_2, y_2), then we must have $Ax_1+By_1+C=0$, $Ax_2+By_2+C=0$, equations which determine the ratios $A:B:C$, and it thus appears that the equation of the line through the two given points is

$$x(y_1-y_2)-y(x_1-x_2)+x_1y_2-x_2y_1=0;$$

or what is the same thing—

$$\begin{vmatrix} x, & y, & 1 \\ x_1, & y_1, & 1 \\ x_2, & y_2, & 1 \end{vmatrix}=0;$$

9. The object still being to illustrate the mode of working with co-ordinates, we consider the theorem of the polar of a point in regard to a circle. Given a circle and a point O (fig. 9), we draw through O any two lines meeting the circle in the points A, A′ and B, B′ respectively, and then taking Q as the intersection of the lines AB′ and A′B, the theorem is, that the locus of the point Q is a right line depending only upon O and the circle, but independent of the particular lines OAA′ and OBB′.

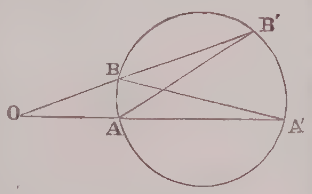


FIG. 9.

Taking O as the origin, and for the axes any two lines through O at right angles to each other, the equation of the circle will be

$$x^2+y^2+2Ax+2By+C=0;$$

and if the equation of the line OAA′ is taken to be $y=mx$, then the points A, A′ are found as the intersections of the straight line with the circle; or to determine x we have

$$x^2(1+m^2)+2x(A+Bm)+C=0.$$

If (x_1, y_1) are the co-ordinates of A, and (x_2, y_2) of A′, then the roots of this equation are x_1, x_2, whence easily

$$\frac{1}{x_1}+\frac{1}{x_2}=-2\frac{A+Bm}{C}\cdot$$

And similarly, if the equation of the line OBB′ is taken to be $y=m'x$, and the co-ordinates of B, B′ to be (x_3, y_3) and (x_4, y_4) respectively, then

$$\frac{1}{x_3}+\frac{1}{x_4}=-2\frac{A+Bm'}{C'}\cdot$$

We have then

$$x(y_1-y_4)-y(x_1-x_4)+x_1y_4-x_4y_1=0,$$
$$x(y_2-y_3)-y(x_2-x_3)+x_2y_3-x_3y_4=0,$$

as the equations of the lines AB′ and A′B respectively; for the first of these equations, being satisfied if we write therein (x_1, y_1) or (x_4, y_4) for (x, y), is the equation of the line AB′, and similarly the second equation is that of the line A′B. Reducing by means of the relations $y_1-mx_1=0$, $y_2-mx_2=0$, $y_3-m'x_3=0$, $y_4-m'x_4=0$, the two equations become

$$x(mx_1-m'x_4)-y(x_1-x_4)+(m'-m)\,x_1x_4=0,$$
$$x(mx_2-m'x_3)-y(x_2-x_3)+(m'-m)\,x_2x_3=0,$$

and if we divide the first of these equations by m_1m_4, and the second by m_2m_3, and then add, we obtain

$$x\left\{m\left(\frac{1}{x_3}+\frac{1}{x_4}\right)-m'\left(\frac{1}{x_1}+\frac{1}{x_2}\right)\right\}-y\left\{\frac{1}{x_3}+\frac{1}{x_4}-\left(\frac{1}{x_1}+\frac{1}{x_2}\right)\right\}$$
$$+2m'-2m=0,$$

or, what is the same thing,

$$\left(\frac{1}{x_1}+\frac{1}{x_2}\right)(y-m'x)-\left(\frac{1}{x_3}+\frac{1}{x_4}\right)(y-mx)+2m'-2m=0,$$

which by what precedes is the equation of a line through the point Q. Substituting herein for $\frac{1}{x_1}+\frac{1}{x_2}$, $\frac{1}{x_3}+\frac{1}{x_4}$ their foregoing values, the equation becomes

$$-(A+Bm)(y-m'x)+(A+Bm')(y-mx)+m'-m=0;$$

that is,

$$(m-m')(Ax+By+C)=0;$$

or finally it is $Ax+By+C=0$, showing that the point Q lies in a line the position of which is independent of the particular lines OAA′, OBB′ used in the construction. It is proper to notice that there is no correspondence to each other of the points A, A′ and B, B′; the grouping might as well have been A, A′ and B′, B; and it thence appears that the line $Ax+By+C=0$ just obtained is in fact the line joining the point Q with the point R which is the intersection of AB and A′B′.

10. The equation $Ax+By+C=0$ of a line contains in appearance 3, but really only 2 constants (for one of the constants can be divided out), and a line depends accordingly upon 2 parameters, or can be made to satisfy 2 conditions. Similarly, the equation $(a, b, c, f, g, h\between x, y, 1)^2=0$ of a conic contains really 5 constants, and the equation $(*)(x, y, 1)^3=0$ of a cubic contains really 9 constants. It thus appears that a cubic can be made to pass through 9 given points, and that the cubic so passing through 9 given points is completely determined. There is, however, a remarkable exception. Considering two given cubic curves $S=0$, $S'=0$, these intersect in 9 points, and through these 9 points we have the whole series of cubics $S-kS'=0$, where k is an arbitrary constant: k may be determined so that the cubic shall pass through a given tenth point ($k=S_0\div S'_0$, if the co-ordinates are (x_0, y_0), and S_0, S'_0 denote the corresponding values of S, S′). The resulting curve $SS'_0-S'S_0=0$ may be regarded as the cubic determined by the conditions of passing through 8 of the 9 points and through the given point (x_0, y_0); and from the equation it thence appears that the curve passes through the remaining one of the 9 points. In other words, we thus have the theorem, any cubic curve which passes through 8 of the 9 intersections of two given cubic curves passes through the 9th intersection.

The applications of this theorem are very numerous; for instance, we derive from it Pascal's theorem of the inscribed hexagon. Consider a hexagon inscribed in a conic. The three alternate sides constitute a cubic, and the other three alternate sides another cubic. The cubics intersect in 9 points, being the 6 vertices of the hexagon, and the 3 Pascalian points, or intersections of the pairs of opposite sides of the hexagon. Drawing a line through two of the Pascalian points, the conic and this line constitute a cubic passing through 8 of the 9 points of intersection, and it therefore passes through the remaining point of intersection—that is, the third Pascalian point; and since obviously this does not lie on the conic, it must lie on the line—that is, we have the theorem that the three Pascalian points (or points of intersection of the pairs of opposite sides) lie on a line.

Metrical Theory.

11. The foundation of the metrical theory consists in the simple theorem that if a finite line PQ (fig. 10) be projected upon any other line OO′ by lines perpendicular to OO′,

then the length of the projection P′Q′ is equal to the length of PQ into the cosine of its inclination to P′Q′; or, what is the same thing, that the perpendicular distance P′Q′ of any two parallel lines is equal to the inclined distance PQ into the cosine of the inclination. It at once follows that the algebraical sum of the projections of the sides of a closed polygon upon any line is $=0$; or, reversing the signs of certain sides, and considering the polygon as consisting of two broken lines, each extending from the same initial to the same terminal point, the sum of the projections of the lines of the first set upon any line is equal to the sum of the projections of the lines of the second set. Observe that if any line be perpendicular to the line on which the projection is made, then its projection is $=0$.

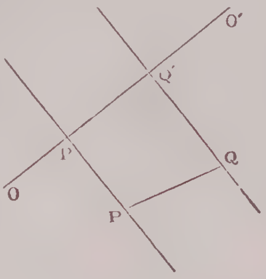


Fig. 10.

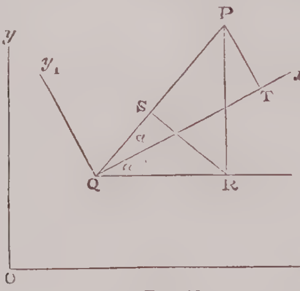


Fig. 11.

Thus, if we have a right-angled triangle PQR (fig. 11), where QR, RP, QP are $=\xi, \eta, \rho$ respectively, and whereof the base-angle is $=\alpha$, then projecting successively on the three sides, we have

$$\xi=\rho\cos\alpha,\ \eta=\rho\sin\alpha,\ \rho=\xi\cos\alpha+\eta\sin\alpha;$$

and we thence obtain

$$\rho^2=\xi^2+\eta^2;\ \cos^2\alpha+\sin^2\alpha=1.$$

And again, by projecting on a line Qx_1, inclined at the angle α' to QR, we have

$$\rho\cos(\alpha-\alpha')=\xi\cos\alpha'+\eta\sin\alpha';$$

and by substituting for ξ, η their foregoing values,

$$\cos(\alpha-\alpha')=\cos\alpha\cos\alpha'+\sin\alpha\sin\alpha'.$$

It is to be remarked that, assuming only the theory of similar triangles, we have herein a *proof* of Euclid, Book I., Prop. 47; in fact, the same as is given Book VI., Prop. 31; and also a *proof* of the trigonometrical formula for $\cos(\alpha-\alpha')$. The formulæ for $\cos(\alpha+\alpha')$ and $\sin(\alpha\pm\alpha')$ could be obtained in the same manner.

Draw PT at right angles to Qx_1, and suppose QT, TP $=\xi_1, \eta_1$ respectively, so that we have now the quadrilateral QRPTQ, or, what is the same thing, the two broken lines QRP and QTP, each extending from Q to P. Projecting on the four sides successively, we have

$$\begin{aligned}\xi &= \xi_1\cos\alpha'-\eta_1\sin\alpha',\\ \eta &= \xi_1\sin\alpha'+\eta_1\cos\alpha',\\ \xi_1 &= \xi\cos\alpha'+\eta\sin\alpha',\\ \eta_1 &= -\xi\sin\alpha'+\eta\cos\alpha',\end{aligned}$$

where the third equation is that previously written

$$\rho\cos(\alpha-\alpha')=\xi\cos\alpha+\eta\sin\alpha.$$

Equations of Right Line and Circle.—Transformation of Co-ordinates.

12. The required formulæ are really contained in the foregoing results. For, in fig. 11, supposing that the axis of x is parallel to QR, and taking a, b for the co-ordinates of Q, and (x, y) for those of P, then we have $\xi, \eta=x-a, y-b$ respectively; and therefore

$$\begin{aligned}x-a&=\rho\cos\alpha,\quad y-b=\rho\sin\alpha,\\ \rho^2&=(x-a)^2+(y-b)^2.\end{aligned}$$

Writing the first two of these in the form

$$\frac{x-a}{\cos\alpha}=\frac{y-b}{\sin\alpha}(=\rho),$$

we may regard Q as a fixed point, but P as a point moving in the direction Q to P, so that α remains constant, and then, omitting the equation $(=\rho)$, we have a relation between the co-ordinates x, y of the point P thus moving in a right line,—that is, we have the equation of the line through the given point (a, b) at a given inclination α to the axis of x. And, moreover, if, using this equation $(=\rho)$, we write $x=a+\rho\cos\alpha$, $y=b+\rho\sin\alpha$, then we have expressions for the co-ordinates x, y of a point of this line, in terms of the variable parameter ρ.

Again, take the point T to be fixed, but consider the point P as moving in the line TP at right angles to QT. If instead of ξ_1 we take p for the distance QT, then the equation $\xi_1=\xi\cos\alpha'+\eta\sin\alpha'$ will be

$$(x-a)\cos\alpha'+(y-b)\sin\alpha'=p;$$

that is, this will be the equation of a line such that its perpendicular distance from the point (a, b) is $=p$, and that the inclination of this distance to the axis of x is $=\alpha'$.

From either form it appears that the equation of a line is, in fact, a linear equation of the form $Ax+By+C=0$. It is important to notice that, starting from this equation, we can determine conversely the α but not the (a, b) of the form of equation which contains these quantities; and in like manner the α' but not the (a, b) or p of the other form of equation. The reason is obvious. In each case (a, b) denote the co-ordinates of a point, fixed indeed, but which is in the first form any point of the line, and in the second form any point whatever. Thus, in the second form the point from which the perpendicular is let fall may be the origin. Here $(a, b)=(0, 0)$, and the equation is $x\cos\alpha'+y\sin\alpha'-p=0$. Comparing this with $Ax+By+C=0$, we have the values of $\cos\alpha'$, $\sin\alpha'$, and p.

13. The equation

$$\rho^2=(x-a)^2+(y-b)^2$$

is an expression for the squared distance of the two points (a, b) and (x, y). Taking as before the point Q, co-ordinates (a, b), as a fixed point, and writing c in the place of ρ, the equation

$$(x-a)^2+(y-b)^2=c^2$$

expresses that the point (x, y) is always at a given distance c from the given point (a, b); viz., this is the equation of a circle, having (a, b) for the co-ordinates of its centre and c for its radius.

The equation is of the form

$$x^2+y^2+2Ax+2By+C=0,$$

and here, the number of constants being the same, we can identify the two equations; we find $a=-A$, $b=-B$, $c^2=A^2+B^2-C$, or the last equation is that of a circle having $-A$, $-B$ for the co-ordinates of its centre, and $\sqrt{A^2+B^2-C}$ for its radius.

14. Drawing (fig. 11) Qy_1 at right angles at Qx_1, and taking Qx_1, Qy_1 as a new set of rectangular axes, if instead of ξ_1, η_1 we write x_1, y_1, we have x_1, y_1 as the new co-ordinates of the point P; and writing also α in place of α' (α now denoting the inclination of the axes Qx_1 and Ox), we have the formulæ for transformation between two sets of rectangular axes. These are

$$\begin{aligned}x-a&=x_1\cos\alpha-y_1\sin\alpha,\\ y-b&=x_1\sin\alpha+y_1\cos\alpha,\end{aligned}$$

and

$$\begin{aligned}x_1&=(x-a)\cos\alpha+(y-b)\sin\alpha,\\ y_1&=-(x-a)\sin\alpha+(y-b)\cos\alpha,\end{aligned}$$

each set being obviously at once deducible from the other one. In these formulæ (a, b) are the xy-co-ordinates of the new origin Q_1, and α is the inclination of Qx_1 to Ox. It is to be noticed that Qx_1, Qy_1 are so placed that, by moving O to Q, and then turning the axes Ox_1, Oy_1 round Q (through an angle α measured in the sense Ox to Oy), the original axes Ox, Oy will come to coincide with Qx_1, Qy_1 respectively. This could not have been done if Qy_1 had been drawn (at right angles always to Qx_1) in the reverse direction, we should then have had in the formulæ $-y_1$ instead of y_1. The new formulæ which would be thus obtained are of an essentially distinct form: the analytical test is that in the formulæ as written down we can, by giving to α a proper value (in fact $\alpha=0$), make the $(x-a)$ and $(y-b)$ equal to x_1 and y_1 respectively; in the other system we could only make them equal to $x_1, -y_1$, or $-x_1, y_1$, respectively. But for the very reason that the second system can be so easily derived from the first, it is proper to attend exclusively to the first system,—that is, always to take the new axes so that the two sets admit of being brought into coincidence.

In the foregoing system of two pairs of equations, the first pair give the original co-ordinates x, y in terms of the new co-ordinates x_1, y_1; the second pair the new co-ordinates x_1, y_1 in terms of the original co-ordinates x, y. The formulæ involve (a, b), the original co-ordinates of the new origin; it would be easy instead of these to introduce (a_1, b_1), the new co-ordinates of the origin. Writing $(a, b) = (0, 0)$, we have, of course, the formulæ for transformation between two sets of rectangular axes *having the same origin*, and it is as well to write the formulæ in this more simple form; the subsequent transformation to a new origin, but with axes parallel to the original axes, can then be effected without any difficulty.

15. All questions in regard to the line may be solved by means of one or other of the foregoing forms—

$$\mathrm{A}x + \mathrm{B}y + \mathrm{C} = 0,$$
$$y = \mathrm{A}x + \mathrm{B},$$
$$\frac{x-a}{\cos\alpha} = \frac{y-b}{\sin\alpha},$$
$$(x-a)\cos\alpha' + (y-b)\sin\alpha' - p = 0;$$

or it may be by a comparison of these different forms: thus, using the first form, it has been already shown that the equation of the line through two given points (x_1, y_1), (x_2, y_2) is

$$x(y_1 - y_2) - y(x_1 - x_2) + x_1y_2 - x_2y_1 = 0,$$

or, as this may be written,

$$y - y_1 = \frac{y_2 - y_1}{x_2 - x_1}(x - x_1).$$

A particular case is the equation

$$\frac{x}{a} + \frac{y}{b} = 1,$$

representing the line through the points $(a, 0)$ and $(0, b)$, or, what is the same thing, the line meeting the axes of x and y at the distances from the origin a and b respectively. It may be noticed that, in the form $\mathrm{A}x + \mathrm{B}y + \mathrm{C} = 0$, $-\frac{\mathrm{A}}{\mathrm{B}}$ denotes the tangent of the inclination to the axis of x, or we may say that $\mathrm{B} \div \sqrt{\mathrm{A}^2+\mathrm{B}^2}$ and $-\mathrm{A} \div \sqrt{\mathrm{A}^2+\mathrm{B}^2}$ denote respectively the cosine and the sine of the inclination to the axis of x. A better form is this: $\mathrm{A} \div \sqrt{\mathrm{A}^2+\mathrm{B}^2}$ and $\mathrm{B} \div \sqrt{\mathrm{A}^2+\mathrm{B}^2}$ denote respectively the cosine and the sine of inclination to the axis of x of the perpendicular upon the line. So of course, in regard to the form $y = \mathrm{A}x + \mathrm{B}$, A is here the tangent of the inclination to the axis of x; $1 \div \sqrt{\mathrm{A}^2+1}$ and $\mathrm{A} \div \sqrt{\mathrm{A}^2+1}$ are the cosine and sine of this inclination, etc. It thus appears that the condition in order that the lines $\mathrm{A}x + \mathrm{B}y + \mathrm{C} = 0$ and $\mathrm{A}'x + \mathrm{B}'y - \mathrm{C}' = 0$ may meet at right angles is $\mathrm{AA}' + \mathrm{BB}' = 0$; so when the equations are $y = \mathrm{A}x + \mathrm{B}$, $y = \mathrm{A}'x + \mathrm{B}'$, the condition is $\mathrm{AA}' + 1 = 0$, or say the value of A′ is $= -1 \div \mathrm{A}$.

The perpendicular distance of the point (a, b) from the line $\mathrm{A}x + \mathrm{B}y + \mathrm{C} = 0$ is $(\mathrm{A}a + \mathrm{B}b + \mathrm{C}) \div \sqrt{\mathrm{A}^2+\mathrm{B}^2}$. In all the formulæ involving $\sqrt{\mathrm{A}^2+\mathrm{B}^2}$ or $\sqrt{\mathrm{A}^2+1}$, the radical should be written with the sign ±, which is essentially indeterminate: the like indeterminateness of sign presents itself in the expression for the distance of two points $\rho = \pm\sqrt{(x-a)^2+(y-b)^2}$; if, as before, the points are Q, P, and the indefinite line through these is z'QPz, then it is the same thing whether we measure off from Q along this line, considered as drawn from z' towards z, a positive distance k, or along the line considered as drawn reversely from z toward z', the equal negative distance $-k$, and the expression for the distance ρ is thus properly of the form $\pm k$. It is interesting to compare expressions which do not involve a radical: thus, in seeking for the expression for the perpendicular distance of the point (a, b) from a given line, let the equation of the given line be taken in the form, $x\cos\alpha + y\sin\alpha - p = 0$ (p being the perpendicular distance from the origin, α its inclination to the axis of x): the equation of the line may also be written $(x-a)\cos\alpha + (y-b)\sin\alpha - p_1 = 0$, and we have thence $p_1 = p - a\cos\alpha - b\sin\alpha$, the required expression for the distance p_1: it is here assumed that p_1 is drawn from (a, b) in the same sense as p is drawn from the origin, and the indeterminateness of sign is thus removed.

16. As an instance of the mode of using the formulæ, take the problem of finding the locus of a point such that its distance from a given point is in a given ratio to its distance from a given line.

We take (a, b) as the co-ordinates of the given point, and it is convenient to take (x, y) as the co-ordinates of the variable point, the locus of which is required: it thus becomes necessary to use other lettters, say (X, Y), for current co-ordinates in the equation of the given line. Suppose this is a line such that its perpendicular distance from the origin is $= p$, and that the inclination of p to the axis of x is $= \alpha$; the equation is $\mathrm{X}\cos\alpha + \mathrm{Y}\sin\alpha - p = 0$. In the result obtained in § 15, writing (x, y) in place of (a, b), it appears that the perpendicular distance of this line from the point (x, y) is

$$= p - x\cos\alpha - y\sin\alpha;$$

hence the equation of the locus is

$$\sqrt{(x-a)^2 + (y-b)^2} = e\,(p - x\cos\alpha - y\sin\alpha),$$

or say

$$(x-a)^2 + (y-b)^2 - e^2\,(x\cos\alpha + y\sin\alpha - p)^2 = 0,$$

an equation of the second order.

The Conics (Parabola, Ellipse, Hyperbola).

17. The conics or, as they were called, conic sections were originally defined as the sections of a right circular cone; but Apollonius substituted a definition, which is in fact that of the last example; the curve is the locus of a point such that its distance from a given point (called the focus) is in a given ratio to its distance from a given line (called the directrix); taking the ratio as $e : 1$, then e is called the eccentricity.

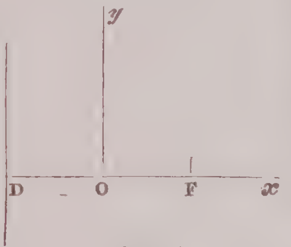


FIG. 12.

Take FD for the perpendicular from the focus F upon the directrix, and the given ratio being that of $e : 1$ ($e >, =,$ or < 1, but positive), and let the distance FD be divided at O in the given ratio, say we have $\mathrm{OD} = m$, $\mathrm{OF} = em$, where m is positive;—then the origin may be taken at O, the axis Ox being in the direction OF (that is from O to F), and the axis Oy at right angles to it. The distance of the point (x, y) from F is $= \sqrt{(x - em)^2 + y^2}$, its distance from the directrix is $= x + m$; the equation therefore is

$$(x - em)^2 + y^2 = e^2\,(x + m)^2;$$

or, what is the same thing, it is

$$(1 - e^2)x^2 - 2me\,(1 + e)x + y^2 = 0.$$

If $e^2 = 1$, or since e is taken to be positive, if $e = 1$, this is

$$y^2 - 4mx = 0,$$

which is the parabola.

If e^2 not $= 1$, then the equation may be written

$$(1 - e^2)\left(x - \frac{me}{1-e}\right)^2 + y^2 = \frac{m^2e^2(1+e)}{1-e}.$$

Supposing e positive and < 1, then, writing $m = \frac{a(1-e)}{e}$, the equation becomes

$$(1 - e^2)(x - a)^2 + y^2 = a^2(1 - e^2),$$

that is

$$\frac{(x-a)^2}{a^2} + \frac{y^2}{a^2(1-e^2)} = 1;$$

or, changing the origin and writing $b^2 = a^2(1 - e^2)$, this is

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1,$$

which is the ellipse.

And similarly if e be positive and > 1, then writing $m = \frac{a(e-1)}{e}$, the equation becomes

$$(1 - e^2)(x + a)^2 + y^2 = a^2(1 - e^2),$$

that is,

$$\frac{(x+a)^2}{a^2} + \frac{y^2}{a^2(1-e^2)} = 1,$$

or changing the origin and writing $b^2 = a^2(e^2 - 1)$, this is

$$\frac{x^2}{a^2} - \frac{y^2}{b^2} = 1,$$

which is the hyperbola.

18. The general equation $ax^2+2hxy+by^2+2fy+2gx+c=0$, or as it is written $(a, b, c, f, g, h)(x, y, 1)^2=0$, may be such that the quadric function breaks up into factors, $=(\alpha x+\beta y+\gamma)(\alpha' x+\beta' y+\gamma')$; and in this case the equation represents a pair of lines, or (it may be) two coincident lines. When it does not so break up, the function can be put in the form $\lambda\{(x-a')^2+(y-b')^2-e^2(x\cos\alpha+y\sin\alpha-p)^2\}$, or, equating the two expressions there will be six equations for the determination of $\lambda, a', b', e, p, \alpha$; and by what precedes, if a', b', e, p, α are real, the curve is either a parabola, ellipse, or hyperbola. The original coefficients $(a, b, c, f, g, h,)$ may be such as not to give any system of real values for a', b', e, p, α; but when this is so the equation $(a, b, c, f, g, h,)(x, y, 1)^2=0$ does not represent a real curve[1]: the imaginary curve which it represents is, however, regarded as a conic. Disregarding the special cases of the pair of lines and the twice repeated line, it thus appears that the only real curves represented by the general equation $(a, b, c, f, g, h)(x, y, 1)^2=0$ are the parabola, the ellipse, and the hyperbola. The circle is considered as a particular case of the ellipse.

The same result is obtained by transforming the equation $(a, b, c, f, g, h)(x, y, 1)^2=0$ to new axes. If in the first place the origin be unaltered, then the directions of the new (rectangular) axes Ox_1, Oy_1 can be found so that h_1 (the coefficient of the term x_1y_1) shall be $=0$; when this is done, then either one of the coefficients of x_1^2, y_1^2 is $=0$, and the curve is then a parabola, or neither of these coefficients is $=0$, and the curve is then an ellipse or hyperbola, according as the two coefficients are of the same sign or of opposite signs.

19. The curves can be at once traced from their equations:—

$y^2=4mx$, for the parabola (fig. 13),

$\dfrac{x^2}{a^2}+\dfrac{y^2}{b^2}=1$, for the ellipse (fig. 14),

$\dfrac{x^2}{a^2}-\dfrac{y^2}{b^2}=1$, for the hyperbola (fig. 15);

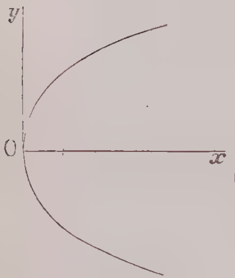


FIG. 13.

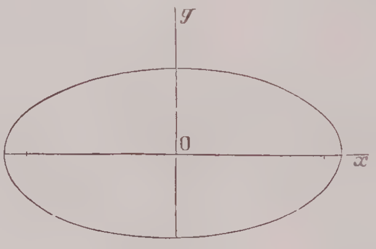


FIG. 14.

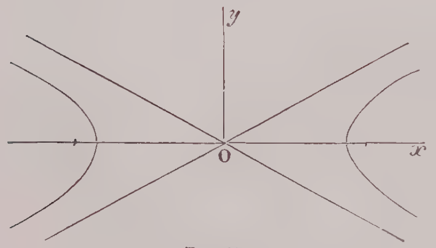


FIG. 15.

and it will be noticed how the form of the last equation puts in evidence the two asymptotes $\dfrac{x}{a}=\pm\dfrac{y}{b}$ of the hyperbola. Referred to the asymptotes (as a set of oblique axes) the equation of the hyperbola takes the form $xy=c$; and in particular, if in this equation the axes are at right angles, then the equation represents the rectangular hyperbola referred to its asymptotes as axes.

Tangent, Normal, Circle and Radius of Curvature, etc.

20. There is great convenience in using the language and notation of the infinitesimal analysis; thus we consider on a curve a point with co-ordinates (x, y), and a consecutive point the co-ordinates of which are $(x+dx, y+dy)$, or again a second consecutive point with co-ordinates $(x+dx+\tfrac{1}{2}d^2x,\ y+dy+\tfrac{1}{2}d^2y)$, etc.; and in the final results the ratios of the infinitesimals must be replaced by differential coefficients in the proper manner; thus, if x, y are considered as given functions of a parameter θ, then dx, dy have in fact the values $\dfrac{dx}{d\theta}d\theta$, $\dfrac{dy}{d\theta}d\theta$, and (only the ratio being really material) they may in the result be replaced by $\dfrac{dx}{d\theta}, \dfrac{dy}{d\theta}$. This includes the case where the equation of the curve is given in the form $y=\phi(x)$; θ is here $=x$, and the increments dx, dy are in the result to be replaced by $1, \dfrac{dy}{dx}$. So also with the infinitesimals of the higher orders d^2x, etc.

21. The tangent at the point (x,y) is the line through this point and the consecutive point $(x+dx, y+dy)$; hence, taking ξ, η as current co-ordinates, the equation is

$$\frac{\xi-x}{dx}=\frac{\eta-y}{dy},$$

an equation which is satisfied on writing therein $\xi, \eta=(x, y)$ or $=(x+dx, y+dy)$. The equation may be written

$$\eta-y=\frac{dy}{dx}(\xi-x),$$

$\dfrac{dy}{dx}$ being now the differential coefficient of y in regard to x; and this form is applicable whether y is given directly as a function of x, or in whatever way y is in effect given as a function of x: if as before x, y are given each of them as a function of θ, then the value of $\dfrac{dy}{dx}$ is $=\dfrac{dy}{d\theta}\div\dfrac{dx}{d\theta}$, which is the result obtained from the original form on writing therein $\dfrac{dx}{d\theta}, \dfrac{dy}{d\theta}$, for dx, dy respectively.

So again, when the curve is given by an equation $u=0$ between the co-ordinates (x, y), then $\dfrac{dy}{dx}$ is obtained from the equation $\dfrac{du}{dx}+\dfrac{du}{dy}\dfrac{dy}{dx}=0$. But here it is more elegant, using the original form, to eliminate dx, dy by the formula $\dfrac{du}{dx}dx+\dfrac{du}{dy}dy$; we thus obtain the equation of the tangent in the form

$$\frac{du}{dx}(\xi-x)+\frac{du}{dy}(\eta-y)=0.$$

For example, in the case of the ellipse $\dfrac{x^2}{a^2}+\dfrac{y^2}{b^2}=1$, the equation is $\dfrac{x}{a^2}(\xi-x)+\dfrac{y}{b^2}(\eta-y)=0$; or reducing by means of the equation of the curve the equation of the tangent is

$$\frac{\xi x}{a^2}+\frac{\eta y}{b^2}=1.$$

The normal is a line through the point at right angles to the tangent; the equation therefore is

$$(\xi-x)dx+(\eta-y)dy=0,$$

where dx, dy are to be replaced by their proportional values as before.

22. The circle of curvature is the circle through the point and two consecutive points of the curve. Taking the equation to be

$$(\xi-\alpha)^2+(\eta-\beta)^2=\gamma^2,$$

the values of α, β are given by

$$x-\alpha=\frac{dy(dx^2+dy^2)}{dxd^2y-dyd^2x},\quad y-\beta=\frac{-dx(dx^2+dy^2)}{dxd^2y-dyd^2x},$$

and we then have

$$\gamma^2, =(x-\alpha)^2+(y-\beta)^2, =\frac{(dx^2+dy^2)^3}{(dx\,d^2y-dy\,d^2x)^2}.$$

In the case where y is given directly as a function of x, then, writing for shortness $p=\dfrac{dy}{dx}$, $q=\dfrac{d^2y}{dx^2}$, this is

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[1] It is proper to remark that, when $(a, b, c, f, g, h)(x, y, 1)^2=0$ *does* represent a real curve, there are in fact four systems of values of a', b', e, p, α, two real, the other two imaginary; we have thus two real equations and two imaginary equations, each of them of the form $(x-a')^2+(y-b')^2=e^2(\cos\alpha+y\cos\beta-p)^2$, representing each of them one and the same real curve. This is consistent with the assertion of the text that the real curve is in every case represented by a real equation of this form.

$\gamma^2 = \frac{(1+p^2)^3}{q^2}$, or, as the equation is usually written, $\gamma = \frac{(1+p^2)^{\frac{3}{2}}}{-q}$, the radius of curvature, considered to be positive or negative, according as the curve is concave or convex to the axis of x.

It may be added that the centre of curvature is the intersection of the normal by the consecutive normal.

The locus of the centre of curvature is the evolute. If from the expressions of α, β regarded as functions of x we eliminate x, we have thus an equation between (α, β), which is the equation of the evolute.

Polar Co-ordinates.

23. The position of a point may be determined by means of its distance from a fixed point and the inclination of this distance to a fixed line through the fixed point. Say we have r the distance from the origin and θ the inclination of r to the axis of x; r and θ are then the polar co-ordinates of the point, r the radius vector, and θ the inclination. These are immediately connected with the Cartesian co-ordinates x, y by the formulæ $x = r\cos\theta$, $y = r\sin\theta$; and the transition from either set of co-ordinates to the other can thus be made without difficulty. But the use of polar co-ordinates is very convenient, as well in reference to certain classes of questions relating to curves of any kind—for instance, in the dynamics of central forces—as in relation to curves having in regard to the origin the symmetry of the regular polygon (curves such as that represented by the equation $r = \cos m\theta$), and also in regard to the class of curves called spirals, where the radius vector r is given as an algebraical or exponential function of the inclination θ.

Trilinear Co-ordinates.

24. Consider a fixed triangle ABC, and (regarding the sides as indefinite lines) suppose for a moment that p, q, r denote the distances of a point P from the sides BC, CA, AB respectively,—these distances being measured either perpendicularly to the several sides, or each of them in a given direction. To fix the ideas each distance may be considered as positive for a point inside the triangle, and the sign is thus fixed for any point whatever. There is then an identical relation between p, q, r: if a, b, c are the lengths of the sides, and the distances are measured perpendicularly thereto, the relation is $ap + bq + cr =$ twice the area of triangle. But taking x, y, z proportional to p, q, r, or if we please proportional to given multiples of p, q, r, then only the ratios of x, y, z are determined; their absolute values remain arbitrary. But the ratios of p, q, r, and consequently also the ratios of x, y, z determine, and that uniquely, the point; and it being understood that only the ratios are attended to, we say that (x, y, z) are the co-ordinates of the point. The equation of a line has thus the form $ax + by + cz = 0$, and generally that of a curve of the nth order is a homogeneous equation of this order between the co-ordinates, $(*\between x, y, z)^n = 0$. The advantage over Cartesian co-ordinates is in the greater symmetry of the analytical forms, and in the more convenient treatment of the line infinity and of points at infinity. The method includes that of Cartesian co-ordinates, the homogeneous equation in x, y, z is in fact an equation in $\frac{x}{z}$, $\frac{y}{z}$, which two quantities may be regarded as denoting Cartesian co-ordinates; or, what is the same thing, we may in the equation write $z = 1$. It may be added that if the trilinear co-ordinates (x, y, z) are regarded as the Cartesian co-ordinates of a point of space, then the equation is that of a cone having the origin for its vertex; and conversely that such equation of a cone may be regarded as the equation in trilinear co-ordinates of a plane curve.

General Point-Co-ordinates.—Line Co-ordinates.

25. All the co-ordinates considered thus far are point-co-ordinates. More generally, any two quantities (or the ratios of three quantities) serving to determine the position of a point in the plane may be regarded as the co-ordinates of the point; or, if instead of a single point they determine a system of two or more points, then as the co-ordinates of the system of points. But, as noticed under CURVE, there are also line co-ordinates serving to determine the position of a line; the ordinary case is when the line is determined by means of the ratios of three quantities ξ, η, ζ (correlative to the trilinear co-ordinates x, y, z). A linear equation $a\xi + b\eta + c\zeta = 0$ represents then the system of lines such that the co-ordinates of each of them satisfy this relation, in fact, all the lines which pass through a given point; and it is thus regarded as the line-equation of this point; and generally a homogeneous equation $(*\between \xi, \eta, \zeta)^n = 0$ represents the curve which is the envelope of all the lines the co-ordinates of which satisfy this equation, and it is thus regarded as the line equation of this curve.

II. SOLID ANALYTICAL GEOMETRY (§§ 26–40).

26. We are here concerned with points in space,—the position of a point being determined by its three co-ordinates x, y, z. We consider three co-ordinate planes, at right angles to each other, dividing the whole of space into eight portions called octants, the co-ordinates of a point being the perpendicular distances of the point from the three planes respectively, each distance being considered as positive or negative according as it lies on the one or the other side of the plane. Thus the co-ordinates in the eight octants have respectively the signs

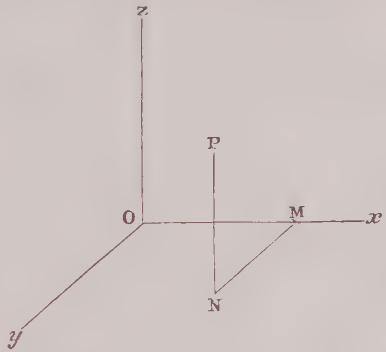

FIG. 16.

x,	y,	z
+	+	+
+	−	+
−	+	+
−	−	+
+	+	−
+	−	−
−	+	−
−	−	−

The positive parts of the axes are usually drawn as in fig. 16, which represents a point P, the co-ordinates of which have the positive values OM, MN, NP.

27. It may be remarked, as regards the delineation of such solid figures, that if we have in space three lines at right angles to each other, say Oa, Ob, Oc, of equal lengths, then it is possible to project these by parallel lines upon a plane in such wise that the projections Oa', Ob', Oc' shall be at given inclinations to each other, and that these length shall be to each other in given ratios: in particular the tw lines Oa', Oc' may be at right angles to each other, and their lengths equal, the direction of Ob', and its proportion to the two equal lengths Oa', Oc' being arbitrary. It thus appears that we may as in the figure draw Ox, Oz at right angles to each other, and Oy in an arbitrary direction; and moreover represent the co-ordinates x, z, on equal scales, and the remaining co-ordinate y on an arbitrary scale (which may be that of the other two co-ordinates x, z, but is in practice usually smaller). The advantage, of course, is that a figure in *one* of the co-ordinate planes xz is represented in its proper form without distortion; but it may be in some cases preferable to employ the isometrical

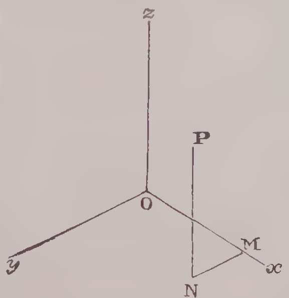

FIG. 17.

projection, wherein the three axes are represented by lines inclined to each other at angles of 120°, and the scales for the co-ordinates are equal (fig. 17).

For the delineation of a surface of a tolerably simple form, it is frequently sufficient to draw (according to the foregoing projection) the sections by the co-ordinate planes; and in particular when the surface is symmetrical in regard to the co-ordinate planes, it is sufficient to draw the quarter-sections belonging to a single octant of the surface; thus fig. 18 is a convenient representation of an octant of the wave surface. Or a surface may be delineated by means of a series of parallel sections, or (taking these to be the sections by a series of horizontal planes) say by a series of contour lines. Of course, other sections may be drawn or indicated, if necessary. For the delineation of a curve, a convenient method is to represent, as above, a series of the points P thereof, each point P being accompanied by the ordinates PN, which serves to refer the point to the plane of *xy*; this is in effect a representation of each point P of the curve, by means of two points P, N such that the line PN has a fixed direction. Both as regards curves and surfaces, the employment of stereographic representations is very interesting.

28. In plane geometry, reckoning the line as a curve of the first order, we have only the point and the curve. In solid geometry, reckoning a line as a curve of the first order, and the plane as a surface of the first order, we have the point, the curve, and the surface; but the increase of complexity is far greater than would hence at first sight appear. In plane geometry a curve is considered in connection with lines (its tangents); but in solid geometry the curve is considered in connection with lines and planes (its tangents and osculating planes), and the surface also in connection with lines and planes (its tangent lines and tangent planes); there are surfaces arising out of the line—cones, skew surfaces, developables, doubly and triply infinite systems of lines, and whole classes of theories which have nothing analogous to them in plane geometry: it is thus a very small part indeed of the subject which can be even referred to in the present article.

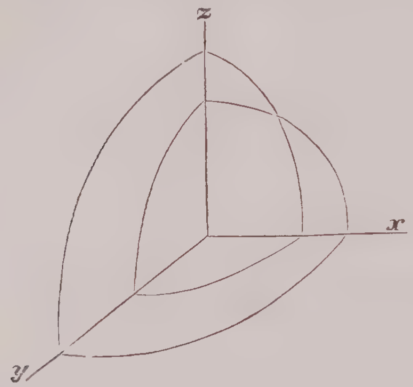

FIG. 18.

In the case of a surface we have between the co-ordinates (x, y, z) a single, or say a onefold relation, which can be represented by a single relation $f(x, y, z)=0$; or we may consider the co-ordinates expressed each of them as a given function of two variable parameters p, q; the form $z=f(x, y)$ is a particular case of each of these modes of representation; in other words, we have in the first mode $f(x, y, z)=z-f(x\ y)$, and in the second mode $x=p$, $y=q$ for the expression of two of the co-ordinates in terms of the parameters.

In the case of a curve we have between the co-ordinates (x, y, z) a twofold relation: two equations $f(x, y, z)=0$, $\phi(x, y, z)=0$ give such a relation; *i.e.*, the curve is here considered as the intersection of two surfaces (but the curve is not always the complete intersection of two surfaces, and they are hence difficulties); or, again, the co-ordinates may be given each of them as a function of a single variable parameter. The form $y=\phi x$, $z=\psi x$, where two of the co-ordinates are given in terms of the third, is a particular case of each of these modes of representation.

29. The remarks under plane geometry as to descriptive and metrical propositions, and as to the non-metrical character of the method of co-ordinates when used for the proof of a descriptive proposition, apply also to solid geometry; and they might be illustrated in like manner by the instance of the theorem of the radical centre of four spheres. The proof is obtained from the consideration that S and S′ being each of them a function of the form $x^2+y^2+z^2+ax+by+cz+d$, the difference $S-S'$ is a mere linear function of the co-ordinates, and consequently that $S-S'=0$ is the equation of the plane containing the circle of intersection of the two spheres $S=0$ and $S'=0$.

Metrical Theory.

30. The foundation in solid geometry of the metrical theory is in fact the before-mentioned theorem that if a finite right line PQ be projected upon any other line OO′ by lines perpendicular to OO′, then the length of the projection P′Q′ is equal to the length of PQ into the cosine of its inclination to P′Q′—or (in the form in which it is now convenient to state the theorem) the perpendicular distance P′Q′ of two parallel planes is equal to the inclined distance PQ into the cosine of the inclination. Hence also the algebraical sum of the projections of the sides of a closed polygon upon any line is $=0$; or, reversing the signs of certain sides and considering the polygon as made up of two broken lines each extending from the same initial to the same terminal point, the sum of the projections of the one set of lines upon any line is equal to the sum of the projections of the other set of lines upon the same line. When any of the lines are at right angles to the given line (or, what is the same thing, in a plane at right angles to the given line) the projections of these lines severally vanish.

31. Consider the skew quadrilateral QMNP, the sides QM, MN, NP being respectively parallel to the three rectangular axes O*x*, O*y*, O*z*; let the lengths of these sides be ξ, η, ζ, and that of the side QP be $=\rho$; and let the cosines of the inclinations (or say the cosine-inclinations) of ρ to the three axes be α, β, γ; then projecting successively on the three sides and on QP we have

$$\xi, \eta, \zeta=\rho\alpha, \rho\beta, \rho\gamma,$$

and

$$\rho=\alpha\xi+\beta\eta+\gamma\zeta,$$

whence $\rho^2=\xi^2+\eta^2+\zeta^2$, which is the relation between a distance ρ and its projections ξ, η, ζ upon three rectangular axes. And from the same equations we obtain $\alpha^2+\beta^2+\gamma^2=1$, which is a relation connecting the cosine inclinations of a line to three rectangular axes.

Suppose we have through Q any other line QT, and let the cosine-inclinations of this to the axes be α', β', γ', and δ be its cosine-inclination to QP; also let p be the length of the projection of QP upon QT; then projecting on QT we have

$$p=\alpha'\xi+\beta'\eta+\gamma'\zeta, =\rho\delta.$$

And in the last equation substituting for ξ, η, ζ their values $\rho\alpha, \rho\beta, \rho\gamma$ we find

$$\delta=\alpha\alpha'+\beta\beta'+\gamma\gamma',$$

which is an expression for the mutual cosine-inclination of two lines, the cosine-inclinations of which to the axes are α, β, γ and $\alpha'\ \beta', \gamma'$ respectively. We have of course $\alpha^2+\beta^2+\gamma^2=1$, and $\alpha'^2+\beta'^2+\gamma'^2=1$; and hence also

$$\begin{aligned}1-\delta^2&=(\alpha^2+\beta^2+\gamma^2)(\alpha'^2+\beta'^2+\gamma'^2)-(\alpha\alpha'+\beta\beta'+\gamma\gamma')^2,\\&=(\beta\gamma'-\beta'\gamma)^2+(\gamma\alpha'-\gamma'\alpha)^2+(\alpha\beta'-\alpha'\beta)^2;\end{aligned}$$

so that the sine of the inclination can only be expressed as a square root. These formulæ are the foundation of spherical trigonometry.

The Line, Plane, and Sphere.

32. The foregoing formulæ give at once the equations of these loci.

For first, taking Q to be a fixed point, co-ordinates (a, b, c) and the cosine-inclinations (α, β, γ) to be constant, then P will be a point in the line through Q in the direction thus determined; or, taking (x, y, z) for its co-ordinates, these will be the current co-ordinates of a point in the line. The values of ξ, η, ζ then are $x-a$, $y-b$, $z-c$, and we thus have

$$\frac{x-a}{\alpha}=\frac{y-b}{\beta}=\frac{z-c}{\gamma}(=\rho),$$

which (omitting the last equation, $=\rho$) are the equations of the line through the point (a, b, c), the cosine-inclinations to the axes being α, β, γ, and these quantities being connected by the relation $\alpha^2+\beta^2+\gamma^2=1$. This equation may be omitted, and then α, β, γ. instead of being equal, will only be proportional to the cosine-inclinations.

Using the last equation and writing

$$x, y, z=a+\alpha\rho, b+\beta\rho, c+\gamma\rho,$$

these are expressions for the current co-ordinates in terms of a parameter ρ, which is in fact the distance from the fixed point (a, b, c).

It is easy to see that, if the co-ordinates (x, y, z) are connected by any two linear equations, these equations can always be brought into the foregoing form, and hence that the two linear equations represent a line.

Secondly, taking for greater simplicity the point Q to be coincident with the origin, and $\alpha', \beta', \gamma', p$ to be constant, then p is the perpendicular distance of a plane from the origin, and α', β', γ' are the cosine-inclinations of this distance to the axes $(\alpha'^2 + \beta'^2 + \gamma'^2 = 1)$. P is any point in this plane, and taking its co-ordinates to be (x, y, z), then (ξ, η, ζ) are $= (x, y, z)$, and the foregoing equation $p = \alpha'\xi + \beta'\eta + \gamma'\zeta$ becomes

$$\alpha' x + \beta' y + \gamma' z = p,$$

which is the equation of the plane in question.

If, more generally, Q is not coincident with the origin, then, taking its co-ordinates to be (a, b, c), and writing p_1 instead of p, the equation is

$$\alpha'(x - a) + \beta'(y - b) + \gamma'(z - c) = p_1;$$

and we thence have $p_1 = p - (a\alpha' + b\beta' + c\gamma')$, which is an expression for the perpendicular distance of the point (a, b, c) from the plane in question.

It is obvious that any linear equation $Ax + By + Cz + D = 0$ between the co-ordinates can always be brought into the foregoing form, and hence that such equation represents a plane.

Thirdly, supposing Q to be a fixed point, co-ordinates (a, b, c) and the distance QP, $= \rho$, to be constant, say this is $= d$, then as before, the values of ξ, η, ζ are $x - a, y - b, z - c$, and the equation $\xi^2 + \eta^2 + \zeta^2 = \rho^2$ becomes

$$(x - a)^2 + (y - b)^2 + (z - c)^2 = d^2,$$

which is the equation of the sphere, co-ordinates of the centre $= (a, b, c)$ and radius $= d$.

A quadric equation wherein the terms of the second order are $x^2 + y^2 + z^2$, viz., an equation

$$x^2 + y^2 + z^2 + Ax + By + Cz + D = 0,$$

can always, it is clear, be brought into the foregoing form; and it thus appears that this is the equation of a sphere, co-ordinates of the centre $-\frac{1}{2}A, -\frac{1}{2}B, -\frac{1}{2}C$, and squared radius $= \frac{1}{4}(A^2 + B^2 + C^2) - D$.

Cylinders, Cones, Ruled Surfaces.

33. A singly infinite system of lines or system of lines depending upon one variable parameter forms a surface; and the equation of the surface is obtained by eliminating the parameter between the two equations of the line.

If the lines all pass through a given point, then the surface is a cone; and, in particular, if the lines are all parallel to a given line, then the surface is a cylinder.

Beginning with this last case, suppose the lines are parallel to the line $x = mz$, $y = nz$, the equations of a line of the system are $x = mz + a$, $y = nz + b$,—where a, b are supposed to be functions of the variable parameter, or, what is the same thing, there is between them a relation $f(a, b) = 0$: we have

$$a = x - mz,\ b = y - nz,$$

and the result of the elimination of the parameter therefore is $f(x - mz, y - nz) = 0$, which is thus the general equation of the cylinder the generating lines whereof are parallel to the line $x = mz$, $y = nz$. The equation of the section by the plane $z = 0$ is $f(x, y) = 0$, and conversely if the cylinder be determined by means of its curve of intersection with the plane $z = 0$, then, taking the equation of this curve to be $f(x, y) = 0$, the equation of the cylinder is $f(x - mz, y - nz) = 0$. Thus, if the curve of intersection be the circle

$$(x - \alpha)^2 + (y - \beta)^2 = \gamma^2,$$

we have $(x - mz - \alpha)^2 + (y - nz - \beta)^2 = \gamma^2$ as the equation of an oblique cylinder on this base, and thus also

$$(x - \alpha)^2 + (y - \beta)^2 = \gamma^2$$

as the equation of the right cylinder.

If the lines all pass through a given point (a, b, c), then the equations of a line are $x - a = \alpha(z - c)$, $y - b = \beta(z - c)$, where α, β are functions of the variable parameter, or, what is the same thing, there exists between them an equation $f(\alpha, \beta) = 0$; the elimination of the parameter gives, therefore,

$$f\left(\frac{x - a}{z - c}, \frac{y - b}{z - c}\right) = 0;$$

and this equation, or, what is the same thing, any homogeneous equation $f(x - a, y - b, z - c) = 0$, or, taking f to be a rational and integral function of the order n, say

$$(*)(x - a,\ y - b,\ z - c)^n = 0,$$

is the general equation of the cone having the point (a, b, c) for its vertex. Taking the vertex to be at the origin, the equation is $(*)(x, y, z)^n = 0$; and in particular, $(*)(x, y, z)^2 = 0$ is the equation of a cone of the second order, or quadricone, having the origin for its vertex.

34. In the general case of a singly infinite system of lines, the locus is a ruled surface (or *regulus*). If the system be such that a line does not intersect the consecutive line, then the surface is a skew surface, or scroll; but if it be such that each line intersects the consecutive line, then it is a developable, or torse.

Suppose, for instance, that the equations of a line (depending on the variable parameter θ) are

$$\frac{x}{a} + \frac{y}{c} = \theta\left(1 + \frac{y}{b}\right), \frac{x}{a} - \frac{z}{c} = \frac{1}{\theta}\left(1 - \frac{y}{b}\right),$$

then, eliminating θ, we have

$$\frac{x^2}{a^2} - \frac{z^2}{c^2} = 1 - \frac{y^2}{b^2}, \text{ or say } \frac{x^2}{a^2} + \frac{y^2}{b^2} - \frac{z^2}{c^2} = 1,$$

the equation of a quadric surface, afterwards called the hyperboloid of one sheet; this surface is consequently a scroll. It is to be remarked that we have upon the surface a second singly infinite series of lines; the equations of a line of this second system (depending on the variable parameter ϕ) are

$$\frac{x}{a} + \frac{z}{c} = \phi\left(1 - \frac{y}{b}\right), \frac{x}{a} - \frac{z}{c} = \frac{1}{\phi}\left(1 + \frac{y}{b}\right).$$

It is easily shown that any line of the one system intersects every line of the other system.

Considering any curve (of double curvature) whatever, the tangent lines of the curve form a singly infinite system of lines, each line intersecting the consecutive line of the system,—that is, they form a developable, or torse; the curve and torse are thus inseparably connected together, forming a single geometrical figure. A plane through three consecutive points of the curve (or osculating plane of the curve) contains two consecutive tangents, that is, two consecutive lines of the torse, and is thus a tangent plane of the torse along a generating line.

Transformation of Co-ordinates.

35. There is no difficulty in changing the origin, and it is for brevity assumed that the origin remains unaltered. We have, then, two sets of rectangular axes, Ox, Oy, Oz, and Ox_1, Oy_1, Oz_1, the mutual cosine-inclinations being shown by the diagram—

	x	y	z
x_1	α	β	γ
y_1	α'	β'	γ'
z_1	α''	β''	γ''

that is, α, β, γ are the cosine-inclinations of Ox_1, to Ox, Oy, Oz; α', β', γ' those of Oy_1, etc.

And this diagram gives also the linear expressions of the co-ordinates (x_1, y_1, z_1) or (x, y, z) of either set in terms of those of the other set; we thus have

$$\begin{aligned} x_1 &= \alpha\ x + \beta\ y + \gamma\ z, & x &= \alpha x_1 + \alpha' y_1 + \alpha'' z_1, \\ y_1 &= \alpha' x + \beta' y + \gamma' z, & y &= \beta x_1 + \beta' y_1 + \beta'' z_1, \\ z_1 &= \alpha'' x + \beta'' y + \gamma'' z, & z &= \gamma x_1 + \gamma' y_1 + \gamma'' z_1, \end{aligned}$$

which are obtained by projection, as above explained. Each of these equations is, in fact, nothing else than the before-mentioned equation $p = \alpha'\xi + \beta'\eta + \gamma'\zeta$, adapted to the problem in hand.

But we have to consider the relations between the nine coefficients. By what precedes, or by the consideration that we must have identically $x^2 + y^2 + z^2 = x_1{}^2 + y_1{}^2 + z_1{}^2$, it appears that these satisfy the relations—

$$\begin{aligned} \alpha^2 + \beta^2 + \gamma^2 &= 1, & \alpha^2 + \alpha'^2 + \alpha''^2 &= 1, \\ \alpha'^2 + \beta'^2 + \gamma'^2 &= 1, & \beta^2 + \beta'^2 + \beta''^2 &= 1, \\ \alpha''^2 + \beta''^2 + \gamma''^2 &= 1, & \gamma^2 + \gamma'^2 + \gamma''^2 &= 1, \\ \alpha'\alpha'' + \beta'\beta'' + \gamma'\gamma'' &= 0, & \beta\gamma + \beta'\gamma' + \beta''\gamma'' &= 0, \\ \alpha''\alpha + \beta''\beta + \gamma''\gamma &= 0, & \gamma\alpha + \gamma'\alpha' + \gamma''\alpha'' &= 0, \\ \alpha\alpha' + \beta\beta' + \gamma\gamma' &= 0, & \alpha\beta + \alpha'\beta' + \alpha''\beta'' &= 0, \end{aligned}$$

either set of six equations being implied in the other set.

It follows that the square of the determinant

$$\begin{vmatrix} \alpha\ , & \beta\ , & \gamma \\ \alpha', & \beta', & \gamma' \\ \alpha'', & \beta'', & \gamma'' \end{vmatrix}$$

is $= 1$; and hence that the determinant itself is $= \pm 1$. The distinction of the two cases is an important one: if the determinant is $= +1$, then the axes Ox_1, Oy_1, Oz_1 are such that they can by a rotation about O be brought to coincide with Ox, Oy, Oz respectively; if it is $= -1$, then they cannot. But in the latter case, by measuring x_1, y_1, z_1 in the opposite directions we change the signs of all the coefficients and so make the determinant to be $= +1$; hence this case need alone be considered, and it is accordingly assumed that the determinant is $= +1$. This being so, it is found that we have a further set of nine equations, $\alpha = \beta'\gamma'' - \beta''\gamma'$, etc.; that is, the coefficients arranged as in the diagram have the values

$\beta'\gamma'' - \beta''\gamma'$	$\gamma'\alpha'' - \gamma''\alpha'$	$\alpha'\beta'' - \alpha''\beta'$
$\beta''\gamma - \beta\gamma''$	$\gamma''\alpha - \gamma\alpha''$	$\alpha''\beta - \alpha\beta''$
$\beta\gamma' - \beta'\gamma$	$\gamma\alpha' - \gamma'\alpha$	$\alpha\beta' - \alpha'\beta$

36. It is important to express the nine coefficients in terms of three independent quantities. A solution which, although unsymmetrical, is very convenient in Astronomy and Dynamics is to use for the purpose the three angles θ, ϕ, τ of fig. 19; say θ = longitude of the node; ϕ = inclination; and τ = longitude of x_1 from node.

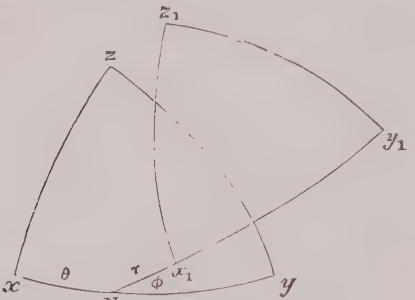

FIG. 19.

The diagram of transformation then is

	x	y	z
x_1	$\cos\tau\cos\theta - \sin\tau\sin\theta\cos\phi$	$\cos\tau\sin\theta + \sin\tau\cos\theta\cos\phi$	$\sin\tau\sin\phi$
y_1	$-\sin\tau\cos\theta - \cos\tau\sin\theta\cos\phi$	$-\sin\tau\sin\theta + \cos\tau\cos\theta\cos\phi$	$\cos\tau\sin\phi$
z_1	$\sin\theta\sin\phi$	$-\cos\theta\sin\phi$	$\cos\phi$

But a more elegant solution (due to Rodrigues) is that contained in the diagram

	x	y	z
x_1	$1 + \lambda^2 - \mu^2 - \nu^2$	$2(\lambda\mu - \nu)$	$2(\lambda\nu + \mu)$
y_1	$2(\lambda\mu + \nu)$	$1 - \lambda^2 + \mu^2 - \nu^2$	$2(\mu\nu - \lambda)$
z_1	$2(\nu\lambda - \mu)$	$2(\mu\nu + \lambda)$	$1 - \lambda^2 - \mu^2 + \nu^2$

$$\div (1 + \lambda^2 - \mu^2 + \nu^2).$$

The nine coefficients of transformation are the nine functions of the diagram, each divided by $1 + \lambda^2 + \mu^2 + \nu^2$; the expressions contain as they should do the three arbitrary quantities λ, μ, ν; and the identity $x_1^2 + y_1^2 + z_1^2 = x^2 + y^2 + z^2$ can be at once verified. It may be added that the transformation can be expressed in the quaternion form

$$ix_1 + jy_1 + kz_1 = (1 + \Lambda)(ix + jy + kz)(1 + \Lambda)^{-1}$$

where Λ denotes the vector $i\lambda + j\mu + k\nu$.

Quadric Surfaces (Paraboloids, Ellipsoid, Hyperboloids).

37. It appears by a discussion of the general equation of the second order $(a, \ldots \between x, y, z, 1)^2 = 0$ that the proper quadric surfaces[1] represented by such an equation are the following five surfaces (a and b positive) —

(1.) $z = \dfrac{x^2}{2a} + \dfrac{y^2}{2b}$, elliptic paraboloid.

(2.) $z = \dfrac{x^2}{2a} - \dfrac{y^2}{2b}$, hyperbolic paraboloid.

(3.) $\dfrac{x^2}{a^2} + \dfrac{y^2}{b^2} - \dfrac{z^2}{c^2} = 1$, ellipsoid.

(4.) $\dfrac{x^2}{a^2} + \dfrac{y^2}{b^2} - \dfrac{z^2}{c^2} = 1$, hyperboloid of one sheet.

(5.) $\dfrac{x^2}{a^2} + \dfrac{y^2}{b^2} - \dfrac{z^2}{c^2} = -1$, hyperboloid of two sheets.

It is at once seen that these are distinct surfaces; and the equations also show very readily the general form and mode of generation of the several surfaces.

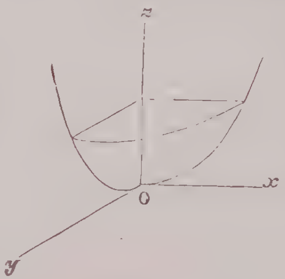

FIG. 20.

In the elliptic paraboloid (fig. 20), the sections by the planes of zx and zy are the parabolas

$$z = \frac{x^2}{2a},\ z = \frac{y^2}{2b},$$

having the common axes Oz; and the section by any plane $z = \gamma$ parallel to that of xy is the ellipse

$$\gamma = \frac{x^2}{2a} + \frac{y^2}{2b};$$

so that the surface is generated by a variable ellipse moving parallel to itself along the parabolas as directrices.

In the hyperbolic paraboloid (fig. 21) the sections by the planes of zx, zy are the parabolas $z = \dfrac{x^2}{2a}$, $z = -\dfrac{x^2}{2b}$, having the opposite axes Oz, Oz', and the section by a plane $z = \gamma$ parallel to that of xy is the hyperbola $\gamma = \dfrac{x^2}{2a} - \dfrac{y^2}{2b}$, which has its transverse axis parallel to Ox or Oy according as γ is positive or negative. The surface is thus generated by a variable hyperbola moving parallel to itself along the parabolas as directrices. The form is best seen from fig. 22, which represents the sections by planes parallel to the plane of xy, or say the contour lines; the continuous lines are the sections above the plane of xy, and the dotted lines the sections below this plane. The form is, in fact, that of a saddle.

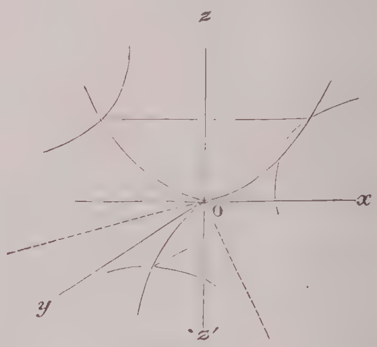

FIG. 21.

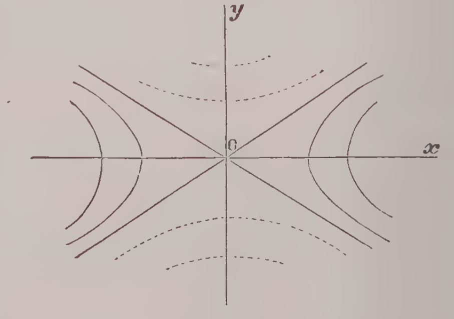

FIG. 22.

In the ellipsoid (fig. 23) the sections by the planes of zx, zy, and xy are each of them an ellipse, and the section by any parallel plane is also an ellipse. The surface may be considered

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[1] The improper quadric surfaces presented by the general equation of the second order are (1) the pair of planes or plane-pair, including as a special case the twice repeated plane, and (2) the cone, including as a special case the cylinder. There is but one form of cone; but the cylinder may be parabolic, elliptic, or hyperbolic.

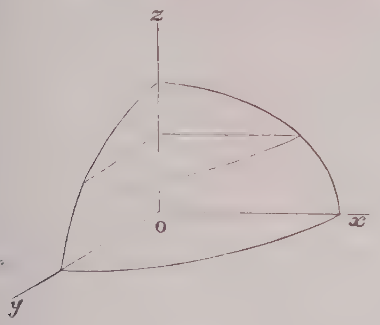

FIG. 23.

as generated by an ellipse moving parallel to itself along two ellipses as directrices.

In the hyperboloid of one sheet (fig. 24), the sections by the planes of zx, zy are the hyperbolas

$$\frac{x^2}{a} - \frac{z^2}{c^2} = 1\,,\ \frac{y^2}{b^2} - \frac{z^2}{c^2} = 1,$$

having a common conjugate axis zOz'; the section by the plane of xy, and that by any parallel plane, is an ellipse; and the

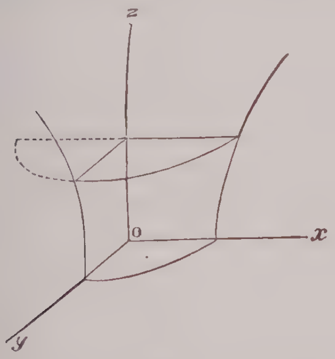

FIG. 24.

surface may be considered as generated by a variable ellipse moving parallel to itself along the two hyperbolas as directrices.

In the hyperboloid of two sheets (fig. 25), the sections by the planes of zx and zy are the hyperbolas $\frac{z^2}{c^2} - \frac{x^2}{a^2} = 1$, $\frac{z^2}{c^2} - \frac{y^2}{b^2} = 1$, having the common transverse axis zOz'; the section by any plane $z = \pm\gamma$ parallel to that of xy, γ being in absolute magnitude $> c$, is the ellipse

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = \frac{y^2}{c^2} - 1$$

and the surface consisting of two distinct portions or sheets, may be considered as generated by a variable ellipse moving parallel to itself along the hyperbolas as directrices.

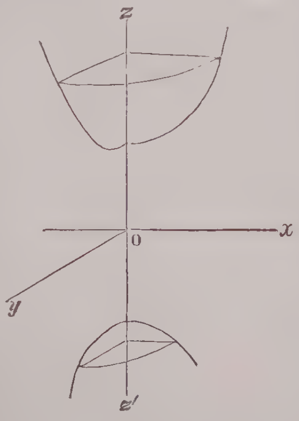

FIG. 25.

The hyperbolic paraboloid is such (and it is easy from the figure to understand how this may be the case) that there exist upon it two singly infinite series of right lines. The same is the case with the hyperboloid of one sheet (ruled or skew hyperboloid, as with reference to this property it is termed). If we imagine two equal and parallel circular disks, their points connected by strings of equal length, so that these are the generating lines of a right circular cylinder, then by turning one of the disks about its centre through the same angle in one or the other direction, the strings will in each case generate one and the same hyperboloid, and will in regard to it be the two systems of lines on the surface, or say the two systems of generating lines; and the general configuration is the same when instead of circles we have ellipses. It has been already shown analytically that the equation $\frac{x^2}{a^2} + \frac{y^2}{b^2} - \frac{z^2}{c^2} = 1$ is satisfied by each of two pairs of linear relations between the co-ordinates.

Curves; Tangent, Osculating Plane, Curvature, etc.

38. It will be convenient to consider the co-ordinates (x, y, z) of the point on the curve as given in terms of a parameter θ, so that dx, dy, dz, d^2x, etc., will be proportional to $\frac{dx}{d\theta}, \frac{dy}{d\theta}, \frac{dz}{d\theta}, \frac{d^2x}{d\theta^2}$, etc. But only a part of the analytical formulæ will be given. ξ, η, ζ are used as current co-ordinates.

The tangent is the line through the point (x, y, z) and the consecutive point $(x+dx, y+dy, z+dz)$; its equations therefore are

$$\frac{\xi - x}{dx} = \frac{\eta - y}{dy} = \frac{\zeta - z}{dz}.$$

The osculating plane is the plane through the point and two consecutive points, and contains therefore the tangent; its equation is

$$\begin{vmatrix} \xi - x, & \eta - y, & \zeta - z \\ dx\ , & dy\ , & dz \\ d^2x\ , & d^2y\ , & d^2z \end{vmatrix} = 0$$

or, what is the same thing,

$$(\xi - x)\ (dyd^2z - dzd^2y) + (\eta - y)\ (dzd^2x - dxd^2z) + (\zeta - z)\ (dxd^2y - dyd^2x) = 0.$$

The normal plane is the plane through the point at right angles to the tangent. It meets the osculating plane in a line called the principal normal; and drawing through the point a line at right angles to the osculating plane, this is called the binormal. We have thus at the point a set of three rectangular axes—the tangent, the principal normal, and the binormal.

We have through the point and three consecutive points a sphere of spherical curvature—the centre and radius thereof being the centre, and radius, of spherical curvature. The sphere is met by the osculating plane in the circle of absolute curvature—the centre and radius thereof being the centre, and radius, of absolute curvature. The centre of absolute curvature is also the intersection of the principal normal by the normal plane at the consecutive point.

Surfaces; Tangent Lines and Plane, Curvature, etc.

39. It will be convenient to consider the surface as given by an equation $f(x, y, z) = 0$ between the co-ordinates; taking (x, y, z) for the co-ordinates of a given point, and $(x+dx, y+dy, z+dz)$ for those of a consecutive point, the increments dx, dy, dz satisfy the condition

$$\frac{df}{dx}dx + \frac{df}{dy}dy + \frac{df}{dz}dz = 0,$$

but the ratio of two of the increments, suppose $dx : dy$, may be regarded as arbitrary. Only a part of the analytical formulæ will be given. ξ, η, ζ are used as current coordinates.

We have through the point a singly infinite series of right lines, each meeting the surface in a consecutive point, or say having each of them two-point intersection with the surface. These lines lie all of them in a plane which is the tangent plane; its equation is

$$\frac{df}{dx}(\xi - x) + \frac{df}{dy}(\eta - y) + \frac{df}{dz}(\zeta - z) = 0,$$

as is at once verified by observing that this equation is satisfied (irrespectively of the value of $dx : dy$) on writing therein $\xi, \eta, \zeta = x+dx, y+dy, z+dz$.

The line through the point at right angles to the tangent plane is called the normal; its equations are

$$\frac{\xi - x}{\frac{df}{dx}} = \frac{\eta - y}{\frac{df}{dy}} = \frac{\zeta - z}{\frac{df}{dz}}.$$

In the series of tangent lines there are in general two (real or imaginary) lines, each of which meets the surface in a second consecutive point, or say it has three-point intersection with the surface; these are called the chief-tangents (Haupt-tangenten). The tangent-plane cuts the surface in a curve, having at the point of contact a node (double point), the tangents to the two branches being the chief tangents.

In the case of a quadric surface the curve of intersection, *qua* curve of the second order, can only have a node by breaking up into a pair of lines; that is, every tangent-plane meets the surface in a pair of lines, or we have on the surface two singly infinite systems of lines; these are real for the hyperbolic paraboloid and the hyperboloid of one sheet, imaginary in other cases.

At each point of a surface the chief-tangents determine two directions; and passing along one of them to a consecutive point, and thence (without abrupt change of direction) along the new chief-tangent to a consecutive point, and so on, we have on the surface a chief-tangent curve; and there are, it is clear, two singly infinite series of such curves. In the case of a quadric surface, the curves are the right lines on the surface.

40. If at the point we draw in the tangent-plane two lines bisecting the angles between the chief-tangents, these lines (which are at right angles to each other) are called the principal tangents.[1] We have thus at each point of the surface a set of rectangular axes, the normal and the two principal tangents.

Proceeding from the point along a principal tangent to a consecutive point on the surface, and thence (without abrupt change of direction) along the new principal tangent to a consecutive point, and so on, we have on the surface a curve of curvature; there are, it is clear, two singly infinite series of such curves, cutting each other at right angles at each point of the surface.

Passing from the given point in an arbitrary direction to a consecutive point on the surface, the normal at the given point is not intersected by the normal at the consecutive point; but passing to the consecutive point along a curve of curvature (or, what is the same thing, along a principal tangent) the normal at the given point is intersected by the normal at the consecutive point; we have thus on the normal two centres of curvature, and the distances of these from the point on the surface are the two principal radii of curvature of the surface at that point; these are also the radii of curvature of the sections of the surface by planes through the normal and the two principal tangents respectively; or say they are the radii of curvature of the normal sections through the two principal tangents respectively. Take at the point the axis of z in the direction of the normal, and those of x and y in the directions of the principal tangents respectively, then, if the radii of curvature be a, b (the signs being such that the co-ordinates of the two centres of curvature are $z=a$ and $z=b$ respectively), the surface has in the neighborhood of the point the form of the paraboloid

$$z=\frac{x^2}{2a}+\frac{y^2}{2b},$$

and the chief-tangents are determined by the equation $0=\frac{x^2}{2a}+\frac{y^2}{2b}$. The two centres of curvature may be on the same side of the point or on opposite sides; in the former case a and b have the same sign, the paraboloid is elliptic, and the chief-tangents are imaginary; in the latter case a and b have opposite signs, the paraboloid is hyperbolic, and the chief-tangents are real.

The normal sections of the surface and the paraboloid by the same plane have the same radius of curvature; and it thence readily follows that the radius of curvature of a normal section of the surface by a plane inclined at an angle θ to that of zx is given by the equation

$$\frac{1}{\rho}=\frac{\cos^2\theta}{a}+\frac{\sin^2\theta}{b}.$$

The section in question is that by a plane through the normal and a line in the tangent plane inclined at an angle θ to the principal tangent along the axis of x. To complete the theory, consider the section by a plane having the same trace upon the tangent plane, but incline to the normal at an angle ϕ; then it is shown without difficulty (Meunier's theorem) that the radius of curvature of this inclined section of the surface is $=\rho\cos\varphi$. (A. CA.)

GEORGE I., king of Great Britain and Ireland (*George Louis*, 1660-1727), born in 1660, was heir through his father Ernest Augustus to the hereditary lay bishopric of Osnabrück, and to the duchy of Calenburg, which formed one portion of the Hanoverian possessions of the house of Brunswick, whilst he secured the reversion of the other portion, the duchy of Celle or Zell, by his marriage (1682) with the heiress, his cousin Sophia Dorothea. The marriage was not a happy one. The morals of German courts in the end of the 17th century took their tone from the splendid profligacy of Versailles. It became the fashion for a prince to amuse himself with a mistress or more frequently with many mistresses simultaneously, and he was often content that the mistresses whom he favored should be neither beautiful nor witty. George Louis followed the usual course. Count Königsmark—a handsome adventurer—seized the opportunity of paying court to the deserted wife. Conjugal infidelity was held at Hanover to be a privilege of the male sex. Count Königsmark was assassinated. Sophia Dorothea was divorced in 1694, and remained in seclusion till her death in 1726. When her descendant in the fourth generation attempted in England to call his wife to account for sins of which he was himself notoriously guilty, free-spoken public opinion reprobated the offence in no measured terms. In the Germany of the 17th century all free-spoken public opinion had been crushed out by the misery of the Thirty Years' War, and it was understood that princes were to arrange their domestic life according to their own pleasure.

The prince's father did much to raise the dignity of his family. By sending help to the emperor when he was struggling against the French and the Turks, he obtained the grant of a ninth electorate in 1692. His marriage with Sophia, the youngest daughter of Elizabeth the daughter of James I. of England, was not one which at first seemed likely to confer any prospect of advancement to his family. But though there were many persons whose birth gave them better claims than she had to the English crown, she found herself, upon the death of the duke of Gloucester, the next Protestant heir after Anne. The Act of Settlement in 1701 secured the inheritance to herself and her descendants. Being old and unambitious she rather permitted herself to be burthened with the honor than thrust herself forward to meet it. Her son George took a deeper interest in the matter. In his youth he had fought with determined courage in the wars of William III. Succeeding to the electorate on his father's death in 1698, he had sent a welcome reinforcement of Hanoverians to fight under Marlborough at Blenheim. With prudent persistence he attached himself closely to the Whigs and to Marlborough, refusing Tory offers of an independent command, and receiving in return for his fidelity a guarantee by the Dutch of his succession to England in the Barrier treaty of 1709. In 1714 when Anne was growing old, and Bolingbroke and the more reckless Tories were coquetting with the son of James II., the Whigs invited George's eldest son, who was duke of Cambridge, to visit England in order to be on the spot in case of need. Neither the elector nor his mother approved of a step which was likely to alienate the queen, and which was specially distasteful to himself, as he was on very bad terms with his son. Yet they did not set themselves against the strong wish of the party to which they looked for support, and it is possible that troubles would have arisen from any attempt to carry out the plan, if the deaths, first of the electress (May 28) and then of the queen (August 1, 1714), had not laid open George's way to the succession without further effort of his own.

In some respects the position of the new king was not unlike that of William III. a quarter of a century before. Both sovereigns were foreigners, with little knowledge of English politics and little interest in English legislation. Both sovereigns arrived at a time when party spirit had been running high, and when the task before the ruler was to still the waves of contention. In spite of the difference between an intellectually great man and an intellectually small one, in spite too of the difference between the king who began by choosing his ministers from both parties, and the king who persisted in choosing his ministers from only one, the work of pacification was accomplished by George even more thoroughly than by William.

George I. was fortunate in arriving in England when a great military struggle had come to an end. He had therefore no reason to call upon the nation to make great sacrifices. All that he wanted was to secure for himself and his family a high position which he hardly knew how to occupy, to fill the pockets of his German attendants and his German mistresses, to get away as often as possible from the uncongenial islanders whose language he was unable to speak, and to use the strength of England to obtain petty advantages for his German principality. In order to do this he attached himself entirely to the Whig party, though he refused to place himself at the disposal of its leaders. He gave his confidence, not to Somers and Wharton and Marlborough, but to Stanhope and Townshend, the statesmen of the second rank. At first he seemed to be playing a dangerous game. The Tories, whom he rejected, were numerically superior to their adversaries, and were strong in the support of the country gentlemen and the country clergy. The strength of the Whigs lay in the towns and in the higher aristocracy. Below both parties lay the mass of the nation, which cared nothing for politics except in special seasons of excitement, and which asked only to be let alone. In 1715 a Jacobite insurrection in the north, supported by the appearance of the Pretender, the son of James II., in Scotland, was suppressed, and its suppression not only gave to the government a character of stability, but displayed its adversaries in an unfavorable light as the disturbers of the peace.

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[1] The point on the surface may be such that the directions of the principal tangents become arbitrary; the point is then an umbilicus. It is in the text assumed that the point on the surface is not an umbilicus.

Even this advantage, however, would have been thrown away, if the Whigs in power had continued to be animated by violent party spirit. What really happened was that the Tory leaders were excluded from office, but that the principles and prejudices of the Tories were admitted to their full weight in the policy of the government. The natural result followed. The leaders to whom no regard was paid continued in opposition. The rank and file who would personally have gained nothing by a party victory were conciliated into quiescence.

This mingling of two policies was conspicuous both in the foreign and the domestic actions of the reign. In the days of Queen Anne, the Whig party had advocated the continuance of war with a view to the complete humiliation of the king of France, whom they feared as the protector of the Pretender, and in whose family connection with the king of Spain they saw a danger for England. The Tory party on the other hand had been the authors of the peace of Utrecht, and held that France was sufficiently depressed. A fortunate concurrence of circumstances enabled George's ministers, by an alliance with the regent of France, the duke of Orleans, to pursue at the same time the Whig policy of separating France from Spain and from the cause of the Pretender, and the Tory policy of the maintenance of a good understanding with their neighbor across the Channel. The same eclecticism was discernible in the proceedings of the home government. The Whigs were conciliated by the repeal of the Schism Act and the Occasional Conformity Act, whilst the Tories were conciliated by the maintenance of the Test Act in all its vigor. The satisfaction of the masses was increased by the general wellbeing of the nation.

Very little of all that was thus accomplished was directly owing to George I. The policy of the reign is the policy of his ministers. Stanhope and Townshend from 1714 to 1717 were mainly occupied with the defence of the Hanoverian settlement. After the dismissal of the latter in 1717, Stanhope in conjunction with Sunderland took up a more decided Whig policy. The Occasional Conformity Act and the Schism Act were repealed in 1719. But the wish of the liberal Whigs to modify if not to repeal the Test Act remained unsatisfied. In the following year the bursting of the South Sea bubble, and the subsequent deaths of Stanhope in 1721 and of Sunderland in 1722, cleared the way for the accession to power of Sir Robert Walpole, to whom and not to the king was due the conciliatory policy which quieted Tory opposition by abstaining from pushing Whig principles to their legitimate consequences.

Nevertheless something of the honor due to Walpole must be reckoned to the king's credit. It is evident that at his accession his decisions were by no means unimportant. The royal authority was still able within certain limits to make its own terms. This support was so necessary to the Whigs that they made no resistance when he threw aside their leaders on his arrival in England. When by his personal intervention he dismissed Townshend and appointed Sunderland, he had no such social and parliamentary combination to fear as that which almost mastered his great-grandson in his struggle for power. If such a combination arose before the end of his reign it was owing more to his omitting to fulfil the duties of his station than from the necessity of the case. As he could talk no English, and his ministers could talk no German, he absented himself from the meetings of the cabinet, and his frequent absences from England and his want of interest in English politics strengthened the cabinet in its tendency to assert an independent position. Walpole at last by his skill in the management of parliament rose as a subject into the almost royal position denoted by the name of prime minister. In connection with Walpole the force of wealth and station established the Whig aristocracy in a point of vantage from which it was afterwards difficult to dislodge them. Yet, though George had allowed the power which had been exercised by William and Anne to slip through his hands, it was understood to the last that if he chose to exert himself he might cease to be a mere cipher in the conduct of affairs. As late as in 1727 Bolingbroke gained over one of the king's mistresses, the duchess of Kendal; and though her support of the fallen Jacobite took no effect, Walpole was not without fear that her reiterated entreaties would lead to his dismissal. The king's death in a carriage on his way to Hanover, in the night between 10th and 11th June in the same year, put an end to these apprehensions.

His only children were his successor George II., and Sophia Dorothea (1687–1757), who married in 1706 Frederick William, crown prince (afterwards king) of Prussia. She was the mother of Frederick the Great. (S. R. G.)

GEORGE II. (*George Augustus*, 1683–1760), the only son of George I., was born in 1683. In 1705 he married Wilhelmina Caroline of Anspach. In 1706 he was created earl of Cambridge. In 1708 he fought bravely at Oudenarde. At his father's accession to the English throne he was thirty-one years of age. He was already on bad terms with his father. The position of an heir-apparent is in no case an easy one to fill with dignity, and the ill treatment of the prince's mother by his father was not likely to strengthen in him a reverence for paternal authority. It was most unwillingly that, on his first journey to Hanover in 1716, George I. appointed the prince of Wales guardian of the realm during his absence. In 1717 the existing ill feeling ripened into an open breach. At the baptism of one of his children, the prince selected one godfather whilst the king persisted in selecting another. The young man spoke angrily, was ordered into arrest, and was subsequently commanded to leave St. James's, and to be excluded from all court ceremonies. The prince took up his residence at Leicester House, and did everything in his power to support the opposition against his father's ministers.

When therefore George I. died in 1727, it was generally supposed that Walpole would be at once dismissed. The first direction of the new king was that Sir Spencer Compton would draw up the speech in which he was to announce to the Privy Council his accession. Compton, not knowing how to set about his task, applied to Walpole for aid. The queen took advantage of this evidence of incapacity, advocated Walpole's cause with her husband, and procured his continuance in office. This curious scene was indicative of the course likely to be taken by the new sovereign. His own mind was incapable of rising above the merest details of business. He made war in the spirit of a drill-sergeant, and he economized his income with the minute regularity of a clerk. A blunder of a master of the ceremonies in marshalling the attendants on a levee put him out of temper. He took the greatest pleasure in counting his money piece by piece, and he never forgot a date. He was above all things methodical and regular. "He seems," said one who knew him well, "to think his having done a thing to-day an unanswerable reason for his doing it to-morrow."

Most men so utterly immersed in details would be very impracticable to deal with. They would obstinately refuse to listen to a wisdom and prudence which meant nothing in their ears, and which brought home to them a sense of their own inferiority. It was the happy peculiarity of George II. that he was exempt from this failing. He seemed to have an instinctive understanding that such and such persons were either wiser or even stronger than himself, and when he had once discovered that, he gave way with scarcely a struggle. Thus it was that, though in his domestic relations he was as loose a liver as his father had been, he allowed himself to be guided by the wise but unobtrusive counsels of his wife until her death in 1737, and that when once he had recognized Walpole's superiority he allowed himself to be guided by the political sagacity of the great minister. It is difficult to exaggerate the importance of such a temper upon the development of the constitution. The apathy of the nation in all but the most exciting political questions, fostered by the calculated conservatism of Walpole, had thrown power into the hands of the great landowners. They maintained their authority by supporting a minister who was ready to make use of corruption, wherever corruption was likely to be useful, and who could veil over the baseness of the means which he employed by his talents in debate and in finance. To shake off a combination so strong would not have been easy. George II. submitted to it without a struggle.

So strong indeed had the Whig aristocracy grown that it began to lose its cohesion. Walpole was determined to monopolize power, and he dismissed from office all who ventured to oppose him. An Opposition formidable in talents was gradually formed. In its composite ranks were to be found Tories and discontented Whigs, discarded official hacks who were hungry for the emoluments of office, and youthful purists who fancied that if Walpole were removed, bribes and pensions would cease to be attractive to a corrupt generation. Behind them was Bolingbroke, excluded from parliament but suggesting every party move. In 1737 the opposition acquired the support of Frederick, prince of Wales. The young man, weak and headstrong, rebelled against the strict discipline exacted by his father. His marriage in 1736 to Augusta of Saxony brought on an open quarrel. In 1737 just as the princess of Wales was about to give birth to her first child, she was hurried away by her husband from Hampton Court to St. James's Palace at the imminent risk of her life, simply in order that the prince might show his spite to his father who had provided all necessary attendance at the former place. George ordered his son to quit St. James's, and to absent himself from court. Frederick in disgrace gave the support of his name, and he had nothing else to give, to the Opposition. Later in the year 1737, on November 20, Queen Caroline died. In 1742 Walpole, weighed down by the unpopularity both of his reluctance to engage in a war with Spain and of his supposed remissness in conducting the operations of that war, was driven from office. His successors formed a composite ministry in which Walpole's old colleagues and Walpole's old opponents were alike to be found.

The years which followed settled conclusively, at least for this reign, the constitutional question of the power of appointing ministers. The war between Spain and England had broken out in 1739. In 1741 the death of the emperor Charles VI. brought on the war of the Austrian succession. The position of George II. as a Hanoverian prince drew him to the side of Maria Theresa through jealousy of the rising Prussian monarchy. Jealousy of France led England in the same direction, and in 1741 a subsidy of £300,000 was voted to Maria Theresa. The king himself went to Germany and attempted to carry on the war according to his own notions. Those notions led him to regard the safety of Hanover as of far more importance than the wishes of England. Finding that a French army was about to march upon his German states, he concluded with France a treaty of neutrality for a year without consulting a single English minister. In England the news was received with feelings of disgust. The expenditure of English money and troops was to be thrown uselessly away as soon as it appeared that Hanover was in the slightest danger. In 1742 Walpole was no longer in office. Lord Wilmington, the nominal head of the ministry, was a mere cipher. The ablest and most energetic of his colleagues, Lord Carteret, attached himself specially to the king, and sought to maintain himself in power by his special favor and by brilliant achievements in diplomacy.

In part at least by Carteret's mediation the peace of Breslau was signed, by which Maria Theresa ceded Silesia to Frederick (July 28, 1742). Thus relieved on her northern frontier, she struck out vigorously towards the west. Bavaria was overrun by her troops. In the beginning of 1743 one French army was driven across the Rhine. On June 27th another French army was defeated by George II. in person at Dettingen. Victory brought elation to Maria Theresa. Her war of defence was turned into a war of vengeance. Bavaria was to be annexed. The French frontier was to be driven back. George II. and Carteret after some hesitation placed themselves on her side. Of the public opinion of the political classes in England they took no thought. Hanoverian troops were indeed to be employed in the war, but they were to be taken into British pay. Collisions between British and Hanoverian officers were frequent. A storm arose against the preference shown to Hanoverian interests. After a brief struggle Carteret, having become Lord Granville by his mother's death, was driven from office in November, 1744.

Henry Pelham, who had become prime minister in the preceding year, thus saw himself established in power. By the acceptance of this ministry, the king acknowledged that the function of choosing a ministry and directing a policy had passed from his hands. In 1745 indeed he recalled Granville, but a few days were sufficient to convince him of the futility of his attempt, and the effort to exclude Pitt at a later time proved equally fruitless.

Important as were the events of the remainder of the reign, therefore, they can hardly be grouped round the name of George II. The resistance to the invasion of the young Pretender in 1745, the peace of Aix-la-Chapelle in 1748, the great war ministry of Pitt at the close of the reign, did not receive their impulse from him. He had indeed done his best to exclude Pitt from office. He disliked him on account of his opposition in former years to the sacrifices demanded by the Hanoverian connection. When in 1756 Pitt became secretary of state in the Devonshire administration, the King bore the yoke with difficulty. Early in the next year he complained of Pitt's long speeches as being above his comprehension, and on April 5, 1757, he dismissed him, only to take him back shortly after, when Pitt, coalescing with Newcastle, became master of the situation. Before Pitt's dismissal George II. had for once an opportunity of placing himself on the popular side, though, as was the case of his grandson during the American war, it was when the popular side happened to be in the wrong. In the true spirit of a martinet, he wished to see Admiral Byng executed. Pitt urged the wish of the House of Commons to have him pardoned. "Sir," replied the king, "you have taught me to look for the sense of my subjects in another place than in the House of Commons." When George II. died in 1760, he left behind him a settled understanding that the monarchy was one of the least of the forces by which the policy of the country was directed. To this end he had contributed much by his disregard of English opinion in 1743; but it may fairly be added that, but for his readiness to give way to irresistible adversaries, the struggle might have been far more bitter and severe than it was.

Of the connection between Hanover and England in this reign two memorials remain more pleasant to contemplate than the records of parliamentary and ministerial intrigues. With the support of George II., amidst the derision of the English fashionable world, the Hanoverian Handel produced in England those masterpieces which have given delight to millions, whilst the foundation of the university of Göttingen by the same king opened a door through which English political ideas afterwards penetrated into Germany.

George II. had three sons—Frederick Louis (1707–1751); George William (1717–1718; and William Augustus, duke of Cumberland (1721–1765); and five daughters, Anne (1709–1759), married to William, prince of Orange, 1734; Amelia Sophia Eleonora (1711–1786); Elizabeth Caroline (1713–1757); Mary (1723–1772), married to Frederick, landgrave of Hesse Cassel, 1740; Louisa (1724–1751), married to Frederick V., king of Denmark, 1743. (S. R. G.)

GEORGE III. (*George William Frederick*, 1738–1820), born 4th June, 1738, was the son of Frederick prince of Wales and the grandson of George II., whom he succeeded in 1760. After his father's death in 1751 he had been educated in seclusion from the fashionable world under the care of his mother and of her favorite counsellor the earl of Bute. He had been taught to revere the maxims of Bolingbroke's "Patriot King," and to believe that it was his appointed task in life to break the power of the Whig houses resting upon extensive property and the influence of patronage and corruption.

That power had already been gravely shaken. The Whigs from their incompetency were obliged when the

Seven Years' War broke out to leave its management in the hands of William Pitt. The nation learned to applaud the great war minister who succeeded where others had failed, and whose immaculate purity put to shame the ruck of barterers of votes for places and pensions. In some sort the work of the new king was the continuation of the work of Pitt. But his methods were very different. He did not appeal to any widely spread feeling or prejudice; nor did he disdain the use of the arts which had maintained his opponents in power. The patronage of the crown was to be really as well as nominally his own; and he calculated, not without reason, that men would feel more flattered in accepting a place from a king than from a minister. The new Toryism of which he was the founder was no recurrence to the Toryism of the days of Charles II. or even of Anne. The question of the amount of toleration to be accorded to Dissenters had been entirely laid asleep. The point at issue was whether the crown should be replaced in the position which George I. might have occupied at the beginning of his reign, selecting the ministers and influencing the deliberations of the cabinet. For this struggle George III. possessed no inconsiderable advantages. With an inflexible tenacity of purpose, he was always ready to give way when resistance was really hopeless. As the first English-born sovereign of his house, speaking from his birth the language of his subjects, he found a way to the hearts of many who never regarded his predecessors as other than foreign intruders. The contrast, too, between the pure domestic life which he led with his wife Charlotte of Mecklenburg-Strelitz, whom he married in 1761, and the habits of three generations of his house, told in his favor with the vast majority of his subjects. Even his marriage had been a sacrifice to duty. Soon after his accession, he had fallen in love with Lady Sarah Lennox, and had been observed to ride morning by morning along the Kensington Road, from which the object of his affections was to be seen from the lawn of Holland House making hay, or engaged in some other ostensible employment. Before the year was over Lady Sarah appeared as one of the queen's bridesmaids, and she was herself married to Sir Charles Bunbury in 1762.

At first everything seemed easy to him. Pitt had come to be regarded by his own colleagues as a minister who would pursue war at any price, and in getting rid of Pitt in 1761 and in carrying on the negotiations which led to the peace of Paris in 1762, the king was able to gather round him many persons who would not be willing to acquiesce in any permanent change in the system of government. With the signature of the peace his real difficulties began. The Whig houses, indeed, were divided amongst themselves by personal rivalries. But they were none of them inclined to let power and the advantages of power slip from their hands without a struggle. For some years a contest of influence was carried on without dignity and without any worthy aim. The king was not strong enough to impose upon parliament a ministry of his own choice. But he gathered round himself a body of dependants known as the king's friends, who were secure of his favor, and who voted one way or the other according to his wishes. Under these circumstances no ministry could possibly be stable; and yet every ministry was strong enough to impose some conditions on the king. Lord Bute, the king's first choice, resigned from a sense of his own incompetency in 1763. George Grenville was in office till 1765; the marquis of Rockingham till 1766; Pitt, becoming earl of Chatham, till illness compelled him to retire from the conduct of affairs in 1767, when he was succeeded by the duke of Grafton. But a struggle of interests could gain no real strength for any Government, and the only chance the king had of effecting a permanent change in the balance of power lay in the possibility of his associating himself with some phase of strong national feeling, as Pitt had associated himself with the war feeling caused by the dissatisfaction spread by the weakness and ineptitude of his predecessors.

Such a chance was offered by the question of the right to tax America. The notion that England was justified in throwing on America part of the expenses caused in the late war was popular in the country, and no one adopted it more pertinaciously than George III. At the bottom the position which he assumed was as contrary to the principles of parliamentary government as the encroachments of Charles I. had been. But it was veiled in the eyes of Englishmen by the prominence given to the power of the British parliament rather than to the power of the British king. In fact the theory of parliamentary government, like most theories after their truth has long been universally acknowledged, had become a superstition. Parliaments were held to be properly vested with authority, not because they adequately represented the national will, but simply because they were parliaments. There were thousands of people in England to whom it never occurred that there was any good reason why a British parliament should be allowed to levy a duty on tea in the London docks and should not be allowed to levy a duty on tea at the wharves of Boston. Undoubtedly George III. derived great strength from his honest participation in this mistake. Contending under parliamentary forms, he did not wound the susceptibilities of members of parliament, and when at last in 1770 he appointed Lord North—a minister of his own selection—prime minister, the object of his ambition was achieved with the concurrence of a large body of politicians who had nothing in common with the servile band of the king's friends.

As long as the struggle with America was carried on with any hope of success they gained that kind of support which is always forthcoming to a Government which shares in the errors and prejudices of its subjects. The expulsion of Wilkes from the House of Commons in 1769, and the refusal of the House to accept him as a member after his re-election, raised a grave constitutional question in which the king was wholly in the wrong; and Wilkes was popular in London and Middlesex. But his case roused no national indignation, and when in 1774 those sharp measures were taken with Boston which led to the commencement of the American rebellion in 1775, the opposition to the course taken by the king made little way either in parliament or in the country. Burke might point out the folly and inexpedience of the proceedings of the Government. Chatham might point out that the true spirit of English government was to be representative, and that that spirit was being violated at home and abroad. George III., who thought that the first duty of the Americans was to obey himself, had on his side the mass of unreflecting Englishmen who thought that the first duty of all colonists was to be useful and submissive to the mother-country. The natural dislike of every country engaged in war to see itself defeated was on his side, and when the news of Burgoyne's surrender at Saratoga arrived in 1777, subscriptions of money to raise new regiments poured freely in.

In March, 1778, the French ambassador in London announced that a treaty of friendship and commerce had been concluded between France and the new United States of America. Lord North was anxious to resign power into stronger hands, and begged the king to receive Chatham as his prime minister. The king would not hear of it. He would have nothing to say to "that perfidious man" unless he would humble himself to enter the ministry as North's subordinate. Chatham naturally refused to do anything of the kind, and his death in the course of the year relieved the king of the danger of being again overruled by too overbearing a minister. England was now at war with France, and in 1779 she was also at war with Spain.

George III. was still able to control the disposition of office. He could not control the course of events. His very ministers gave up the struggle as hopeless long before he would acknowledge the true state of the case. Before the end of 1779, two of the leading members of the cabinet, Lords Gower and Weymouth, resigned rather than bear the responsibility of so ruinous an enterprise as the attempt to overpower America and France together. Lord North retained office, but he acknowledged to the king that his own opinion was precisely the same as that of his late colleagues.

The year 1780 saw an agitation rising in the country for economical reform, an agitation very closely though indirectly connected with the war policy of the king. The public meetings held in the country on this subject have no unimportant place in the development of the constitution. Since the presentation of the Kentish Petition in the reign of William III. there had been from time to time upheavings of popular feeling against the doings of the legislature, which kept up the tradition that parliament existed in order to represent the nation. But these upheavings had all been so associated with ignorance and violence as to make it very difficult for men of sense to look with displeasure upon the existing emancipation of the House of Commons from popular control. The Sacheverel riots, the violent attacks upon the Excise Bill, the no less violent advocacy of the Spanish war, the declamations of the supporters of Wilkes at a more recent time, and even in this very year the Gordon riots, were not likely to make thoughtful men anxious to place real power in the hands of the classes from whom such exhibitions of folly proceeded. But the movement for economical reform was of a very different kind. It was carried on soberly in manner, and with a definite practical object. It asked for no more than the king ought to have been willing to concede. It attacked useless expenditure upon sinecures and unnecessary offices in the household, the only use of which was to spread abroad corruption amongst the upper classes. George III. could not bear to be interfered with at all, or to surrender any element of power which had served him in his long struggle with the Whigs. He held out for more than another year. The news of the capitulation of York Town reached London on November 25, 1781. On March 20, 1782, Lord North resigned.

George III. accepted the consequences of defeat. He called the marquis of Rockingham to office at the head of a ministry composed of pure Whigs and of the disciples of the late earl of Chatham, and he authorized the new ministry to open negotiations for peace. Their hands were greatly strengthened by Rodney's victory over the French fleet, and the failure of the combined French and Spanish attack upon Gibraltar; and before the end of 1782 a provisional treaty was signed with America, preliminaries of peace with France and Spain being signed early in the following year. On September 3, 1783, the definitive treaties with the three countries were simultaneously concluded. "Sir," said the king to Mr. Adams the first minister of the United States of America accredited to him, "I wish you to believe, and that it may be understood in America, that I have done nothing in the late contest but what I thought myself indispensably bound to do by the duty which I owed to my people. I will be very frank with you. I was the last to consent to the separation; but the separation having been made and having become inevitable, I have always said, as I say now, that I would be the first to meet the friendship of the United States as an independent power."

Long before the signature of the treaties Rockingham died (July 1, 1782). The king chose Lord Shelburne, the head of the Chatham section of the Government, to be prime minister. Fox and the followers of Rockingham refused to serve except under the duke of Portland, a minister of their own selection, and resigned office. The old constitutional struggle of the reign was now to be fought out once more. Fox, too weak to obtain a majority alone, coalesced with Lord North, and defeated Shelburne in the House of Commons on February 17, 1783. On April 2 the coalition took office, with Portland as nominal prime minister, and Fox and North the secretaries of state as its real heads.

This attempt to impose upon him a ministry which he disliked made the king very angry. But the new cabinet had a large majority in the House of Commons, and the only chance of resisting it lay in an appeal to the country against the House of Commons. Such an appeal was not likely to be responded to unless the ministers discredited themselves with the nation. George III. therefore waited his time. Though a coalition between men bitterly opposed to one another in all political principles and drawn together by nothing but love of office was in itself discreditable, it needed some more positive cause of dissatisfaction to arouse the constituencies, which were by no means so ready to interfere in political disputes at that time as they are now. Such dissatisfaction was given by the India Bill, drawn up by Burke. As soon as it had passed through the Commons the king hastened to procure its rejection in the House of Lords by his personal intervention with the Peers. He authorized Lord Temple to declare in his name that he would count any peer who voted for the Bill as his enemy. On December 17, 1783, the Bill was thrown out. The next day ministers were dismissed. William Pitt became prime minister. After some weeks' struggle with a constantly decreasing majority in the Commons, the king dissolved parliament on March 25, 1784. The country rallied round the crown and the young minister, and Pitt was firmly established in office.

Since the publication of a letter from Mr. Orde in Lord E. Fitzmaurice's *Life of Shelburne* (iii. 393) there can be no reasonable doubt that Pitt not only took advantage of the king's intervention in the Lords, but was cognizant of the intrigue before it was actually carried out. It was upon him too that the weight of reconciling the country to an administration formed under such circumstances lay. How he acquitted himself under the task, what were his great achievements, and what his still greater unaccomplished projects should be told in connection with his name rather than with that of the king. The general result, so far as George III. was concerned, was that to all outward appearance he had won the great battle of his life. It was he who was to appoint the prime minister, not any clique resting on a parliamentary support. But the circumstances under which the victory was won were such as to place the constitution in a position very different from that in which it would have been if the victory had been gained earlier in the reign. Intrigue there was indeed in 1783 and 1784 as there had been twenty years before. Parliamentary support was conciliated by Pitt by the grant of royal favors as it had been in the days of Bute. The actual blow was struck by a most questionable message to individual peers. But the main result of the whole political situation was that George III. had gone a long way towards disentangling the reality of parliamentary government from its accidents. His ministry finally stood because it had appealed to the constituencies against their representatives. At the present day it has properly become a constitutional axiom that no such appeal should be made by the crown itself. But it may reasonably be doubted whether any one but the king was at that time capable of making the appeal. Lord Shelburne, the leader of the ministry expelled by the coalition, was unpopular in the country, and the younger Pitt had not had time to make his great abilities known beyond a limited circle. The real question for the constitutional historian to settle is not whether under ordinary circumstances a king is the proper person to place himself really as well as nominally at the head of the government; but whether under the special circumstances which existed in 1783 it was not better that the king should call upon the people to support him, than that government should be left in the hands of men who rested their power on close boroughs and the dispensation of patronage, without looking beyond the walls of the House of Commons for support.

Of the glories of Pitt's ministry this is not the place to write. That the king gained credit by them far beyond his own deserts is beyond a doubt. Nor can there be any reasonable doubt that his own example of domestic propriety did much to strengthen the position of his minister. It is true that that life was unsufferably dull. No gleams of literary or artistic taste lightened it up. The dependants of the court became inured to dull routine unchequered by loving sympathy. The sons of the household were driven by the sheer weariness of such an existence into the coarsest profligacy. But all this was not visible from a distance. The tide of moral and religious improvement which had set in in England since the days of Wesley brought popularity to a king who was faithful to his wife, in the same way that the tide of manufacturing industry and scientific progress brought popularity to the minister who in some measure translated into practice the principles of the *Wealth of Nations*.

Nor were there wanting subjects of importance beyond the circle of politics in which George III. showed a lively interest. The voyages of discovery which made known so large a part of the islands and coasts of the Pacific Ocean received from him a warm support. In the early days of the Royal Academy, its finances were strengthened by liberal grants from the privy purse. His favorite pursuit, however, was farming. When Arthur Young was issuing his *Annals of Agriculture*, he was supplied with information by the king, under the assumed name of Mr. Ralph Robinson, relating to a farm at Petersham.

The life of the king was suddenly clouded over. Early in his reign, in 1765, he had been out of health, and it is now known—what was studiously concealed at the time—

that symptoms of mental aberration were even then to be perceived. In October, 1788, he was again out of health, and in the beginning of the following month his insanity was beyond a doubt. Whilst Pitt and Fox were contending in the House of Commons over the terms on which the regency should be committed to the prince of Wales, the king was a helpless victim to the ignorance of physicians and the brutalities of his servants. At last Dr. Willis, who had made himself a name by prescribing gentleness instead of rigor in the treatment of the insane, was called in. Under his more humane management the king rapidly recovered. Before the end of February, 1789, he was able to write to Pitt thanking him for his warm support of his interests during his illness. On April 23 he went in person to St. Paul's to return thanks for his recovery.

The popular enthusiasm which burst forth around St. Paul's was but a foretaste of a popularity far more universal. The French Revolution frightened the great Whig landowners till they made their peace with the king. Those who thought that the true basis of government was aristocratical were now of one mind with those who thought that the true basis of government was monarchical; and these two classes were joined by a far larger multitude which had no political ideas whatever but which had a moral horror of the guillotine. As Elizabeth had once been the symbol of resistance to Spain, George was now the symbol of resistance to France. He was not, however, more than the symbol. He allowed Pitt to levy taxes and incur debts, to launch armies to defeat, and to prosecute the English imitators of French revolutionary courses. At last, however, after the Union with Ireland was accomplished, he learned that Pitt was planning a scheme to relieve the Catholics from the disabilities under which they labored. The plan was revealed to him by the chancellor, Lord Loughborough, a selfish and intriguing politician who had served all parties in turn, and who sought to forward his own interests by falling in with the king's prejudices. George III. at once took up the position from which he never swerved. He declared that to grant concessions to the Catholics involved a breach of his coronation oath. All thinking men of a later generation are of opinion that the objection was untenable. But no one has ever doubted that the king was absolutely convinced of the serious nature of the objection, or that he believed the measure itself to be beyond measure injurious to church and state. Nor can there be any doubt that he had the English people behind him. Both in his peace ministry and in his war ministry Pitt had taken his stand on royal favor and on popular support. Both failed him alike now, and he resigned office at once. The shock to the king's mind was so great that it brought on a fresh attack of insanity. This time, however, the recovery was rapid. On March 14, 1801, Pitt's resignation was formally accepted, and the late speaker, Mr. Addington, was installed in office as prime minister.

The king was well pleased with the change. He was never capable of appreciating high merit in any one; and he was unable to perceive that the question on which Pitt had resigned was more than an improper question, with which he ought never to have meddled. "Tell him," he said, in directing his physician to inform Pitt of his restoration to health, "I am now quite well, quite recovered from my illness; but what has he not to answer for, who has been the cause of my having been ill at all?" Addington was a minister after his own mind. Thoroughly honest and respectable, with about the same share of abilities as was possessed by the king himself, he was certainly not likely to startle the world by any flights of genius. But for one circumstance Addington's ministry would have lasted long. So strong was the reaction against the Revolution that the bulk of the nation was almost as suspicious of genius as the king himself. Not only was there no outcry for legislative reforms, but the very idea of reform was unpopular. The country gentlemen were predominant in parliament, and the country gentlemen as a body looked upon Addington with respect and affection. Such a minister was therefore admirably suited to preside over affairs at home in the existing state of opinion. But those who were content with inaction at home would not be content with inaction abroad. In time of peace Addington would have been popular for a season. In time of war even his warmest admirers could not say that he was the man to direct armies in the most terrible struggle which had ever been conducted by an English Government.

For the moment this difficulty was not felt. On October 1, 1801, preliminaries of peace were signed between England and France, to be converted into the definitive peace of Amiens on March 27, 1802. The ruler of France was now Napoleon Bonaparte, and few persons in England believed that he had any real purpose of bringing his aggressive violence to an end. "Do you know what I call this peace?" said the king; "an experimental peace, for it is nothing else. But it was unavoidable."

The king was right. On May 18, 1803, the declaration of war was laid before parliament. The war was accepted by all classes as inevitable, and the French preparations for an invasion of England roused the whole nation to a glow of enthusiasm only equalled by that felt when the Armada threatened our shores. On October 26 the king reviewed the London volunteers in Hyde Park. He found himself the centre of a great national movement with which he heartily sympathized, and which heartily sympathized with him.

On February 12, 1804, the king's mind was again affected. When he recovered, he found himself in the midst of a ministerial crisis. Public feeling allowed but one opinion to prevail in the country,—that Pitt, not Addington, was the proper man to conduct the administration in time of war. Pitt was anxious to form an administration on a broad basis, including Fox and all prominent leaders of both parties. The king would not hear of the admission of Fox. His dislike of him was personal as well as political, as he knew that Fox had had a great share in drawing the prince of Wales into a life of profligacy. Pitt accepted the king's terms, and formed an administration in which he was the only man of real ability. Eminent men such as Lord Grenville refused to join a ministry from which the king had excluded a great statesman on purely personal grounds.

The whole question was reopened on Pitt's death on January 23, 1806. This time the king gave way. The ministry of All the Talents, as it was called, included Fox amongst its members. At first the king was observed to appear depressed at the necessity of surrender. But Fox's charm of manner soon gained upon him. "Mr. Fox," said the king, "I little thought that you and I should ever meet again in this place; but I have no desire to look back upon old grievances, and you may rest assured I never shall remind you of them." On September 13 Fox died, and it was not long before the king and the ministry were openly in collision. The ministry proposed a measure enabling all subjects of the crown to serve in the army and navy in spite of religious disqualifications. The king objected even to so slight a modification of the laws against the Catholics and Dissenters, and the ministers consented to drop the bill. The king asked more than this. He demanded a written and positive engagement that this ministry would never, under any circumstances, propose to him "any measure of concession to the Catholics, or even connected with the question." The ministers very properly refused to bind themselves for the future. They were consequently turned out of office, and a new ministry was formed with the duke of Portland as first lord of the treasury and Mr. Perceval as its real leader. The spirit of the new ministry was distinct hostility to the Catholic claims. On April 27, 1807, a dissolution of parliament was announced, and a majority in favor of the king's ministry was returned in the elections which speedily followed.

The elections of 1807, like the elections of 1784, gave the king the mastery of the situation. In other respects they were the counterpart of one another. In 1784 the country declared, though perhaps without any clear conception of what it was doing, for a wise and progressive policy. In 1807 it declared for an unwise and retrogressive policy, with a very clear understanding of what it meant. It is in his reliance upon the prejudices and ignorance of the country that the constitutional significance of the reign of George III. appears. Every strong Government derives its power from its representative character. At a time when the House of Commons was less really representative than at any other, a king was on the throne who represented the country in its good and bad qualities alike, in its hatred of revolutionary violence, its moral sturdiness, its contempt of foreigners, and its defiance of all ideas which were in any way strange. Therefore it was that his success was not permanently injurious to the working of the constitution as the success of Charles I. would have been. If he were followed by a king less English than himself, the strength of representative power would pass into other hands than those which held the sceptre.

The overthrow of the ministry of All the Talents was the last political act of constitutional importance in which George III. took part. The substitution of Perceval for Portland as the nominal head of the ministry in 1809 was not an event of any real significance, and in 1811 the reign practically came to an end. The king's reason finally broke down after the death of the Princess Amelia, his favorite child. The remaining nine years of his life were passed in insanity and blindness, and when he died on January 29, 1820, in his eighty-second year, no political results were to be anticipated.

George III. had nine sons. After his successor came Frederick, duke of York and Albany (1763–1827); William Henry, duke of Clarence, afterwards King William IV. (1765–1837); Edward Augustus, duke of Kent (1767–1825), father of Queen Victoria; Ernest Augustus, duke of Cumberland, afterwards king of Hanover (1771–1851); Augustus Frederick, duke of Sussex (1773–1843); Adolphus Frederick, duke of Cambridge (1774–1850); Octavius (1779–1783); Alfred (1780–1782). He had also six daughters—Charlotte Augusta (1766–1816), married in 1797 to Frederick, king of Würtemberg; Augusta Sophia (1768–1840); Elizabeth (1770–1840), married Frederick landgrave of Hesse-Homburg, 1818; Mary (1776–1857), married to William Frederick, duke of Gloucester, 1816; Sophia (1777–1848); Amelia (1783–1810). (S. R. G.)

GEORGE IV. (*George Augustus Frederick*, 1762–1830), lived long enough to strip the crown of the leadership of the nation which his father had won for it. Born on August 12, 1762, he was noted in the years of his early manhood for good looks, for ease of carriage, and graciousness of manner. He soon plunged into the whirl of sensual excitement. His life was passed in the grossest profligacy. He was false as well as licentious. His word was never to be trusted. Not even an occasional gleam of brightness lights up the dark picture of his career. If he now and then flung to a dependant a kindly word which cost him nothing, no serious project of well-doing ever occupied his thoughts. Politics had no attraction for him except so far as changes of Government might minister to his ease, or bring him money to be squandered in some new scheme of folly.

Such a character was probably beyond the reach of any education. But it is certain that the education which he received in the strict and formal domestic circle of his parents was only fitted to repel him from the path of virtue. His father became to him the type of uninteresting formality. He gladly sought the society of his father's Whig opponents, and was initiated by Fox and Sheridan in the vices of the fashionable world. In 1783 he naturally supported the coalition ministry which his father detested, and the coalition ministry in return proposed to raise his income from £50,000 to £100,000. The king saved the ministry from committing one more blunder in its career by refusing to sanction the proposition. In 1786 the prince's friends urged Pitt to increase the allowance, but Pitt refused to do anything of the kind. All the world knew that the money would be frittered away at the gambling table or in some other equally disreputable way. Applying to the king and getting a distinct refusal, the prince sold his horses and carriages, shut up his house, and dismissed his servants. As it was well known that these were not the expenses which had brought him to distress, he was only laughed at for his pains. A lower depth was soon reached. The prince fell in love with Mrs. Fitzherbert who had been twice a widow at twenty-five. She was ready to marry him, but she would yield to him on no other terms. She was a Roman Catholic, and the marriage by the heir of the crown with a Roman Catholic forfeited his succession by the Act of Settlement. Nor, by the Royal Marriage Act, could he legally contract marriage even with a Protestant without his father's consent, unless at the end of a year after formal notice had been given, and then only if parliament had not expressed its disapprobation. Believing truly that he could contract no legal marriage with Mrs. Fitzherbert, he was quite ready to go through the form of marriage. Mrs. Fitzherbert, holding that the performance of the ceremony by a priest of her church was of sacramental efficacy, was indifferent to the legality of the proceeding. The marriage took place. Not long afterwards, in April, 1787, Alderman Newenham moved in the House of Commons for a grant in relief of the prince. In the course of debate allusion was made to a marriage which might bring in question the succession. Fox went to the prince, and was assured by him that the marriage had never even formally taken place. Fox, deceived by his apparent openness, came down to the House and assured the Commons that the whole story was a malicious falsehood. The next day a friend of Fox's opened his eyes to the trick which had been played on him. "I see by the papers, Mr. Fox," he said, "that you have denied the fact of the marriage of the prince of Wales with Mrs. Fitzherbert. You have been misinformed. I was present at that marriage." The prince was not content with his original falsehood. He threw out hints to his friends that Fox had exceeded his instructions. He led Mrs. Fitzherbert to believe that Fox had uttered the denial unsuggested. "Only conceive, Maria," he said to her, "what Fox did yesterday. He went down to the House and denied that you and I were man and wife." The denial however cleared away for the moment one cause of the prince's unpopularity. With the consent of the Government he received an addition of £10,000 to his income, £161,000 to pay his debts, and £20,000 for the repairs of Carlton House. The temporary insanity of the king in 1788 again brought the prince's name prominently before the public. Fox maintained and Pitt denied that the prince of Wales, as the heir-apparent, had a right to assume the regency independently of any parliamentary vote. Pitt, with the support of both Houses, proposed to confer upon him the regency with certain restrictions. The recovery of the king in February, 1789, put an end to the prince's hopes. During the king's illness he had been in the habit of amusing his companions by mimicry of his unfortunate father. The disgust caused by his behavior had doubtless some part in the enthusiasm with which the king was received when he went in state to St. Paul's to return thanks for his recovery. In 1795 the prince married Caroline of Brunswick, because his father would not pay his debts on any other terms. Her behavior was light and flippant, and he was brutal and unloving. The ill-assorted pair soon parted, and soon after the birth of their only child, the Princess Charlotte, they were formally separated. With great unwillingness the House of Commons voted fresh sums of money to pay the prince's debts. In 1811 the prince at last became regent in consequence of his father's definite insanity. No one doubted at that time that it was in his power to change the ministry at his pleasure. He had always lived in close connection with the Whig opposition, and he now empowered Lord Grenville to form a ministry. There soon arose differences of opinion between them on the answer to be returned to the address of the Houses, and the prince regent then informed the prime minister, Mr. Perceval, that he should continue the existing ministry in office. The ground alleged by him for this desertion of his friends was the fear lest his father's recovery might be rendered impossible if he should come to hear of the advent of the Opposition to power. Lord Wellesley's resignation in February, 1812, made the reconstruction of the ministry inevitable. As there was no longer any hope of the king's recovery, the former objection to a Whig administration no longer existed. Instead of taking the course of inviting the Whigs to take office, he asked them to join the existing administration. The Whig leaders however refused to join, on the ground that the question of the Catholic disabilities was too important to be shelved, and that their difference of opinion with Mr. Perceval was too glaring to be ignored. The prince regent was excessively angry, and continued Perceval in office till that minister's assassination on May 11, when he was succeeded by Lord Liverpool, after a negotiation in which the proposition of entering the cabinet was again made to the Whigs and rejected by them. In the military glories of the following years the prince regent had no share. When the allied sovereigns visited England in 1814, he played the part of host to perfection. So great was his unpopularity at home that hisses were heard in the streets as he accompanied his guests into the city. The disgust which his profligate and luxurious life caused amongst a people suffering from almost universal distress after the conclusion of the war rapidly increased. In 1817 the windows of the prince regent's carriage were broken as he was on his way to open parliament.

The death of George III. on January 29, 1820, gave to his son the title of king without in any way altering the position which he had now held for nine years. Indirectly, however, this change brought out a manifestation of popular feeling such as his father had never been subjected to even in the early days of his reign, when mobs were burning jack-boots and petticoats. The relations between the new king and his wife unavoidably became the subject of public discussion. In 1806 a charge against the princess of having given birth to an illegitimate child had been conclusively disproved, and the old king had consequently refused to withdraw her daughter, the Princess Charlotte, from her custody. When in the regency the prince was able to interfere, and prohibited his wife from seeing her daughter more than once a fortnight. On this, in 1813, the princess addressed to her husband a letter setting forth her complaints, and receiving no answer published it in the *Morning Chronicle.* The prince regent then referred the letter, together with all papers relating to the inquiry of 1806, to a body of twenty-three privy councillors for an opinion whether it was fit that the restrictions on the intercourse between the Princess Charlotte and her mother should continue in force. All except two answered as the regent wished them to answer. But if the official leaning was towards the husband, the leaning of the general public was towards the wife of a man whose own life had not been such as to justify him in complaining of her whom he had thrust from him without a charge of any kind. Addresses of sympathy were sent up to the princess from the city of London and other public bodies. The discord again broke out in 1814 in consequence of the exclusion of the princess from court during the visit of the allied sovereigns. In August in that year she left England, and after a little time took up her abode in Italy. The accession of George IV. brought matters to a crisis. He ordered that no prayer for his wife as queen should be admitted into the Prayer Book. She at once challenged the accusation which was implied in this omission by returning to England. On June 7 she arrived in London. Before she left the Continent she had been informed that proceedings would be taken against her for adultery if she landed in England. Two years before, in 1818, commissioners had been sent to Milan to investigate charges against her, and their report, laid before the cabinet in 1819, was made the basis of the prosecution. On the day on which she arrived in London a message was laid before both Houses recommending the criminating evidence to parliament. A secret committee in the House of Lords after considering this evidence brought in a report on which the prime minister founded a Bill of Pains and Penalties to divorce the queen and to deprive her of her royal title. The bill passed the three readings with diminished majorities, and when on the third reading it obtained only a majority of nine, it was abandoned by the Government. The king's unpopularity, great as it had been before, was now greater than ever. Public opinion, without troubling itself to ask whether the queen was guilty or not, was roused to indignation by the spectacle of such a charge being brought by a husband who had thrust away his wife to fight the battle of life alone, without protection or support, and who, whilst surrounding her with spies to detect, perhaps to invent, her acts of infidelity, was himself living in notorious adultery. In the following year (1821) she attempted to force her way into Westminster Abbey to take her place at the coronation. On this occasion the popular support failed her; and her death not long afterwards relieved the king from further annoyance.

Immediately after the death of the queen, the king set out for Ireland. He remained there but a short time, and his effusive declaration that rank, station, honors, were nothing compared with the exalted happiness of living in the hearts of his Irish subjects gained him a momentary popularity which was beyond his attainment in a country where he was better known. His reception in Dublin encouraged him to attempt a visit to Edinburgh in the following year (August, 1822). Since Charles II. had come to play the sorry part of a covenanting king in 1650 no sovereign of the country had set foot on Scottish soil. Sir Walter Scott took the leading part in organizing his reception. The enthusiasm with which he was received equalled, if it did not surpass, the enthusiasm with which he had been received in Dublin. But the qualities which enabled him to fix the fleeting sympathies of the moment were not such as would enable him to exercise the influence in the government which had been indubitably possessed by his father. He returned from Edinburgh to face the question of the appointment of a secretary of state which had been raised by the death of Lord Londonderry, better known to the world by his earlier title of Castlereagh. It was upon the question of the appointment of ministers that the battle between the Whigs and the king had been fought in the reign of George III. George IV. had neither the firmness nor the moral weight to hold the reins which his father had grasped. He disliked Canning for having taken his wife's side very much as his father had disliked Fox for taking his own. But Lord Liverpool insisted on Canning's admission to office, and the king gave way. Tacitly and without a struggle the constitutional victory of the last reign was surrendered. But it was not surrendered to the same foe as that from which it had been won. The coalition ministry in 1784 rested on the great landowners and the proprietors of rotten boroughs. Lord Liverpool's ministry had hitherto not been very enlightened, and it supported itself to a great extent upon a narrow constituency. But it did appeal to public opinion in a way that the coalition did not, and what it wanted itself in popular support would be supplied by its successors. What one king had gained from a clique another gave up to the nation. Once more, on Lord Liverpool's death in 1827, the same question was tried with the same result. The king not only disliked Canning personally, but he was opposed to Canning's policy. Yet after some hesitation he accepted Canning as prime minister; and when, after Canning's death and the short ministry of Lord Goderich, the king in 1828 authorized the duke of Wellington to form a ministry, he was content to lay down the principle that the members of it were not expected to be unanimous on the Catholic question. When in 1829 the Wellington ministry unexpectedly proposed to introduce a Bill to remove the disabilities of the Catholics, he feebly strove against the proposal and quickly withdrew his opposition. The worn-out debauchee had neither the merit of acquiescing in the change nor the courage to resist it.

George IV. died on June 26, 1830. He had rendered to the constitution of his country the service of tacitly abandoning a position which had been perhaps necessarily achieved by his father, but which it was not desirable that the sovereigns of England should permanently occupy.

His only child by his wife Queen Caroline was the Princess Charlotte Augusta, married in 1816 to Leopold of Saxe-Coburg, afterwards king of the Belgians. She died in childbirth November 6, 1817. (S. R. G.)

GEORGE OF CAPPADOCIA, who from 356 to 361 was Arian archbishop of Alexandria, was born about the beginning of the 4th century. According to Ammianus (xxii. 11), he was a native of Epiphania, in Cilicia; but universal tradition makes him a Cappadocian. Gregory Nazianzen tells us that his father was a fuller, and that he himself soon became notorious as a parasite of so mean a type that he would "sell himself for a cake." By his powers of insinuation he succeeded in obtaining a lucrative contract for supplying bacon to the army, but fulfilled its terms so ill that he was soon compelled to abscond after he had with difficulty escaped death at the hands of the indignant soldiers. After many wanderings, in the course of which he seems to have lived for some time at Constantinople, and to have amassed a considerable fortune as receiver of taxes, he ultimately reached Alexandria. It is not known how or when he obtained ecclesiastical orders; but after Athanasius had been banished in 356, George was promoted by the influence of the then prevalent Arian faction to the vacant see. His persecutions and oppressions of the orthodox ultimately raised a rebellion which compelled him to flee for his life; but his authority was restored, although with difficulty, by a military demonstration. Untaught by experience he resumed his course of selfish tyranny over Christians and heathen alike, and raised the irritation of the populace to such a pitch that, within a few days after the accession of Julian, they rose *en masse*, dragged him out of prison, where he had been placed by the magistrates for safety, paraded him with every indignity through the streets on the back of a camel, burnt his dead body, and cast the ashes into the sea (December 24, 361). With much that was sordid and brutal in his character George combined a highly cultivated literary taste, and in the course of his chequered career he had found the means of collecting a splendid library, which Julian ordered to be carefully preserved and conveyed to Antioch for his own use. The original sources for the facts of the life of George of Cappadocia are Ammianus, Gregory Nazianzen, Epiphanius, and Athanasius. In modern times his character has been drawn with graphic fidelity by Gibbon in the 23d chapter of the *Decline and Fall*.

GEORGE, SAINT, according to Metaphrastes the Byzantine hagiologist, whose narrative is substantially repeated in the Roman *Acta Sanctorum* and in the Spanish breviary, was born in Cappadocia of noble Christian parents, from whom he received a careful religious training. Having embraced the profession of a soldier, he rapidly rose under Diocletian to high military rank. When that emperor had begun to manifest a pronounced hostility towards Christianity George sought a personal interview with him, in which he made a deliberate profession of his faith, and, earnestly remonstrating against the persecution which had begun, resigned his commission. He was immediately laid under arrest, and after various tortures, finally put to death at Nicomedia (or, according to other accounts, at Lydda) April 23, 303. His festival is observed on that anniversary by the entire Roman Church as a semi-duplex, and by the Spanish Catholics as a duplex of the first-class with an octave. The day is also celebrated as a principal feast in the Greek Church, where the saint is distinguished by the titles *μεγαλόμαρτυρ* and *τροπαιοφόρος*.

In the canon of Pope Gelasius (494) George is mentioned among the martyrs whom the Roman Church venerates, but whose gesta it does not read.[1] The language implies that even at that date much had been written concerning him, but little that the Catholic Church could accept as trustworthy. Numerous traits from the biography of the heretical archbishop had already crept, it would seem, into the acts of the orthodox soldier; and it was feared that any vigorous attempt to eliminate these would leave but a small residue of fact. Modern investigation has proved that apprehension to have been well-founded; for even on the Catholic side in the controversy regarding the existence and character of St. George, the chief contention is simply the improbability that within the space of 150 years a turbulent and unscrupulous Arian ecclesiastic should have come to be reputed a holy martyr for the Catholic faith. The caution displayed with regard to St. George in the 5th century was not long preserved; Gregory of Tours, for example, asserts that his relics actually existed in the French village of Le Maine, where many miracles were wrought by means of them; and the venerable Bede, while still explaining that the gesta of St. George are reckoned apocryphal, commits himself to the statement that the martyr was beheaded under Dacian, king of Persia, whose wife Alexandra, however, adhered to the Catholic faith. The dragon was a still later introduction into the legend, which, as given by Jacobus de Voragine and later writers, ceases to represent the hero as in any sense a sufferer. In its current popular form the story of his successful conflict is probably a mere modification of the old Aryan mythus, to which many interpreters are now disposed to attach a solar interpretation.

The popularity of the name of St. George in England dates from the time of Richard Cœur de Lion, who, it was said had successfully invoked his aid during the first crusade; but it was not till the time of Edward III. that he was made patron of the kingdom, although at the council of Oxford in 1222 it had already been ordered that his feast should be kept as a national festival. The republics of Genoa and Venice were also under his protection; and his name is much revered in all the Oriental churches.

See Heylin, *The History of that most famous Saynt and Souldier of Christ Jesus, St. George of Cappadocia* (1631); and Milner, *An Historical and Critical Inquiry into the Existence and Character of St. George, Patron of England* (1795). For some account of the numerous artistic representations, whether of his martyrdom or of his triumph, see Jamieson's *Sacred and Legendary Art*, vol. ii.

GEORGE, known as PISIDES or PISIDA, a Byzantine writer of the 7th century, was, as his surname implies, a native of Pisidia; but of his personal history nothing is known except that he had been ordained a deacon, and that he held either simultaneously or successively the offices of "Chartophylax," "Scenophylax," and "Referendarius" in the "Great Church" (that of St. Sophia) at Constantinople. He is also believed to have accompanied the first expedition (622) of the emperor Heraclius against the Persians; at all events his earliest work, consisting of 1098 iambic trimeter verses under the title *'Εις τὴν κατὰ Περσῶν ἐκστρατείαν 'Ηρακλείου τοῦ βασιλέως ἀκροάσεις τρεῖς*, is devoted to such a description of that campaign as could hardly have come from any other than an eye-witness. This composition was followed by the *'Αβαρικά* or *Πόλεμος 'Αβαρικός* in 541 verses, containing the details of a futile attack on Constantinople made by the Avari in 626, while the emperor was absent and the Persian army in occupation of Chalcedon; and by the *'Ηρακλιάς*, a general survey of the exploits both at home and abroad of Heraclius down to the final overthrow of Chosroes in 627, which is believed to have been written before the end of 628. In addition to these three works, which have been edited by Bekker in the *Corpus scriptorum histor. Byzant.* (1836), we have from the pen of George of Pisidia the *'Εξαήμερον ἤτοι Κοσμουργία*, a poem upon the creation of the world, containing in its present form 1910 trimeter iambic verses; a treatise on the vanity of life, *'Εις τὸν μάταιον βίον*, in 262 verses; a controversial composition against Severus of Antioch, *Κατὰ Σευήρου*, in 731 verses; two short poems upon the resurrection of Christ and upon the temple of the Virgin at Blachernæ respectively, and a prose encomium upon Anastasius the martyr (*'Εγκώμιον εἰς τὸν ἅγιον Ἀναστάσιον μάρτυρα*). George of Pisidia is known to have written several other works, which, however, are no longer extant; and there is no sufficient reason for assigning to him the compilation of the *Chronicon Paschale*, or the astronomical poem entitled *Empedoclis Sphæra*. The *Hexaemeron* and *De Vanitate Vitæ* were first printed along with a Latin version at Paris in 1584 or 1585, by Fredericus Morellus. They are also to be found in the *Max. Bibliotheca Vett. Patrum*, xii. p. 322 (1677); and in the 46th vol. of Migne's *Patrologia Græca*. The only complete edition of all the extant works is that of Quercus in Foggini's *Corp. Hist. Byzant. Nova Appendix* (Rome, 1777). As a versifier George is correct and even elegant; as a chronicler of contemporary events he is exceedingly useful; but the modern verdict on his merits as a poet has not confirmed that of those later Byzantine writers whose enthusiastic admiration led them to compare him with and even prefer him to Euripides. Recent criticism is unanimous in characterizing his composition as artificial and almost uniformly dull.

GEORGE OF TREBIZOND (1396–1486), one of the distinguished writers in the great controversy between Aristotelianism and Platonism in the 15th century, was born at Chandace in the island of Crete. He received his cognomen apparently from the fact that his ancestors had come from Trebizond. At what period he came to Italy is not absolutely certain; according to some accounts he arrived as early as 1430, and settled as teacher of philosophy and rhetoric at Venice; according to others he did not come over to Italy till the period of the council of Florence (1438–9). His reputation as a teacher and as translator of Aristotle was very great, and he was selected as secretary by Pope Nicholas V., an ardent Aristotelian. The needless bitterness of his attacks upon Plato (in the *Comparatio Aristotelis et Platonis*), which drew forth a powerful response from BESSARION (*q.v.*), and the manifestly hurried and inaccurate character of his translations both of Plato and of Aristotle, combined to ruin his fame as a scholar, and to endanger his position as a teacher of philosophy. The indignation against him on account of his first-named work was so great that he would probably have been compelled to leave Italy, had not Alphonso V. given him protection at the court of Naples. He died at Rome in 1486. Many of his translations of Aristotelian treatises are to be found in the older editions of Aristotle. A notice of his other writings is given in Fabricius, *Biblioth. Græca.*

GEORGETOWN, the port of entry for the District of Columbia in the United States of North America, is situated on the left bank of the Potomac at the head of navigation, about 2½ miles W. N. W. of the capitol of Washington City, with which it communicates by four iron bridges thrown across Rock Creek. Founded by the colonial Government of Maryland in 1751, Georgetown was a city with a distinct administration from 1789 to 1871; but in the latter year it was merged in the District of Columbia, and in 1878 it was incorporated with the city of Washington, so that now it has properly no distinct existence. It is beautifully situated along a range of hills, whose loftier eminences, locally called the Heights, afford delightful positions for villas and country seats, with extensive prospects over the river and Washington. The most noteworthy institution is Georgetown College, the oldest Roman Catholic college in the United States, which occupies two handsome brick buildings in the midst of extensive grounds at the west end. It was founded as an academy in 1789, was chartered as a college in 1799, and in 1815 received the right of conferring degrees. Its medical department, originated in 1851, and the legal department, dating from 1870, are both in Washington. The university has a library of upwards of 30,000 volumes, an extensive apparatus for physical science, and a museum of natural history. In 1873 the teaching staff numbered 35. Among the other institutions in the town may be mentioned the Convent of the Visitation, with a female academy attached; the Peabody library; the Linthicum institute (founded in 1872 by a retired merchant, who left $50,000 for the education of poor white boys); the aged women's house, maintained by voluntary subscription; and the industrial home for juvenile vagrants. The aqueduct which conveys a branch of the Chesapeake and Ohio canal over the Potomac is 1446 feet long, and its granite piers, nine in number, rise 36 feet above the ordinary surface of the water, and rest on the solid rock 17 feet below the bottom of the river. A great decline has taken place in the commercial activity of Georgetown. Its foreign trade is very slight, being represented in the year ending June 30, 1878, by no more than 6113 dollars of imports and 10,056 dollars of exports; but its share in the coasting trade is still considerable, 187 steamers and 45 sailing vessels, affording a total tonnage of 96,339 tons, having entered in the year already mentioned; its position at the terminus of the Chesapeake and Ohio canal secures for it a fair share in the shipping of the coal from the Alleghany fields; and its fisheries render it a great market for shad and herrings. Among the industrial establishments the first place is held by the flour-mills, six in number; but there are also corn-mills, timberyards, tanneries, foundries, breweries, a paper-mill, and a vinegar factory. The principal cemetery for Washington occupies a beautiful situation on Georgetown Heights. In 1830 the population of Georgetown was 8441; in 1840 it was only 7312; by 1860 it had reached 8733; and in 1870 it was 11,384.

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[1] The full text of this canon is given by Heylin, p. ii. c. 9.

GEORGETOWN, known as Stabroek during the Dutch period, now the capital of British Guiana, is situated in the county of Demerara on the east bank of the Demerara river, about a mile from its mouth, in 6° 49′ 30″ N. lat. and 58° 11′ 30″ W. long. It is one of the prettiest towns of that part of the world, and presents an unusually attractive appearance to the approaching voyager. The streets are wide and straight, intersecting each other at right angles, and recalling, by the canals that run along the centre, the memory of the Dutch; and the houses are so richly embosomed by cabbage-palms, cocoa-nut trees, and other trees and shrubs, that they look rather like a collection of villas than a town. The street along the river side, where the shops and stores are mainly situated, forms, however, an exception; there everything is plain, bare, and business-like. Private dwelling-houses are usually built of wood and raised 3 or 4 feet above the soil on wooden piles or brick pillars; they are painted in various simple colors, for the most part in white; in front they have open verandas. Among the public edifices the first place is due to a building in the centre of the town which was erected between 1829 and 1834 at a cost of £60,000, to accommodate the legislative council, the courts of justice, the custom house, the treasury, and other administrative offices; it is of considerable extent and architectural beauty, with shady porticoes and marble-paved galleries supported on cast-iron columns. Besides a cathedral, which cost £15,000, there are churches belonging to the Wesleyans, the Baptists, the London Missionary Society, and other ecclesiastical organizations, several liberally-maintained hospitals, an icehouse, and two market-places, of which the one opened in 1844 cost £11,400, and the other opened in 1852 cost £2450. The prison, a large building, or rather collection of buildings, surrounded by a strong wooden wall, can accommodate upwards of 200 prisoners. A fort, the Frederick William, situated below the town, only contains a small battery, but in the vicinity there are extensive and well-organized barracks. One of the principal disadvantages due to the position of Georgetown is the lack of drinking water; but this is so far remedied by the construction of both private and public tanks for the storage of the rain, by the introduction of water from the Lamaha creek, by a canal, and further by the boring of Artesian wells. The first attempt to apply the Artesian principle was made in 1831 by Major Staple, and his example has been widely imitated not only in the town itself but also in the surrounding country. Though the water thus obtained is strongly impregnated with iron, carbonic acid gas, salt, and magnesia, it is readily drunk by horses and cattle, and after it has been scummed and filtered it can be used for cooking. As it rises to the surface the water has a temperature of 84° Fahr., 5° higher than the water in the river. Ice is almost a necessity of life in the town, and it forms a regular import from Boston, along with fresh meat and other northern produce. The population of Georgetown in 1851 was 25,508; in 1861 it was 29,174; and by 1871 it had reached 36,562. (See Appun, *Unter den Tropen*, Jena, vol. ii.)

GEORGIA, a kingdom in central Transcaucasia, remarkable for the long list of its sovereigns, the monarchy having extended over a period of upwards of 2000 years, the kings reigning at times independently, or under the rule of Persia, Turkey, or the Eastern Empire. The earliest name of the country was Karthli; the ancients knew it as Iberia, bounded on the one side by Colchis and on the other by Albania; and it has for centuries been called Georgia.

Georgia proper, which includes Karthli and Kakhetia, is bounded on the N. by Ossety and Daghestan, on the E. by Shekynn, on the S. by Shamshadyl and the khanates of Erivan and Kars, and on the W. by Gouria and Imeritia; but the kingdom at times included Gouria, Mingrelia, Abkhasia, Imeritia, and Daghestan, and extended from the great mountain range to the Araxes. It now forms the government of Tiflis, divided into the districts of Doushett, Telav, Sygnah, Gori, and Akhalzikh, having an area of nearly 25,000 square miles, and in 1873 a population of 635,313, made up chiefly of Georgians and Armenians,—there being also Persians, Tatars, and a few Jews and Europeans. The chief city is the ancient capital of Tiflis, the seat of government, under a governor-general, for the whole of Transcaucasia, and the principal centre of commerce. See CAUCASUS and TIFLIS.

Vegetable Products.—The valleys and declivities are fertile, producing maize, millet, barley, oats, rice, beans, lentils, and corn (which is best in the plains near Gori), also cotton, flax, and hemp, now exported exclusively to Russia. The vineyards cover 75,400 acres, the average produce of wine being at the rate of 230 gallons per acre; the valley of the Alazan yields the best qualities. It is consumed in the country and adjoining districts, the only wine exported being that produced from vine-canes brought from the Crimea. Grapes are gathered in September, and the wine is fit for use one month after it has been put into a *bourdyouk*, "skin," or *kvevry*, a huge earthen jar in which it may be preserved for years. New vines are planted every six, eight, or ten years, according to the nature of the soil and are cut after the fruit is gathered, and again in March and April when the soil is turned up. The *Lecanium vitis* and *Oidium* have attacked the plants from time to time, though not in severe form, but the *Phylloxera vastatrix* has been hitherto quite unknown. In the vineyards are often seen the apple, pear, and quince trees; other fruits include the pomegranate, peach, apricot, plum, almond, mulberry, pistachio, fig, cherry, walnut, hazel-nut, medlar, melon and water-melon, raspberry, etc. In summer the banks of streams are covered with beautiful wild flowers,—the primrose in double form, the crocus of varied colors, and snowdrops appearing early in March in the greatest profusion.

Animals.—The domestic animals are the camel, ox, mule, ass, and buffalo as beasts of burden, with the goat, and an immense number of pigs, pork being favorite food. The horse—small, hardy, and enduring—is ridden more frequently unshod, except in the hills; no pains are taken to improve the breed. The wild animals of greatest importance are the bear, ibex, wolf, hyæna, fox, wild boar, wild goat, and antelope; while the pheasant, woodcock, quail, and "partridge of the Caucasus" are the principal winged game. The fish taken in the Kour and other rivers are the sturgeon, silurus, carp, perch, trout, gudgeon, and a fish resembling the salmon, called *oragoula* by the Georgians. The great sturgeon, *belouga* or hansen, is taken at the estuary of the Kour in the Caspian.

Communication.—A railroad connects Tiflis with Poti on the Black Sea, the line over the Souram pass, 3037 feet above the sea, being laid at gradients of 1 in 22, over a distance of about 8 miles. Lines of rail are projected for connecting Vladykavkaz in the north, and Djoulpha at the

Persian frontier, with the capital. Post-roads are excellent, and saddle-horses and comfortable vehicles for post-horses are to be obtained at the principal towns. Locomotion is very inexpensive.

History.—The material at the disposal of the historian of Georgia is scanty. An anonymous work of the 12th century gives the history from the earliest times to the year 1124; another, also anonymous, is a continuation to the division of the kingdom in 1445; and a third is the compilation by the Czarevitch Wakhoucht, being the complete annals from the earliest times to the year 1745. These, and a few pamphlets indifferently edited, if we except the memoirs of his family by Stephen Orbeliani, archbishop of Siouny in the 13th century, comprise all that is left to us during an interval of upwards of 2000 years.

The earliest Armenian chroniclers have included facts on Georgia, which it is believed were founded on traditions they received from the Georgians. According to these authorities, the Georgian, Armenian, Kakhetian, Lesghian, Mingrelian, and other races in Transcaucasia are the descendants of Thargamos, who was the great-grandson of Japhet, the son of Noah, though we read in Gen. x. 3 that Togarmah was the son of Gomer, who was the son of Japhet. Those different populations were afterwards included under the general name of Thargomosiany. The second son of Thargamos, named Karthlos, having settled in that part where is now the rivulet Karthli, became the patriarch and king of the people in the land around, called Karthli after himself. His son Mtzkhethos founded the city of Mtzkhetha, which became the capital; and a son of Mtzkhethos, named Ouphlis, was the author of the rock-cut town near Gori. At that period the title assumed by the ruler was *mamasaklysy*, "lord or head of the house," the worship being that of the sun, moon, and five planets. The first to revive the title of king was Pharnawaz, 302–237 B. C., who rid the country of the tyrant Ason, a governor appointed by Alexander the Great. Pharnawaz originated the orthography of the Georgian language, and is said to have invented the military alphabet. In 140 B. C., Mirvan became king. His son and successor was dethroned by his own subjects, and the crown offered to Ardaces I., whose son, Arshag, ascended the throne 71 B. C., the dynasty of Arsaces thus commencing its rule. The deeds of Sulla, Lucullus, Pompey, and Mithradates next serve to illustrate the courage and warlike qualities of the people of Iberia. In 265 the Sassanian dynasty commenced in the person of Miriam, son of Shapour I., who was married to a daughter of the late king Asphagor. Miriam and all his subjects were converted to Christianity by Nouna or Nina, a poor captive, who had escaped the persecution of Tiradates, king of Armenia. She prevailed upon the people of Karthli to desist from offering human victims, and to overturn their pagan altars; and the king erected a sanctuary, which was afterwards replaced by a noble edifice, 364–379, on the spot where now stands the cathedral at M'zhett. Miriam applied to Constantine for priests to instruct his people, and many were sent, among them being Eustace of Antioch. In 469 King Vakhtang, surnamed *Gourgasal*, "wolf-lion," founded a city which he called Tbylysys-Kalaky, now Tiflis, on account of the warm springs there. Vakhtang established a patriarchate at Mtzkhetha, and constructed the fortress of Souram. He conquered Mingrelia, and brought the Ossets and Abkhasians under subjection. He also took possession of a large part of Armenia, and having formed an alliance with Chosroes, king of Persia, even advanced into India. The seat of government was transferred from Mtzkhetha to Tbylysys-Kalaky, when Datchy came to the throne in 499. At this epoch the Georgian and Armenian Churches had separated; and a century later, the Georgian and Russian Churches united. On the death of Stephanos, who had ruled under the protection of the Eastern empire, a Bagratide named Gouram was nominated couropolate by the emperor. Soon after the appearance of Mahomet in the 7th century, the Arabs, having conquered the Persians, entered Armenia and Georgia, and for nearly a century compelled all, under pain of death, to embrace Mahometanism. In 787 the Sassanian dynasty came to an end. Ashod I., *Medz*, "the Great," a Bagratide, succeeded, receiving from the caliph Haroun al Raschid the title of grand prince, and that of couropolate from the emperor; but it was not until about 841 that the sovereign (Bagrat I.) was recognized by the caliph as ruler, the country during the interval having been continually ravaged by the Arabs. Their last expedition, in the reign of Bagrat I., included the occupation of Tiflis. The reign of Bagrat III. marks an epoch, for that monarch, who was king of Abkhasia, succeeded to the crown of Georgia by right of inheritance, his sovereignty extending from the Black Sea to the Caspian. He encouraged the arts and sciences, and was the founder of the noble cathedral at Koutaïs, the first building in the style of architecture thenceforth denominated Georgian. During the reign of Bagrat IV. the Seljuks commenced in 1048 a succession of invasions, until they were effectually repulsed by Liparit Orboulk at the head of a comparatively small force of Georgians, Armenians, and Greeks. Liparit himself was taken prisoner, and Bagrat carried off his wife in his absence; but, regaining his liberty, Liparit took up arms against his sovereign, and drove him out of his capital into Abkhasia. Bagrat appealing to the emperor, it was arranged that he should return to his kingdom of Georgia and Abkhasia, Liparit being suffered, as his dutiful subject, to retain the province of Meskhy.

In 1064 the Seljuks under Arp-Aslan again overran Georgia, destroying Tiflis and slaughtering the inhabitants. In 1072 George II. ascended the throne, and in his reign Tiflis was again devastated by the Seljuks, the king himself being forced to fly. With his valiant son and successor, David III., the fortunes of Georgia changed, for the enemy was driven out of the plains of Kakhetia, and the land from Tiflis to Ani was freed of his presence in 1123 by Ivan Orbeliani, whose signal services were rewarded by elevation to the rank of constable. The next monarchs were Demetrius I. and David IV., the latter, at his death, entrusting his son Demna or Demetrius to the guardianship of Ivan Orbeliani, and the regency to his brother George, who with the assistance of Ivan, greatly extended the Georgian territory, rescuing from the Seljuks a large portion of Armenia. When in 1177 Demna had attained his majority, the nobles desirous of supporting the young prince's claims called upon Ivan, whose popularity had meanwhile been increasing, to place him on the throne. George fortified himself at Tiflis and awaited events; his rule, however, was too firmly established to be easily shaken, and many of Ivan's partisans espousing his cause, he at length set out to besiege Lorhy, which Ivan and his charge had made their headquarters. Numerous desertions reduced the ranks of the besieged, until young Demna fled at last to the encampment of his uncle, and entreated him to spare his life. His prayer was granted, but he was deprived of his eyes, and otherwise mutilated. The prince having surrendered, Ivan declared his readiness to submit on condition that he should be honorably treated. George assented, showed his prisoner all honor until he had got the whole of his relatives into his power, when he ordered that all should be massacred, Ivan himself being blinded and brutally treated. Three only of his kinsmen were saved — a brother named Liparit, and his two sons who had gone to Persia to solicit the aid of the atabek Ildegouz. From them are descended the Orbeliani of the present day. At the time of their extermination, the possessions of the Orboulk comprised more than the half of Georgia. It is related that the ancestors of this powerful family, princes of the family of Djenkapour, of the royal race of Djenesdan, first came to Karthli from that part of Asia which lies between China and the Ural; the fortress of Orpeth was given to them for a residence. In return for the friendly reception accorded to them, they united with the Karthlosides in throwing off the Persian yoke, a service which obtained for the chief Orboulk the rank of *sbasalar* or generalissimo. During the reign of Pharnawaz, the Orboulk took precedence next to the sovereign, and matrimonial alliances were formed with the royal house. The first of the family individualized in the annals was the warrior Liparit (875–900). George III. died in 1184, and was succeeded by his only child Thamar, whose kingdom extended from the Caspian to the Black Sea, and from beyond the Caucasus to Armenia, for Trebizond, Erzeroum, Tovin, Kars, and Ani fell to her arms. Her missionaries travelled far and wide, and numerous churches were constructed, and thus it was that her many virtues and brilliant rule secured to her the title of *Mep'he* "king." This great queen was succeeded in 1212–13 by her son George IV., surnamed *Lasha*, "He who enlightens the world," who, assisted by the powerful noble, Ivan Mkhargrdzelidze, of the family that had replaced the Orbeliani in the royal favor, vanquished the Persians in many battles, conquering Gandja, and permanently occupying Kars. In 1220 and 1222 the Mongols again visited Georgia. The king left an infant son who afterwards reigned as David IV., but his own sister, Roussoudan, seized the crown in 1223, and passed a life not free from reproach. To revenge himself upon the queen, who refused his suit, Jalal-uddin twice occupied her capital, and her kingdom was again overrun by the Mongols, who committed fearful ravages. Next follow the exploits of Timur, who invaded Georgia in 1386, and, having seized upon the capital, carried away the king, Bagrat V., who feigned conversion to Islamism that he might gain the confidence of the conqueror. By this means he succeeded in obtaining from Timur a force of 12,000 men, for the purpose of prevailing upon his people to embrace Mahometanism. Bagrat had preconcerted his plans, and in due course every Tatar in his suite was slaughtered by his own warriors. In an ungovernable passion Timur re-entered Georgia (1393–94), and laid waste the entire country, levelling towns and villages, without sparing a single life. Satiated of bloodshed, he withdrew to the plains of Karabagh, and George VII., son and successor to Bagrat, returned upon the death of his father (1401) from the mountains where he had remained concealed, and occupied the capital. Timur made war upon him as well, compelling his submission, and in 1403 finally quitted the country. George was succeeded by Constantine II., whose successor, Alexander I., son of George VII., restored the kingdom to prosperity; but towards the close of his days he conceived the unhappy idea of dividing his kingdom among his three sons, an act that was followed by internecine wars, rebellions, massacres, and foreign invasions. From about this period commence the relations of Russia with Georgia and its neighboring principalities, for in 1492, during the war fomented between Turkey and Persia, Alexander, king of Kakhetia, sought the protection of the czar John III. Again, in 1587, Boris Godounoff was appealed to for succor; and when, in 1618, Shah Abbas invaded Georgia, Teimouraz I. applied for assistance to Michael Feódorovitch (the first of the Romanoffs), as did also, in 1621, George III. king of Imeritia, and Mamia Gouriel the ruler of Gouria. In 1638 Levan, sovereign of Mingrelia, took the oath of allegiance to Alexis Michaelovitch, and in 1650 Alexander of Imeritia acknowledged the sovereignty of Russia. That empire, however, could not render material assistance to those petty sovereigns in distress, and little was done until fresh excesses committed by the Turks and Persians afforded Peter the Great the excuse for sending an expedition, in 1716, under Bekevitch a Circassian chieftain, to survey the Caspian shore and erect defences. Bekevitch was overpowered by the Tatars, and slaughtered with the whole of his force. Peter then occupied the western shore of the Caspian, taking the king of Georgia under his protection. This was Vakhtang VI., the author of a code that was in vogue until 1841, when Russian laws were in great measure introduced. But he was unable to resist Nadir Shah, and abdicating in 1724, retired to Astrakhan, where he died. Peter being at peace with Turkey, and having concluded the treaty of Nystadt with Sweden, left Moscow, May 24, 1722, and embarked at Astrakhan with troops destined for Georgia and the Persian provinces. Derbent, Bakou, Ghylan, and Mazanderan fell into his power, and he constructed a fort on the river Soulak, which he named St. Croix. All these places were ceded by treaty, in 1732, after Nadir Shah had delivered Karthli and Kakhetia from Turkish oppression. A few years later, in 1735, Turkey renounced all claim to those countries in favor of Persia. When war broke out with Turkey in 1768, General Todleben was sent to the assistance of Solomon I., king of Imeritia, and the Turks were expelled that kingdom. Then followed the treaty of Kainardschi in 1744, by which Georgia, Imeritia, and Mingrelia were placed under the protection of Russia. In 1795 Aga Mahomet Shah laid Tiflis in ruins, a disaster that was succeeded by dissensions in the royal family; and Heraclius II., who in 1783 had declared himself the vassal of Russia, now appealed to that country for protection. The next sovereign, George XIII., renewed this appeal, which would have been granted but for the sudden death of the emperor Paul. Alexander I. hesitated for a time, until George finally renounced his crown in 1799 in favor of Russia, drawing down upon him the hatred and curses of his country. His younger brother, Alexander, made an effort to secure the crown, but the chiefs saw the hopelessness of attempting to throw off the Russian yoke, and, being but poorly supported, the prince was beaten on the banks of the Lora. George died the following year, being the last of the Bagratides to occupy the throne of Georgia, which his ancestors had held for the space of 1029 years. It may be stated that the Bagrations claim descent from David, by his adulterous intercourse with the wife of Uriah! Georgia was now virtually annexed to the empire, and on September 12, 1801, Alexander I. issued a proclamation announcing the fact to the people of that country. In 1810 the prince of Imeritia revolted against Russia; but this movement was quickly suppressed, and the principality annexed. Mamia V. the ruler of Gouria, recognized the suzerainty of Russia in the same year, his principality being eventually annexed in 1829.

See Wakhoucht, *Historie de la Géorgie*, trans. by Brosset, and additions, 5 vols., St. Petersburg, 1849; Vladykyn, *Subesyědnyk v'pouteshestvyry pa Kavkazou*, Moscow, 1874; Zeidleitz, *Otcherk Vynadyelya Kavkaza*, Tiflis, 1875; Comm. J. Buchan Telfer, R. N., *The Crimea and Transcaucasia*, 1877. (J. B. TE.)

Ethnology.—Of the three main groups into which the Caucasian races are now usually divided, the Georgian is in every respect the most important and interesting. It has accordingly largely occupied the attention of Orientalists almost incessantly from the days of Klaproth to the present time. Yet such are the difficulties connected with the origin and mutual relations of the Caucasian peoples that its affinities are still far from being clearly established. Anton Schiefner and P. V. Uslar, however, who must be accepted as undoubtedly the greatest authorities on the subject, have at least arrived at some negative conclusions valuable as starting points for further research. In their valuable papers, published in the *Memoirs* of the St. Petersburg Imperial Academy of Sciences and elsewhere, they have finally disposed of the views of Bopp and Brosset, who attempted on linguistic grounds to connect the Georgians with the Aryan family. They also clearly show that Max Müller's "Turanian" theory is untenable, and they go a long way towards proving that the Georgian, with all the other Caucasian languages except the Ossetian, forms a distinct linguistic family absolutely independent of all others. This had already been suspected by Klaproth, and as the same conclusion has been arrived at by Fr. Müller and Zagarelli, it is not likely to be set aside by further investigation.

Uslar's "Caucasian Family" comprises the following three great divisions:—

1. Western Group. Typical races: Tcherkessians and Abkhasians.
2. Eastern Group. Typical races: Tchetchenzes and Lesghians.
3. Southern Group. Typical race: Georgians.

Here the term "family" must be taken in a far more elastic sense than when applied, for instance, to the Aryan, Semitic, or Eastern Polynesian divisions of mankind. Indeed, Uslar would perhaps be the first to admit that the fundamental unity of the three groups has not yet been established, and that they present at least as wide divergencies as are found to exist between the Semitic and Hamitic linguistic families, whose primitive relationship has not yet been definitely determined. Thus, while the Abkhasian of group 1 is still at the agglutinating, the Lesghian of group 2 has fairly reached the inflecting state, and the Georgian seems still to waver betwen the two. In consequence of these different stages of development, Uslar hesitates finally to fix the position of Georgian in the family, regarding it as possibly a connecting link between groups 1 and 2, but possibly also radically distinct from both.

Including all its numerous ramifications, the Georgian or southern group occupies the greater part of Transcaucasia, reaching from about the neighborhood of Batoum on the Euxine eastwards to the Caspian, and merging southwards with the Armenians of Aryan stock. It comprises altogether nine subdivisions, as in the subjoined table:—

1. The GEORGIANS PROPER, who are the *Iberians* of the ancients and the *Grusya* of the Russians, but who call themselves *Karthalinians*, and who in mediæval times were masters of the Rion and Upper Kur as far as its junction with the Alazan.
2. The IMERITIANS, west of the Suram mountains as far as the river Tzchenis-Tzchali.
3. The GURIANS, between the Rion and Lazistan.
4. The LAZES of Lazistan on the Euxine.
5. The SWANITHIANS, SHVANS, or SWANIANS, on the Upper Ingur and Tzchenis-Tzchali rivers.
6. The MINGRELIANS, between rivers Tzchenis-Tzchali, Rion, Ingur, and the Black Sea.
7. The TUSHES or MOSOKS............
8. The PSHAVS or PH'TCHAVY....... } about the headstreams of the Alazan and Jora rivers.
9. The KHEVSURS.........................

All these formed jointly the ancient kingdom of Iberia, whose *mep'hé* or "king" resided at Mtzkhet till 469 A. D., when the seat of government was removed to the neighboring Tphlissi or Tphiliskalaki, *i. e.*, "warm town," so called from its thermal springs. This place has ever since continued to be the capital of the kingdom, and now bears the abbreviated name of Tiflis. The representative branch of the race have always been the Karthalinians, a name which the native Christian chroniclers profess to trace back to Khartlos, second son of Thargamos, son of Japhet, son of Noah. From Thargamos all their tribes are by their writers called, collectively, Thargamossiani, and from Khartlos their country receives the name of Karthveli of Karthli. But no weight can be attached to these genealogies and etymologies, which would doubtless never have been heard of but for the national desire to connect the race with the Mosaic account of the dispersion. It is now pretty well established that the Georgians are the descendants of the aborigines of the Pambaki highlands, and that they found their way to their present homes from the south-east some four or five thousand years ago, possibly under pressure from the great waves of Aryan migration flowing from the Eranian table-land westwards to Asia Minor and Europe. The terms Georgian and Grusya are simply corruptions of the Persian *Gurj*, as in Gurjistan = Gurjland = Georgia. The Georgians proper are limited on the east by the Alazan, on the north by the Caucasus, on the west by the Meskhian hills, separating them from the Imeritians, and on the south by the Kur river and the Karadagh and the Pambaki mountains. Southwards, however, no hard and fast ethnical line can be drawn, for even immediately south of Tiflis, Georgians, Armenians, and Tatars are found intermingled confusedly together.

The Georgian race, which represents the oldest elements of civilization in the Caucasus, is distinguished by some excellent mental qualities, and is especially noted for personal courage and a passionate love of music. The people, however, are described as fierce and cruel, and addicted to the vice of intemperance, though Von Thielmann speaks of them as "rather hard drinkers than drunkards." Physically they are a fine athletic race of pure Cacuasian type; hence during the Moslem ascendency Georgia supplied, next to Circassia, the largest number of female slaves for the Turkish harems and of recruits for the Osmanli armies, more especially for the select corps of the famous Mameluks.

The social organization rested on a highly aristocratic basis, and the lowest classes were separated by several grades of vassalage from the highest. But since their incorporation with the Russian empire, these relations have become greatly modified, and a more sharply defined middle class of merchants, traders, and artisans has been developed. The power of life and death, formerly claimed and freely exercised by the nobles over their serfs, has also been expressly abolished. They are altogether at present in a fairly well-to-do condition, and it cannot be denied that under the Russian administration they have become industrious, and have made considerable moral and material progress.

Missionaries sent by Constantine the Great introduced Christianity about the beginning of the 4th century. Their efforts were greatly aided by the exemplary life of a female slave named Nina, who came into Georgia during the reign of King Miriam (265–318), and who occupies a prominent place in the ecclesiastical records of the country. Since that time the people have, under severe pressure from surrounding Mahometan communities, remained faithful to the principles of Christianity, and are still amongst the most devoted adherents of the orthodox Greek Church. Indeed it was their attachment to the national religion that caused them to call in the aid of the Christian Muscovites against the proselytizing attempts of the Shiite Persians—a step which ultimately brought about their political extinction.

As already stated, the Karthli language is not only fundamentally distinct from the Aryan linguistic family, but cannot be shown to possess any clearly ascertained affinities with either of the two northern Caucasian groups. It resembles them chiefly in its phonetic system, so that according to Rosen (*Sprache der Lazen*) all the languages of central and western Caucasus might be adequately rendered by the Georgian alphabet. Though certainly not so harsh as the Avar, Serghian, and other Daghestan languages, it is very far from being euphonious, and the frequent recurrence of such sounds as *ts, ds, thz, kh, khh, gh* (Arab. غ), *q* (Arab. ق), for all of which there are distinct characters, renders its articulation rather more energetic and rugged than is agreeable to ears accustomed to the softer tones of the Irenian and western Aryan tongues. It presents great facilities for composition, the laws of which are very regular. Its peculiar morphology, standing midway between agglutination and true inflexion, is well illustrated by its simple declension common to noun, adjective, and pronoun, and its more intricate verbal conjugation, with its personal endings, seven tenses, and incorporation of pronominal subject and object, all showing decided progress towards the inflecting structure of the Aryan and Semitic tongues.

Georgian is written in a native alphabet obviously based on the Armenian, and like it attributed to St. Mesropius (Mesrob), who flourished in the 6th century. Of this alphabet there are two forms, differing so greatly in outline and even in the number of the letters that they might almost be regarded as two distinct alphabetic systems. The first and oldest, used exclusively in the Bible and liturgical works, is the square or monumental *Khutsuri, i. e.,* "sacerdotal," consisting of 38 letters, approaching the Armenian in appearance. The second is the *Mkhedrūli khēli, i. e.,* "soldier's hand," used in ordinary writing, and consisting of 40 letters, neatly shaped and full of curves, hence at first sight not unlike the modern Burmese form of the Pali.

Of the Karthli language there are several varieties; and, besides those comprised in the above table, mention should be made of the Kakhetian current in the historic province of Kakhetia. A distinction is sometimes drawn between the Karthalinians proper and the Kakhetians, but it rests on a purely political basis, having originated with the partition in 1424 of the ancient Iberian estates into the three new kingdoms of Karthalinia, Kakhetia, and Imeritia. On the other hand, both the Laz of Lazistan and the Swanian present such serious structural and verbal differences from the common type that they seem to stand rather in the relation of sister tongues than of dialects to the Georgian proper. All derive obviously from a common source, but have been developed independently of each other. The *Tush* or *Mosok* appears to be fundamentally a Kistian or Tchetchenz idiom affected by Georgian influences.

The Bible is said to have been translated into Georgian as early as the 5th century. The extant version, however, dates only from the 8th century, and is attributed to St. Euthymius. But even so, it is far the most ancient work known to exist in the language. Next in importance is, perhaps, the curious poem entitled *The Amours of Turiel and Nestan Darejan*, or *The man clothed in the panther's skin,* attributed to Rusteval, who lived during the prosperous reign of Queen Thamar (11th century). Prince Leonidze of Akhmeti in Kakhetia showed Baron von Thielmann a rare and very old MS. of this poem, written on fine hemp paper in exquisite Mkhedruli characters, and embellished with arabesques and miniatures evidently the work of an eminent artist. Other noteworthy compositions are the national epics of the *Baramiani* and the *Rostomiani*, and the prose romances of *Visramiani* and *Darejaniani*, the former by Sarg of Thmogvi, the latter by Mosi of Khoni. Apart from these, the great bulk of Georgian literature consists of ecclesiastical writings, hymns sacred and profane, national codes, and chronicles.

See Baron Max von Thielmann's *Journey in the Caucasus, Persia, and Turkey in Asia*, translated by Dr. Charles Hemeage, London, 1875; Fr. Müller's *Ethnographie* and *Reise der Oestr. Fregatte Novarra*, Vienna 1868; Anton Schiefner and General P. V. Uslar, numerous papers in the Bulletins of the Académie Impériale des Sciences de Saint Petersbourg for 1859, etc.; M. Zagarelli's *Examen de la littérature relative à la grammaire Géorgienne*, St. Petersburg, 1873; Michel Smirnow's paper paper in *Revue d'Anthropologie*, April 15, 1878. (A. H. K.)

Plate III.

GEORGIA*: ITS HISTORY, CONDITION AND RESOURCES. WITH MAP. (*Copyright, 1879, by Charles Scribner's Sons.*)—Georgia, one of the thirteen original States of the American Union, has Tennessee and North Carolina on the N., South Carolina and the Atlantic Ocean on the E., Florida S., and Alabama W. The Savannah river separates the State on the E. from South Carolina; the St. Mary's, on the S., divides it in part from Florida; the Chattahoochee, on the W., flows between Georgia and Alabama for nearly half its course. Georgia lies between 30° 21′ 39″ and 35° N. lat., and between 81° and 85° 53′ 38″ W. long. It is 320 miles long from N. to S., and 256 miles in its greatest breadth from E. to W., with an area of 58,000 square miles.

Surface.—Georgia has three distinctly marked zones, varying in soil, climate, and productions. Her sea-coast is similar to that of the Carolinas, being skirted by fertile islands, separated from the mainland by narrow lagoons or by sounds. This section is essentially tropical. Beginning at the sea-coast, a gradually ascending sandy plain extends northward and westward as far as the head of navigation on the Savannah, Ogeechee, Oconee, and Ocmulgee rivers, where it meets a Primary formation. Augusta, Milledgeville, and Macon indicate the northern limit of this tract. Here begins the hilly and finally mountainous region, the most extensive, fertile, and salubrious of the State. A second plateau, 60 or 70 miles broad, stretches above the falls of the rivers until it meets the southernmost ranges of the great Appalachian chain of mountains which traverses Virginia, North Carolina, and northern Georgia under the name of the Blue Ridge, and is finally lost in Alabama. This picturesque district extends in Georgia from Rabun county in the north-east corner of the State to Dade in the extreme north-west, where the summit of Lookout Mountain dominates the valley of the Tennessee. Here are the sources of the two principal rivers of the State; here is the gold-producing region; and here is also the theatre of some of the most sanguinary battles of the civil war. The elevations of the Blue Ridge vary from 1200 to 4000 feet. In the south-east of the State is the extensive Okefinokee swamp, which has an estimated circumference of 180 miles, is filled with pools and islands, and is the congenial home of alligators, lizards, and other reptiles.

Rivers and Harbors.—There are many fine rivers in Georgia. A north and south line passing through Macon would nearly divide the streams flowing into the Atlantic from those discharging into the Gulf of Mexico. The Savannah, Ogeechee, Altamaha, Santilla, and St. Mary's fall into the Atlantic, and the Chattahoochee, Flint, and tributaries of the Suwanee flow to the Gulf coast. The rivers are generally navigable for steamboats to the falls which occur on the great central plateau of the State—that is to say, the Savannah to Augusta, the Oconee and Ocmulgee (confluents of the Altamaha) to Milledgeville and Macon, and the Chattahoochee to Columbus. Besides their ordinary purposes as avenues of travel and commerce, her rivers have given to Georgia the character of a manufacturing State, and she is developing and increasing their abundant water-powers with energy and success.

The Savannah is formed of two small streams which rise near the North Carolina line, and unite on the boundary between S. Carolina and Georgia in Hart county. Flowing thence in a nearly S. S. E. direction for 450 miles, it enters the Atlantic near 32° N. lat. The Savannah is navigable from November to June. Ships ascend it 18 miles to the city of Savannah, steamboats to Augusta, 230 miles, and by means of a canal around the falls there, constructed in 1845, light draught vessels navigate it 150 miles higher. This canal, 9 miles long, furnishes the water-power of Augusta. The river is here about 300 yards wide. From Augusta the traveller descends the Savannah through the cotton-fields of the table-lands, and the long reaches of semi-tropical vegetation dominated by groves of live oak, to the rich rice plantations of the sea-board.

The Chattahoochee is one of the largest and most interesting rivers of Georgia. It rises on the declivity of the Blue Ridge, in Habersham county, in the N. E. of the State, pursues a devious S. W. course through the gold region of upper Georgia

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until it reaches West Point, on the Alabama frontier. It then flows nearly south to the Florida State line, where it is joined by the Flint, when the two streams flow on through Florida to the Gulf under the name of the Appalachicola. Large steamboats ascend the Chattahoochee in the season of navigation to Columbus, 350 miles from the Gulf. The whole estimated length of the river is 550 miles. The falls at Columbus create a valuable water-power, constituting that city one of the three important manufacturing centres of the State. Just above Columbus the Chattahoochee is broken into picturesque rapids, overlooked by a rocky cliff called the "Lover's Leap," which is the subject of an interesting legend. Besides Columbus, the towns of West Point and Fort Gaines are the most important on the Chattahoochee in Georgia; Appalachicola at its embouchure on the Gulf is its shipping and distributing port, but is decreasing in importance since the railway system of the State has assumed a large share of the traffic once confined to the navigable streams.

The Oconee and Ocmulgee rise near each other, in the N. of the State, flow through its centre to within 100 miles of the sea, when their united streams pass on S. E. to the Atlantic under the name of the Altamaha. Milledgeville, the former capital of Georgia, is on the Oconee, and Macon on the Ocmulgee. Darien on the Altamaha is reached by vessels drawing 11 to 14 feet of water. The Ogeechee, rising also in the north, is about 200 miles long. It drains the country between the Savannah and Altamaha, entering the Atlantic a few miles south of the Savannah. The Ogeechee is navigable for light vessels 30 or 40 miles, and for keel-boats to Louisville. The Santilla and St. Mary's drain the south-eastern counties, and are each navigable 30 or 40 miles for sloops. The Flint, Ockloconee, and Suwanee drain the south-western counties; the Flint is navigable to Albany, 250 miles from the Gulf, for steamboats. The Tallapoosa and Coosa, head-waters of the Alabama, and the Hiawassee, one of the sources of the Tennessee, rise in the mountains of Georgia—the last, however, finding its way to the Gulf of Mexico by the Ohio and Mississippi valleys.

Georgia has about 128 miles of sea-coast, but has few good harbors, except within the rivers emptying upon it. St. Mary's, Brunswick, Darien, and Savannah are the principal. The chain of islands lying off the mainland produces the celebrated Sea-island cotton, but owing to the changes brought about by the secession war it is now little cultivated. These islands are flat, and generally little elevated above the sea. Cumberland island, one of the most attractive, is nearly 30 miles long. It is covered with magnificent forests of oak, and its shores are skirted with palms, palmettos, and tropical shrubbery. Other islands from S. to N. are Jykill, St. Simon's, Sapello, St. Catharine's, Ossabaw, and Cabbage. The Sea Islands, with the main shore, constitute a coast of 480 miles. St. Andrew's, St. Simon's, Altamaha, Doboy, Sapello, St. Catharine's, and Ossabaw are the principal sounds.

Climate, Soil, and Productions.—The central and southern portions of Georgia, including the seaboard, are subject to excessive heats in summer. At Savannah observations show the mean temperature for July to have sometimes reached 99° Fahr. In the northern district of the State the same season is cooler and less enervating. Indeed, the mountain region is becoming noted for its genial and healthful climate, and is attracting invalids and pleasure seekers from all parts of the Union. In the low marshy lands lying contiguous to or upon the coast, malarious fevers prevail in spring and summer. The belt of country stretching from Augusta across the State to Columbus, having a width of from 30 to 60 miles, is pronounced a very healthy district. At Augusta the mean summer temperature is about 79°, the winter 47°. At Atlanta careful observations give the average of summer heat as 75°, and winter 45°. Diseases of the respiratory organs are rare among natives of northern and central Georgia. The interior is comparatively free from the dreaded epidemics cholera and yellow fever, but Savannah and the coast are periodically scourged by them.

There is in Georgia as great diversity of soil as of climate. Beginning with the Sea Islands, which are composed of a sandy alluvium, intermixed with decomposed coral, we pass from the rich alluvions near the coast, in which the great rice plantations are, to the thinner soil of the Pine Belt, sometimes inaptly denominated Pine Barrens. These are at present valuable for their timber and naval stores, but are susceptible of cultivation. The middle region consists of a red loam, once productive, but from long cultivation impoverished. With the aid of fertilizers it produces cotton, tobacco, and the cereals. We now reach the so-called Cherokee country of the north, containing lands among the most fertile in the State, lands which, notwithstanding their tillage from an unknown period by the aboriginal inhabitants, grow wheat, corn, Irish potatoes, pease, beans, etc., abundantly. Cotton may also be successfully cultivated, but with less advantage than in other districts of the State. This fibre is chiefly produced along the fertile bottom-lands or contiguous uplands of the rivers. The same lands yield rice, Indian corn, and sugar. Middle and south-west Georgia are the most productive cotton areas. In the south-west the soil, though light and sandy, produces cotton. In southern Georgia there are millions of acres of magnificent yellow pine forests of great value for house or ship-building, and in these forests turpentine plantations have been opened. The live-oak, also valuable for ship-building purposes, abounds in the south-east of the State. The swamps afford cedar and cypress, the central region oak and hickory. Walnut, chestnut, ash, gum, magnolia, poplar, sycamore, beech, elm, maple, fir, and spruce trees are found in different localities; but in the older settled districts the original forests have disappeared.

It is frequently said that there is nothing grown in any of the States except Florida that Georgia cannot profitably produce. A few of the tropical fruits of Florida cannot be raised in Georgia, but all those of the temperate zone succeed well. Tobacco may be grown in any part of the State, although it is not extensively cultivated for export. Cotton is the great crop of Georgia. She ranks third among the eight cotton States, having exported or consumed in her own manufactures, for the year ending September, 1878, 604,676 bales, worth at the point of export $30,000,000. Of this crop 3608 bales is classed as Sea-island. Her crop for 1877 was 491,800 bales. The counties of Burke, Dougherty, Lee, Monroe, Stewart, Sumter, and Washington yield 25 per cent. of the whole product of the State.

The emancipation of the slaves in the Southern States has naturally produced great and important changes in the labor system of that section. The planter must now purchase the labor he formerly owned. The black is free to dispose of his labor to the best advantage. The contracts for labor are of three kinds,—for money wages by the month or year, for a share of the crop, or for specific rent in money or products. The first has been practised to a limited extent by the best and most prosperous planters. The share system has been the one generally adopted, because the blacks greatly affected quasi-proprietorship of the soil, and because the owners were inexperienced in the management of free labor, and not inclined to come personally in contact with it. The share varies in different localities, but usually one-third to half the crop goes to the laborers, the landlords furnishing the necessary tools. The readjustment of labor in the South is watched with the keenest interest in other sections of the Union as one of the difficult problems growing out of the suddenly changed relation between white and black; and though some traces of his original servitude remain a cause of irritation between North and South, the agreement between the enfranchised black and his late master is likely to be harmonious, where each is so dependent on the other as is the case in the cotton-growing States of the Union.

Statistics.—A carefully tabulated statement shows that, in addition to her cotton crop, Georgia produced, in 1876, 23,629,000 bushels of Indian corn, valued at $14,172,000; 2,840,000 bushels of wheat, worth $3,805,600; 5,700,000 bushels of oats, worth $3,876,000; and 23,600 tons of hay, worth $347,628. To these principal crops should be added the timber and naval stores exported from Atlantic outports. In January, 1877, there were in Georgia 118,300 horses, 404,900 oxen and other cattle, 96,200 mules, 270,400 milch cows, 378,600 sheep, and 1,483,100 swine, having a total valuation of $30,815,117. The State is admirably adapted for stock-raising, but, as cotton culture offers the quickest returns, it has hitherto engrossed the attention of planters and farmers. The grain and root crops are largely cultivated for the support of the agricultural population.

The rice crop of Georgia in 1870 was 22,277,380 ℔; tobacco, 288,596 ℔; molasses, 553,192 gals.; wine, 21,927 gals.; sugar, 644 hhds; sweet potatoes, 2,621,562 bush.; Irish potatoes, 197,101 bush.; butter, 4,499,572 ℔; honey, 610,877 ℔; wool, 846,947 ℔, increased in 1878 to about 1,000,000 ℔. The latest official census shows that 6,831,856 acres, valued at $94,559,468, are improved in farms; value of farm implements and machinery, $4,614,701; estimated value of all farm products,

$80,390,228; estimated value of manufactured products, $31,196,115. The total valuation of the State in 1870 was $268,169,207, against $645,895,237 in 1860. The decrease is owing to the emancipation of the slaves; but the State is steadily gaining ground in increased acreage cultivated, increased number and value of manufactories, and increased productive capacity everywhere.

Mineral products.—Georgia was perhaps the El Dorado of which the Spaniards who invaded Florida were in search. Before the gold discovery in California, the "placers" of northern Georgia were profitably worked for many years; but since 1852 their produce has almost wholly ceased. The gold-bearing region is comprised in the counties of Lumpkin, Habersham, Forsyth, and Hall,—the precious metal being found in the alluvial deposits of the streams, and also intermixed with the quartz rock of the hills. A branch mint was established by the Government at Dahlonega, the shire town of Lumpkin county. In 1853 it coined gold bullion of nearly half a million dollars' value; but, as in California, the placers, or surface deposits, have become exhausted. Besides this precious metal, Georgia contains, mainly in N. E. or Cherokee Georgia, coal and fossiliferous iron ore distributed along the ridges between the Tennessee and Alabama border. The Cohutta mountains contain copper, and also silver and lead ores. Iron ore, manganese, slate, baryta, and brown hæmatite are found on the western declivity of this range. Between the Cohutta mountains and the Blue Ridge is a vein of marble, and adjacent to it are the gold-bearing schists, which reappear on the south side of the Blue Ridge. Other minerals are granite, gypsum, limestone, sienite, marl, burrstone, soapstone, asbestos, shales, tripoli, fluor-spar, kaolin, porcelain clay, arragonite, tourmaline, emerald, carnelian, ruby, opal, calcedony, agate, amethyst, jasper, garnets, schorl, zircon, rose-quartz, beryl, and even diamonds.

Population.—The latest official census of Georgia (1870) gives a population of 1,184,709 souls, 638,926 being white and 545,142, or nearly one half, black. This population is distributed among 136 counties, which include 8 cities and 134 incorporated towns. Georgia, which ranks tenth in area, is the twelfth of the Union in respect to population. Though showing an increase of 127,423 persons in the previous decade, which embraced the period of the war with the North, she has fallen behind one in her rank; but indications of prosperity in her agricultural and manufacturing interests warrant the belief that Georgia will show a marked gain in 1880. A large proportion of this anticipated increase may be confidently assigned to the northern section of the State, though the middle section is at present most thickly settled.

Counties.—There are 136 counties in the State, viz:—Appling, Baker, Baldwin, Banks, Bartow, Berrien, Bibb, Brooks, Bryan, Bullock, Burke, Butts, Calhoun, Campbell, Camden, Carroll, Cass, Catoosa, Charlton, Chatham, Chattahoochee, Chattooga, Clarke, Cherokee, Clay, Clayton, Clinch, Cobb, Coffee, Colquitt, Columbia, Cowetta, Crawford, Dade, Dawson, Decatur, De Kalb, Dodge, Dooly, Dougherty, Douglas, Early, Echols, Effingham, Elbert, Emmanuel, Fannin, Fayette, Floyd, Forsyth, Franklin, Fulton, Gilmer, Glasscock, Glynn, Gordon, Greene, Gwinnett, Habersham, Hall, Hancock, Haralson, Harris, Hart, Heard, Henry, Houston, Irwin, Jackson, Jasper, Jefferson, Johnson, Jones, Laurens, Lee, Liberty, Lincoln, Lowndes, Lumpkin, Macon, Madison, Marion, M'Duffie, M'Intosh, Meriwether, Miller, Milton, Mitchell, Monroe, Montgomery, Morgan, Murray, Muscogee, Newton, Oglethorpe, Paulding, Pickens, Pierce, Pike, Polk, Pulaski, Putnam, Quitman, Rabun, Randolph, Richmond, Rockdale, Schley, Scriven, Spalding, Stewart, Sumter, Talbot, Taliafero, Tatnall, Taylor, Telfair, Terrell, Thomas, Towns, Troupe, Twiggs, Union, Upson, Walker, Walton, Ware, Warren, Washington, Wayne, Webster, White, Whitfield, Wilcox, Wilkes, Wilkinson, and Worth.

Cities and Towns.—Georgia has no large cities. Savannah, the chief sea-port, has a population of about 30,000; Atlanta, the capital, 35,000; Augusta, 23,768; Macon, 10,810; Columbus, 7401; Athens, 4251; Milledgeville, 2750; and Rome, 2748. The important towns are Albany, Americus, Bainbridge, Brunswick, Cartersville, Covington, Cuthbert, Dalton, Dawson, Eatonton, Fort Valley, Griffin, La Grange, Marietta, Newnan, Thomasville, Valdosta, Washington, and West Point. Columbus, Americus, Atlanta, and Rome, as well as Savannah, are considerable shipping points, for cotton; Athens is the seat of the university of Georgia; Augusta and Columbus are manufacturing centres; Macon has three religious colleges; Darien, Brunswick, and St. Mary's manufacture and export lumber. Andersonville, in Sumter county, acquired terrible celebrity during the civil war as the site of the chief military prison of the Southern Confederacy. Atlanta is by far the best example of rapid growth the State affords. From a population of 21,189 exhibited by the census of 1870 the city advanced to 35,000 in 1876. It is a railway and manufacturing centre. In the vicinity and for its possession were conducted some of the most important military operations of the secession war.

Manufactures.—Georgia is the foremost southern State in her railway and manufacturing enterprises. Both have been chiefly developed since the war, from which everything in the south of the Union dates. Her rivers and railways afford abundant facilities for the movement of merchandise as well as crops. Her streams also provide excellent and unfailing water-power. In the development of her industries a great future is predicted for Georgia. Indeed some of the more sanguine claim that she is already becoming a formidable rival of New England in the manufacture of cotton and woollen fabrics.

There are in the State 38 cotton factories, with 123,233 spindles and 2125 looms. There are 14 woollen factories, with 4200 spindles and 135 looms. Augusta and Columbus take the lead in the number and capacity of these works, for which certain important advantages are claimed. The water-power is so ample that the mills are run by it alone. The streams do not freeze in winter. The cotton and wool are grown at the factory door, saving to the mill-owner the cost of transporting his raw material from a great distance. Labor is cheaper. Finally, the State in order to encourage the investment of foreign capital in manufactures, has by law exempted such capital from taxation for ten years. The product of the Georgia mills finds a ready market in the Southern and Western States. It is asserted on good authority that during the years 1875, 1876, and 1877—years of unparalleled depression to the manufacturing interests of the United States—the mills of Georgia, especially those of Augusta and Columbus, were never idle, and paid a handsome return on their invested capital. Besides the 52 factories which convert so large a share of her raw product into cloths, there are 1375 grain mills, having 1453 run of stones for corn and 556 for wheat. There are 734 sawmills, 77 wagon and carriage factories, 6 iron-furnaces, 7 iron-foundries, 11 limekilns, 4 potteries, 68 tanneries, 6 turpentine-distilleries, 2 rolling-mills, 5 paper-mills, 12 furniture manufactories, 3 rice-mills, etc. The manufacture of rope, bagging, twine, tobacco, ice, sashes and blinds, agricultural implements, boilers and machinery, fertilizers, etc., is carried on more or less extensively. Besides Augusta and Columbus, the largest manufacturing city of the State, there are cotton factories at Athens, Macon, West Point, Decatur, and Atlanta. The latter city also has large iron works. Thomasville, Dalton, Albany, Marietta, and Rome are also manufacturing points.

Commerce.—Large vessels can enter only four harbors, viz., Savannah, Darien, Brunswick, and St. Mary's. The inlets or sounds which divide the coast islands from each other or from the mainland are generally only navigable for small craft. At mean low tides the bar of the Savannah (Tybee entrance) has 19, the Altamaha 14, that of St. Simon's sound (entrance to Brunswick) 17, and that of St. Mary's river 14 feet of water. Savannah, Brunswick, and St. Mary's are ports of entry. Cotton and lumber are the principal exports. Of the former 610,419 bales of Upland, and 11,309 of Sea-island were exported during the year ending September 2, 1878. The shipment of wool for the same time was 988,389 ℔. These figures should not be taken to represent the crop of the State. The ship-timber, boards, deals, clapboards, etc., are chiefly shipped from the other ports. About 100 vessels, of 22,000 tons burden, are employed in the foreign and coastwise trade. For the year ending December 31, 1878, the total tonnage of the port of Savannah was—entered, 280,995 tons foreign and 385,532 coastwise; cleared, 223,885 foreign and 418,958 coastwise; value of imports $505,596, and of exports $24,014,535. In the district of Brunswick and Darien the entries were 124,711 and the clearances 32,579 tons; value of exports $1,030,943. The St. Mary's entries were 16,052 tons foreign and 20,065 coastwise; value of exports $120,186, and of imports $1421.

Railways.—Atlanta, Columbus, Macon, Albany, and Augusta are railway centres. In 1860 there were in Georgia 1404 miles of completed railway; in 1878 there are 2340 miles. The Atlantic and Gulf Railway crosses the State from Savannah to Bainbridge, in the extreme south-west, on the Flint river. It is 236 miles long, passing through Blackshear, Valdosta, and Thomasville (from which there is a branch line to Albany—58 miles—and Macon), while from Dupont there is a junction with the Florida lines. The Brunswick and Albany also extends from the coast at Brunswick to Albany, 172 miles, whence it is to be continued in a westerly direction to the Chattahoochee, in Early county. A third line connects Brunswick with Macon (187 miles); and another, the Central Georgia, unites Savannah with Macon and Atlanta (294 miles). The Central Georgia works a branch-line from Millen to Augusta; the Milledgeville and Eatonton from Gordon to Eatonton (22 miles); the South-Western from Macon to Eufaula, Ala. (144 miles), with branches from Fort Valley to Columbus (72 miles), Smithville to Albany (23½ miles), Cuthbert to Fort Gaines (20 miles), Fort Valley to Perry (13 miles), and Albany to Arlington (36 miles); the Macon and Western from Macon to Atlanta; and the Upson County line from Barnesville to Thomaston (16 miles).

Atlanta is situated on the great iron highways from Boston, New York, and Philadelphia to Mobile and New Orleans, and from Chicago to Florida. The Western and Atlantic connects Atlanta and the Georgia system with the Tennessee lines at Chattanooga (138 miles). Several great battles were fought for the possession of this railway during the secession war. The Atlanta and Charlotte Air Line extends to Charlotte, N. C. (269 miles). The Georgia railway connects Atlanta with Augusta (171 miles), with lateral lines from Carnak to Warrenton (4 miles), Union Point to Athens, (40 miles), and Barnet to Washington (18 miles); it also works the Macon and Augusta line from Carnak to Augusta (70 miles). The Atlanta and West Point (80 miles) unites those places. The Alabama and Chattanooga crosses the N. W. corner of the State. The Cherokee extends from Cartersville on the Western and Atlantic to Rockmart (23 miles). The Columbus and Atlanta, projected between Columbus and Rome, the Memphis branch (Rome to Decatur, Ala.), and Savannah, Griffin, and N. Alabama, from Griffin to Newnan, to be extended to Guntersville, Ala., are in progress. The Georgia Southern extends from Dalton to the Ala. State line (portion of Selma, Rome, and Dalton road); North-Eastern from Athens to Lulah (39 miles); Ocmulgee and Horse Creek (7 miles); Rome Railroad, Rome to Kingston (20 miles).

Government.—The executive power is vested in a governor elected for four years by a majority of the people. If there is no election by the people, the general assembly chooses one of the two receiving the highest number of votes. The legislative authority is conferred upon a senate, members of which are elected for four years, and a house of representatives elected for two years. The legislature holds annual sessions, beginning on the second Wednesday of January. The State judiciary consists of a supreme court of three judges, who hold office for twelve years, one retiring every four years, and of inferior courts, presided over by nineteen judges, appointed by the executive with the consent of the senate. Except in probate cases, these courts have original jurisdiction, civil and criminal, in law and equity. County courts are established in most of the counties. There is an ordinary for each county elected for four years, who holds a court of ordinary and probate. The organic law of the State now forbids slavery or involuntary servitude except for the punishment of crime. Imprisonment for debt, and legislation affecting the free exercise of that personal liberty guaranteed to the citizen by the amendments to the constitution of the United States, are also prohibited. All male inhabitants between eighteen and forty-five are subject to military duty. There is a homestead exemption of $2000 on real and $1000 on personal property, except for taxes, for money borrowed or expended on the homestead, or for labor or materials used upon it. The property held by a married woman at the time of marriage, or subsequently inherited or acquired by her, is not liable for the husband's debts. A married woman may also sue and be sued in matters pertaining to her separate estate, and may carry on trade as if single. Georgia is entitled to seven representatives and two senators in Congress.

Education.—Previous to the war, there was no common school system in Georgia. Although a plan of public instruction was organized at an earlier date, it was not given effect to until 1873. In that year the schools were put in working condition, and are now to be found in every county of the State. The attendance in 1876 was—whites 121,418, colored 57,987, showing a small but steady increase for the three years the schools had been in operation. It is computed by the school commission at 200,000 for 1879. The higher branches of education are well represented. As early as 1801 steps for founding a university were taken at Athens. The first commencement took place in 1804. The college proper (Franklin College at Athens) annually admits free of charge "fifty meritorious young men of limited means," and also such as may be studying for the ministry who need aid. There is also connected with the university a medical college, located at Augusta, and an agricultural college at Dahlonega, with nearly 250 students, whose tuition is free. The State college of agriculture and mechanic arts, also connected with the university, has a special endowment derived from the United States of $240,000; the whole endowment of the university is $376,500. The university, exclusive of its establishments at Augusta and Dahlonega, has five departments, 13 professors, and 200 students, with a library of 14,000 volumes, and two literary societies. Besides the usual collegiate course, there are a preparatory school and a law school. Mercer College, at Macon, is a Baptist institution. It was founded in 1838; and until 1870 it was located at Penfield, in Greene county. It has an endowment of $160,000, a library of 12,000 volumes, and about 135 students. Besides the regular academic course, there are schools of law and theology. The high schools at Penfield and Dalton are connected with this college. Emory College at Oxford, Newton county, was chartered in 1836. It is the property of the Georgia and Florida conferences of the Methodist Episcopal Church (South). The present number of students is 156. Emory has a valuable college apparatus and a good working library, but lacks an endowment. The Wesleyan Female College at Macon was one of the first female colleges, if not the first, in the world, its charter having been granted in 1836. It has 200 students, and is the property of the Methodist denomination. Since 1840 degrees have been conferred upon 1080 graduates. The Southern Masonic Female College at Covington belongs to the Grand Lodge of Georgia, and is designed to educate female orphans of freemasons. Pio Nono College at Macon is a recently established Catholic institution, chiefly founded by the efforts of the bishop of Savannah. The Atlanta University for the education of negroes was established by the now extinct Freedmen's Bureau and various charitable societies of the Northern States. It receives an annual appropriation from the Georgia legislature of $8000. It accommodates 240 pupils. There are a number of institutions, in addition to those enumerated, that are entitled colleges, but come more properly within the designation of high schools. There are also institutions for the blind (at Macon), and for the deaf and dumb (near Rome).

Objects of Interest.—Perhaps the most beautiful scenery in Georgia is to be found in the mountain region traversed by the Air Line railway. About 2½ miles from the town of Toccoa the creek of that name falls 185 feet over a precipice. Fifteen miles beyond Toccoa are the cascades of Tallulah, where the river descends successive terraces of broken rock between the walls of a chasm 800 feet deep. In this vicinity are the charming valley of Nacoochee and Mount Yonah. In the extreme north-east is Rabun gap and the cascades of Eastatoia. Connected with this region, once the hunting-grounds of the warlike Cherokees, are many Indian legends. The country between Atlanta and Chattanooga is deeply interesting from having been the battle-ground of opposing armies in the civil war. Kenesaw mountain, itself the scene of a bloody encounter, commands a view of the country which for two months the Confederate commanders disputed foot by foot. Stone mountain, 9 miles from Decatur, is much visited. The Chattahoochee, in the neighborhood of Columbus, is picturesque; and Savannah is one of the most attractive and idiosyncratic cities of the Union. There are numerous mineral springs scattered over the State, which are much resorted to by invalids.

History.—Before the arrival of Europeans the country now embraced in Georgia was inhabited by the Cherokee and Creek Indians. The Cherokees possessed the north, the Creeks the south. Both were very powerful and warlike, the Cherokees numbering 6000 warriors, and having 64 towns and villages. To be more precise, the Cherokee country extended from the 34th parallel north to the country of the Six Nations, and from the heads of the rivers emptying upon the South Carolina coast westward to the Mississippi. The whole course of the Tennessee was within this magnificent domain, now mostly embraced in the four States of Georgia, Alabama, Mississippi, and Tennessee. In 1729 this extensive territory was surrendered by treaty to the crown of Great Britain. The following year the Cherokees made formal submission to Sir A. Cuming, Bart.

Georgia was the only one of the original thirteen colonies that received any aid in its settlement from the Government of England. General James Oglethorpe conceived and executed the plan of founding an English colony in that portion of the Carolina proprietaries' grant between the Savannah and Altamaha. His purpose was to create an asylum in the New World where insolvent debtors, and persons fleeing from religious persecution, might begin life anew or enjoy religious freedom. By royal letters-patent issued in June, 1732, the proposed colony was called Georgia in honor of the reigning prince; and the House of Commons granted £10,000, which was soon increased by private subscription to £36,000. Under the charter the trustees had powers of legislation, but could receive no reward for their services. Even grants of land to themselves were forbidden.

With 116 emigrants Oglethorpe sailed from England in November, 1732, arriving in the Savannah in February. He landed at the present site of Savannah, where he was soon after hospitably received by delegates from the Lower Creeks, who consented that the English might peaceably inhabit among them. The next year a small number of Bavarians came over, and were settled in what is now Effingham county. Oglethorpe also established settlements at Darien, at Augusta, and on St. Simon's island. In 1736 the colony received considerable accessions of emigrants, with whom came John and Charles Wesley, the founders of Methodism. In 1738 the Rev. George Whitefield visited Georgia, founding the orphan-house at Bethseda, near Savannah, from funds chiefly collected on his tour in the northern colonies.

Anticipating invasion by the Spaniards of Florida, who claimed Georgia, Oglethorpe, on the renewal of war between England and Spain, led an expedition to St. Augustine, Florida, which he besieged without success at the head of 2000 men. The Spaniards retaliated by landing in 1742 a small force on St. Simon's island, from which they were expelled by Oglethorpe. They then abandoned further attempts. Slavery was introduced into Georgia about 1750. In 1752 the trustees surrendered their privileges to the crown. A royal governor and council were appointed to administer, in conjunction with delegates of the people, the government of the province. During the French and Indian wars the remote settlements suffered somewhat from incursions of the Cherokees. The treaties of 1763 with France and Spain extended the boundaries of Georgia to the Mississippi on the W., and to St. Mary's on the S. After this the colony flourished greatly until the breaking out of war with England, at which time the colony was estimated to have a population of about 70,000 souls. In 1775 Sir James Wright, the crown governor, left the province. Delegates were sent to represent Georgia in the continental congress who signed the Declaration of Independence. In 1778 a British land and naval force occupied Savannah and Augusta, but were subsequently compelled to abandon the latter place. In September of the same year a combined American and French force, under Lincoln and D'Estaing, unsuccessfully attempted the recovery of Savannah, losing nearly 1000 men in an assault. Augusta was reoccupied by the conquerors. Charleston being surrendered by General Lincoln in 1780, the patriots of South Carolina and Georgia were only able to maintain a partisan warfare, until the advance of General Greene from the north, at the head of considerable forces, resulted in the expulsion of the royal troops from those provinces. Georgia at the conclusion of peace ratified the several Acts constituting her one of the United States of America. She framed her first constitution in 1777, a second in 1789, and a third (which has been several times amended) in 1798.

In 1803 Georgia ceded to the general government all her territory west of the Chattahoochee, amounting to nearly 100,000 square miles, out of which the States of Alabama and Mississippi were subsequently formed. The cession of Louisiana to the United States was of great benefit to Georgia in ending hostilities which the Spaniards were continually inciting the Indians to commit upon the scattered settlements. By a treaty with the Creeks, Georgia became possessed of a large tract in the south-west of the State. The second war with England (1812–15) involved Georgia in hostilities with the Indians on her western border, who were finally subdued by General Andrew Jackson. In 1821 the cession of Florida to the United States relieved Georgia from the long series of Spanish aggressions beginning with her existence as a colony.

In 1825 a serious difficulty arose between the State and national authorities in consequence of proceedings by the Georgia executive to extinguish the title to lands in the State held by the Creeks and Cherokees. The head chief of the Creeks, M'Intosh, was assassinated by his people for signing away these lands to the whites. By an Act of Congress passed in 1830, these Indians were subsequently removed to the Indian territory west of the Mississippi.

Georgia formally seceded from the Union in January, 1861. The government forts and arsenals were seized. The first military operations were on the coast. In April, 1862, Fort Pulaski, one of the defences of Savannah, was recaptured by the Federal forces under Com. Du Pont. St. Mary's, Brunswick, Darien, and St. Simon's island were also occupied.

In the beginning of 1863 the Federal forces were in possession of middle and west Tennessee. In September they occupied Chattanooga in strong force, the Confederates falling back by the Western and Atlantic Railway to Lafayette, Ga. A further advance by General Rosecrans, the Federal commander, brought on the severely contested battle of Chickamauga, on the creek of that name (September 20). The Federals retreated to Chattanooga, which was soon threatened by the Confederates under Bragg. In November the Union army under General Grant drove Bragg from all his positions. In the spring of 1864 the southern army was at Dalton, Ga., on the railway to Atlanta, which it covered. In May General Sherman moved forward against this force a numerous and well-appointed Union army. Severe battles took place at Resaca, Kingston, and Allatoona Pass. A series of strategical movements, signalized by frequent bloody conflicts between the rival armies, resulted in the possession of Atlanta by the Union forces, September 2. From this point Sherman began in November his memorable march across Georgia to the sea. On December 10th he arrived in the neighborhood of Savannah, captured Fort M'Allister by assault, and occupied the city on the 21st. A cavalry force under General Wilson entered Georgia from Alabama in April, 1865, capturing Columbus, West Point, and Macon, and making Davis, the Confederate States president, prisoner. In June, 1865, a provisional governor was appointed for the State by the president of the United States. A convention assembled in October at Milledgeville, which repealed the ordinance of secession, abolished slavery, and declared the war debt void. A new constitution was framed and ratified in 1868, and Rufus B. Bullock inaugurated as governor. The restoration of civil government under the new forms was not effected in Georgia without complications which retarded its reestablishment on a solid foundation, but the amendments to the national constitution were at length adopted, and her senators and representatives were admitted to seats in Congress in December, 1870. During the war Georgia furnished about 80,000 soldiers for the Confederate armies. She emerged from it with her industries prostrated, her treasury empty, her social and political system revolutionized, her most flourishing cities in ruins. Her great natural resources are fast advancing her to a commanding position among her sister States; and these resources are developing in the hands of a free people with greater rapidity and advantage than when half the population was enslaved. Texas possibly excepted, no southern State has a greater future than Georgia.

GEORGSWALDE, a town of Northern Bohemia, on the borders of Saxony, in the circle of Leitmeritz, about 35 miles E. of Dresden, with a station on the North Bohemian railway. Besides Old and New Georgswalde, it comprises Wiesenau and Philippsdorf, the latter a place which since 1868 has attained celebrity through the miracles attributed to its image of the Virgin. Georgswalde was founded in the beginning of the 17th century, and ranks as one of the oldest industrial centres of Bohemia, sharing with the neighboring town of Rumburg a reputation for excellent linen. The parish church is a fine building. In 1869 the total population was 8220, of whom 5671 were in Old Georgswalde.

GERA, the chief town of the principality of Reuss-Schleiz, stands in a valley on the banks of the White Elster, 35 miles S. S. W. of Leipsic. It has been all rebuilt since a great fire in 1780, and the streets are in general wide and straight, and contain many handsome houses. The principal buildings are the churches of St. Salvator's and St. Trinity, the town-hall, the buildings of the imperial bank and of the Gera bank, the music hall, and the central hall. Its educational establishments include a gymnasium, a general town school (which contains a real school of the first order, a higher female school, and three citizen schools), a commercial school, a normal school, and a weaving school. The castle of Osterstein, the residence of the prince of Reuss, dates from the 9th century, but has been nearly all rebuilt within the last thirty years. Gera has long been noted for its industrial activity. Its manufactures comprise woollen, cotton, and silk goods, tapestry, artificial flowers, oil-cloth, leather, hats, tobacco, soap, beer, vinegar, chocolate, glue, porcelain and other earthenware, bricks, musical instruments, and carriages.

Gera was raised to the rank of a town in the 11th century, at which time it belonged to the counts of Groitch. In the 12th century it came into the possession of the lords of Reuss. It was stormed and sacked by the Bohemians in 1450, was two-thirds burned down by the Swedes in 1639 during the Thirty Years' War, and suffered afterwards from great conflagrations in 1686 and 1780, being in the latter year almost completely destroyed. The population in 1875 was 20,810, nearly all of whom are Protestants.

GERACE or Gieraci, a town of Italy in the province of Reggio di Calabria, about 59 miles from Reggio on the railway between that city and Monasterace, is situated on a limestone hill not far from the coast, 30 miles N. N. E. of Cape Spartivento, between the rivers Merico and Novito. It is the seat of a bishop and of a subprefect, and has a civil and criminal court dependent on that of Catanzaro. The citadel, formerly of great strength, was reduced to ruins by the earthquake of 1793; and the cathedral was at the same time so severely injured that only a portion of the crypt remained available for public worship. There is a good trade in a white wine known as *Vino Greco;* silk is manufactured; and the warm sulphur springs of the neighborhood attract patients to the town. About 5 miles off, at Torre di Gerace, are the ruins of the Greek city of Locri Epizephyrii, from which Gerace derived materials for its buildings, and more especially fine marble columns for the cathedral. The population in 1871 was 7257. This Gerace is not to be confounded with Gerace Siculo, a town of between 3000 and 4000 inhabitants, 4 miles from Cefalu, which was the first place in Sicily erected into a marquisate.

GERANIUM is the name of a genus of polypetalous exogenous plants, which is taken by botanists as the type of the natural order *Geraniaceæ.* The name, as a scientific appellation, has a much more restricted application than when taken in its popular sense. Formerly the genus *Geranium* was almost conterminous with the order *Geraniaceæ,* which latter had then a more limited meaning than is given to it by those of our leading botanists of the present day, who include in it the *Tropæolaceæ,* the *Oxalidaceæ,* and the *Balsaminaceæ.* Then as now the geranium was very popular as a garden plant, and the species included in the original genus became widely known under that name, which has more or less clung to them ever since, in spite of scientific changes which have removed the larger number of them to the genus *Pelargonium.* This result has been probably brought about in some degree by an error of the nurserymen, who seem in many cases to have acted on the conclusion that the group commonly known as *Scarlet Geraniums* were really geraniums and not pelargoniums, and have in consequence inserted them under the former name in their trade catalogues. In fact it may be said that, from a popular point of view, the pelargoniums of the botanist are better known as geraniums than are the geraniums themselves.

The species of *Geranium* bear the English name of Cranesbill, and consist mostly of herbs, of annual or perennial duration, dispersed throughout the temperate regions of the world. They number nearly a hundred, and bear a considerable family resemblance. The leaves are for the most part palmately-lobed, and the flowers are regular, consisting of five sepals, five imbricating petals, alternating with five glandules at their base, ten stamens, and a beaked ovary. Some dozen or more species are natives of the British Isles; and many of those of exotic origin form handsome border plants in our gardens of hardy perennials. Amongst these *G. ibericum. G. platypetalum, G. sanguineum, G. Backhousianum,* and the double-flowered varieties of *G. pratense* are conspicuous. The genus is not without its virtues, *G. maculatum* being the alum-root of North America, used there as an astringent in diarrhœa, dysentery, and such like complaints, while the native Herb Robert of English hedgesides, *G. Robertianum,* which is both astringent and aromatic, is used as a remedy in nephritic disorders.

From these regular-flowered herbs, with which they had been mixed up by the earlier botanists, L'Heritier in 1787 separated those plants which have since borne the name of *Pelargonium,* and which, though agreeing with them in certain points of structure, differ in others which are admitted to be of generic value. One obvious distinction of *Pelargonium* is that the flowers are irregular, the two petals which stand uppermost being different—larger, smaller, or differently marked—from the other three, which latter are occasionally wanting. This difference of irregularity the modern florist has done very much to annul, for the increased size given to the flowers by high breeding has usually been accompanied by the enlargement of the smaller petals, so that a very near approach to regularity has been in some cases attained. Another well-marked difference however remains in *Pelargonium:* the back or dorsal sepal is furnished with a hollow spur, which spur is adnate, *i. e.,* joined for its whole length with the flower-stalk; while in *Geranium* there is no spur. This peculiarity is best seen by cutting clean through the flower-stalk just behind the flower, when in *Pelargonium* there will be seen the hollow tube of the spur, which in the case of *Geranium* will not be found as it does not exist, but the stalk will appear as a solid mass. There are other characters which support those already pointed out, such as the absence of the glandules, and the declination of the stamens; but the features already described offer the most ready and obvious distinctions.

To recapitulate, the geraniums properly so-called are regular flowered herbs with the flower stalks solid, while many geraniums falsely so-called in popular language are really pelargoniums, and may be distinguished by their irregular flowers and hollow flower stalks. In a great majority of cases too, the pelargoniums so commonly met with in greenhouses and summer parterres are of shrubby or subshrubby habit.

GERARD OF CREMONA (1114–1187), the mediæval translator of Ptolemy and Avicenna, was born at Cremona, Lombardy, in 1114. Dissatisfied with the meagre philosophies of his Italian teachers, he went to Toledo to study among the Moors, who were at that time the chief depositaries and interpreters of the wisdom of the ancients; and, having thus acquired a knowledge of the Arabic language, he appears to have devoted the remainder of his life to the business of making Latin translations from its literature. The date of his return to his native town is uncertain, but he is known to have died there in 1187. His original version of Avicenna's *Canon of Medicine* was the basis of all the very numerous subsequent Latin editions of that well-known work; and the Latin translation by which alone Ptolemy's *Almagest* until the discovery of the original *μεγάλη σύνταξις* was known to Europe is also ascribed to him. In addition to these, he translated various other treatises in medicine, mathematics, and astronomy, to the number, it is said, of sixty-six; but some of the works with which he has been credited (including the translation of the *Almansorius* of Er-Razi or Rhazes) are more probably due to a later Gerard also called "Cremonensis," but more precisely "de Sabloneta." See Boncompagni, *Della Vita e delle Opere di Gherardo Cremonense e di Gherardo da Sabbionetta.*

GERARD, variously surnamed TUM, TUNC, TENQUE, or THOM (*c.* 1040–1120), founder of the order of the knights hospitallers of St. John or of Malta, was born at Amalfi about the year 1040. According to other accounts Martigues in Provence was his birthplace, while one authority even names the Château d'Avesnes in Hainault. Whether as a soldier or a merchant, he in the course of the latter part of the 11th century found his way to Jerusalem, where a hospice had for some time existed for the convenience of those who wished to visit the holy places. Of this institution Gerard became guardian or provost at a date not later than 1100; and here he organized that religious order of St. John which received papal recognition from Pascal II. in 1113, by a bull which was renewed and confirmed by Calixtus II. shortly before the death of Gerard in 1120.

GÉRARD, ETIENNE MAURICE, COUNT (1773–1852), a distinguished French general, was born at Damvilliers in the department of Meuse, 4th April, 1773. He joined the second battalion of the Meuse in 1791, and served in the campaigns of 1792–1793 under Generals Dumouriez and Jourdan. In 1798 he accompanied Bernadotte as aide-de-camp in his embassy to Vienna. In 1799 he was named chief of a squadron, and in 1800 colonel. He distinguished himself by a brilliant charge against the Russian imperial guard at the battle of Austerlitz, and being raised to the rank of general in November, 1806, played a prominent part in the battles of Halle, Jena, and Erfurt; and for his conduct in the battle of Wagram, where he greatly contributed to the victory, he was created a baron. In the Spanish campaign of 1810 and 1811 he gained special distinction at the battle of Fuentes-de-Onoro; and in the subsequent expedition to Russia he was present at the capture of Smolensk, had a principal share in the victory of Walontina-Gora, displayed such bravery and ability in the battle of the Moskova that he was made general of division, and by his coolness and energy in the disastrous retreat from Moscow saved the rearguard of the French army at the passage of the Wilna. In the campaign of 1813, in command of a division under Macdonald, he took part in the battles of Lützen, Bautzen, Goldberg, and Leipsic, where he was dangerously wounded. After the battle of Bautzen he was created by Napoleon a count of the empire. In the campaign of France in 1814, in command of the army of reserves composed chiefly of recruits, he by his skilful manœuvres powerfully assisted in securing the victories of Nogent, Nangis, and Montereau-sur-Yonne. After the first restoration he was named by Louis XVIII. grand cross of the legion of honor and chevalier of St. Louis. On the return of Napoleon from Elba he was entrusted with the command of the army of the Moselle, and took part in the battle of Ligny. On the morning of the battle of Waterloo, being under the orders of Grouchy, who was marching towards Wavre, he strongly urged him to proceed in the direction whence they heard cannon firing, but his advice was not followed. Gérard retired to Brussels after the fall of Napoleon, and did not return to France till 1817. He was chosen a member of the chamber of deputies in 1822, and was re-elected in 1823 and 1827. He took part in the revolution of 1830, after which he was appointed minister of war and named a marshal of France. On account of his health he resigned the office of war minister in the October following, but in 1831 he took the command of the northern army, and was successful in thirteen days in driving the army of Holland out of Belgium. In 1832 he compelled the surrender of Antwerp, and in the same year he was raised to the peerage of France. He was again chosen war minister in July, 1834, and again resigned that office in the October following. In 1835 he was named grand chancellor of the legion of honor, and in 1838 commander-general of the national guards of the Seine, an office which he held till 1842. He became a senator under the empire in 1852, and died in April of the same year.

GÉRARD, François, Baron (1770–1837), was born on May 4, 1770, at Rome, where his father occupied a post in the house of the French ambassador. At the age of twelve Gérard left Rome with his family for Paris, and there obtained admission into the Pension du Roi. From the Pension he passed to the studio of Pajou (sculptor), which he left at the end of two years for that of the painter Brenet, whom he quitted almost immediately to place himself under David. In 1789 Gérard competed for the Prix de Rome, which was carried off by his comrade Girodet. In the following year (1790) he again presented himself, but the death of his father prevented the completion of his work, and obliged him to accompany his mother to Rome. In 1791 he returned to Paris; but his poverty was so great that he was forced to forego his studies in favor of employment which should bring in immediate profit. David at once availed himself of his help, and one of that master's most celebrated portraits—Le Pelletier de St. Fargeau—is due to the hand of "le petit Gérard." This portrait was executed early in 1793, the year in which Gérard, at the request of David, was named a member of the revolutionary tribunal, from the fatal decisions of which he, however, invariably absented himself. In 1794 he obtained the first prize in a competition, the subject of which was "The Tenth of August," and, further stimulated by the successes of his rival and friend Girodet in the Salons of 1793 and 1794, Gérard (nobly aided by Isabey the miniaturist) produced in 1795 his famous "Bélisaire." In 1796 a portrait of his generous friend (Louvre) obtained undisputed success, and the money received from Isabey for these two works enabled Gérard to execute in 1797 his "Psyché et l'Amour." At last, in 1799, his portrait of Madame Bonaparte established his position as one of the first portrait painters of the day. In 1808 as many as eight, in 1810 no less than fourteen portraits by him, were exhibited at the Salon, and these figures afford only an indication of the enormous numbers which he executed yearly; all the leading figures of the empire and of the restoration, all the most celebrated men and women of Europe, sat to Gérard. This extraordinary vogue was due partly to the charm of his manner and conversation, for his *salon* was as much frequented as his studio; Madame de Stael, Canning, Talleyrand, the duke of Wellington, have all borne witness to the attraction of his society. Rich and famous, Gérard was stung by remorse for earlier ambitions abandoned; at intervals he had indeed striven to prove his strength with Girodet and other rivals, and his "Bataille d'Austerlitz" (1810) showed a breadth of invention and style which are even more conspicuous in "L'Entré d'Henri IV." (Versailles),—the work with which in 1817 he did homage to the Bourbons. After this date Gérard declined, watching with impotent grief the progress of the Romantic school. Loaded with honors—baron of the empire, member of the Institute, officer of the legion of honor, first painter to the king—he worked on sad and discouraged; the revolution of 1830 added to his disquiet; and in 1837 on 11th January, after three days of fever, he died. By his portraits Gérard is best remembered; the color of his paintings has suffered, but his drawings show in uninjured delicacy the purity of his line; and those of women are specially remarkable for a virginal simplicity and frankness of expression.

M. Ch. Lenormant published in 1846 *Essai de Biographie et de Critique sur François Gérard*, a second edition of which appeared in 1847; and M. Delécluze devoted several pages to the same subject in his work *Louis David, son école et son temps*.

GÉRARD, Jean Ignace Isidore (1803–1847), a French caricaturist generally known by the pseudonym of Grandville—the professional name of his grandparents, who were actors—was born at Nancy, 13th September, 1803. He received his first instruction in drawing from his father, a miniature painter, and at the age of twenty-one came to Paris, where he soon afterwards published a collection of lithographs entitled *Les tribulations de la petite propriété*. He followed this by *Les plaisirs de tout âge*, and *La sibylle des salons;* but the work which first established his fame was *Métamorphoses du jour*, published in 1828, a series of 70 scenes in which individuals with the bodies of men and faces of animals are made to play a human comedy. These drawings are remarkable for the extraordinary skill with which human characteristics are represented in animal features, but they are liable to the objection of attempting to express by the pencil what can be properly done only by the pen; while at the same time, in conquering difficulties incident to his purpose, much ingenuity and labor has been wasted which might have been employed otherwise with better results. The success of this work led to his being engaged as artistic contributor to various periodicals such as *La Silhouette*, *L'Artiste*, *La Caricature*, *Le Charivari;* and his political caricatures, which were characterized by marvellous fertility of satirical humor, soon came to enjoy a general popularity which never diminished. Besides supplying illustrations for various standard works, such as the songs of Béranger, the fables of La Fontaine, *Don Quixote*, *Gulliver's Travels*, *Robinson Crusoe*, he also continued the issue of various lithographic collections, among which may be mentioned *La vie privée et publique des animaux*, *Les cent proverbes*, *L'autre monde*, and *Les fleurs animées*. Though the designs of Gérard are occasionally unnatural and absurd, they usually display keen analysis of character and marvellous inventive ingenuity, and his humor is always tempered and refined by delicacy of sentiment and a vein of sober thoughtfulness. He died of mental disease 17th March, 1847.

A short notice of Gérard under the name of Grandville, is contained in Theophile Gautier's *Portraits Contemporains*. See also Charles Blanc, *Grandville*, Paris, 1855.

GERARD, John (1545–1608), herbalist and surgeon, was born towards the end of 1545 at Nantwich in Cheshire. He was educated at Wisterson, or Willaston, 2 miles from Nantwich, and eventually, after spending some time in travelling, took up his abode in London, where he exercised his profession. For more than twenty years he also acted as superintendent of the gardens of Lord Burghley, secretary of state to Queen Elizabeth. In 1596 he published a catalogue of plants cultivated in his own garden, 1039 in number, inclusive of varieties of the same species. Their English as well as their Latin names are given in a revised edition of the catalogue issued in 1599. In 1597 appeared Gerard's well-known *Herball*, described by him in its preface as "the first fruits of these mine own labors," but more truly an adaptation of the *Stirpium historiæ pemptades* of Rembert Dodoens, published in 1583, or rather of a translation of the whole or part of the same by Dr. Priest, with L'Obel's arrangement. Of the numerous illustrations of the *Herball* sixteen appear to be original, the remainder are mostly impressions from the wood blocks employed by Jacob Theodorus (Tabernæmontanus) in his *Icones Stirpium*, published at Frankfort in 1590. A second edition of the *Herball*, with considerable improvements and additions, was brought out by Thomas Johnson in 1633, and reprinted in 1636. Gerard was elected a member of the court of assistants of the barber-surgeons in 1595, by which company he was appointed an examiner in 1598, junior warden in 1605, and master in 1608. He died in February, 1612, and was buried at St. Andrew's, Holborn.

See Johnson's preface to his edition of the *Herball;* and *A Catalogue of plants cultivated in the Garden of John Gerard in the years 1596–1599, edited with Notes, References to Gerard's Herball, the Addition of modern Names, and a Life of the*

Author, by Benjamin Daydon Jackson, F. L. S., privately printed, Lond., 1876, 4to.

GÉRARD DE NERVAL (1808–1855) is the adopted name of Gérard Labrunie, a French litterateur, and that by which he is generally known. The son of an officer in the army, and born at Paris, May 21, 1808, he received his early education chiefly from his father, who taught him German, and he afterwards studied at the college of Charlemagne. He made his literary début by the publication of a volume of political odes, and in 1828 he published a translation of Goethe's *Faust*, of which Goethe himself expressed high approval, and the choruses of which were afterwards made use of by Berlioz for his legend-symphony, *The Damnation of Faust*. Several other translations from the German, contributed chiefly to the *Mercure de France*, a number of poetical pieces, and three comedies combined to acquire for him, at the age of twenty-one, a considerable literary reputation, and led to his being associated with Theophile Gautier in the preparation of the dramatic *feuilleton* for the *Presse*. On the death of Jennie Colon, an actress with whom he had contracted a *liaison*, he resigned his connection with the *Presse*, and travelled in various parts of Europe, leading a somewhat dissipated life. He contributed an account of his travels to the *Revue des Deux Mondes* and other periodicals. After his return to Paris in 1844 he resumed for a short time the *feuilleton*. From 1841 he was subject to periodical attacks of insanity, and he committed suicide by hanging, 25th January, 1855. The literary style of Gérard is simple and unaffected, and he has a peculiar faculty of giving to his imaginative creations an air of naturalness and reality. In a series of novelettes, afterwards published under the name of *Les Illuminés ou les Precurseurs du Socialisme* (1852), he gave a sort of analysis of the feelings which followed his third attack of insanity; and among his numerous other works the principal are *Élégies nationales et Satires politiques*, 1827; *Scènes de la Vie Orientale*, 2 vols., 1848–1850; *Contes et Facéties*, 1852; *La Bohême galante*, 1856; and *L'Alchimiste*, a drama in five acts, the joint composition of Gérard and Alexander Dumas. His *Œuvres complètes* were published in 1868 in 5 volumes.

GERASA, the modern GERASH or JERASH, a city of Palestine, in the Decapolis of Peræa, situated amid the mountains of Gilead, about 1757 feet above the level of the sea, at a distance of 20 miles from the Jordan and 21 miles to the north of Philadelphia. Of its origin nothing is known. Its name is never mentioned in the Old Testament, and in the New Testament the only reference to its existence is the alternative reading of Gerasenes for Gadarenes in Matthew viii. 28. From Josephus we learn that it was captured by Alexander Jannæus, burned by the Jews in revenge for the massacre at Cæsarea, and again plundered and depopulated by Annius, the general of Vespasian; but in spite of these disasters it was still in the 2d and 3d centuries of the Christian era one of the wealthiest and most flourishing cities of Palestine. As late as 1121 it gave employment to the soldiers of Baldwin II., who found it defended by a castle built by a king of Damascus; but at the beginning of the following century the Arabian geographer Yakut speaks of it as deserted and overthrown. The ruins of Jerash, discovered by Seitzen about 1806 and since then frequently visited and described, still attest the splendor of the Roman city. They are distributed along both banks of the Kerwan, a brook which flows south through the Wady-ed-Dêr to join the Zerka or Jabbok; but all the principal buildings are situated on the level ground to the right of the stream. The town walls, which can still be traced and indeed are partly standing, had a circuit of not more than 2 miles, and the main street was less than half a mile in length; but remains of buildings skirt the road for fully a mile beyond the south gate, and show that the town had far outgrown the limit of its fortifications. The most striking feature of the ruins is the profusion of columns, no fewer than 230 being even now in position: the main street is a continuous colonnade, a large part of which is still entire, and it terminates to the south in a forum of similar formation. Among the public buildings still recognizable are a theatre capable of accommodating 6000 spectators, a naumachia or circus for naval combats, and several temples, of which the largest was probably the grandest structure in the city, possessing a portico of Corinthian pillars 38 feet high. The desolation of the city is probably due to earthquake; and the absence of Moslem erections or restorations would seem to show that the disaster took place before the Mahometan period.

GERBA or JERBA, German *Dscherba*, an island off the African coast in the Gulf of Gabes, belonging to the regency of Tunis. It is flat and well wooded with date palms, has an area of 425 square miles, and contains a population of 30,000. Most of the inhabitants are of Berber origin, though a certain proportion have adopted the Arabic language. About 5000 Jews live apart in villages of their own, and a number of European merchants are settled in the chief town of Haumt-es-Suk for the purposes of trade. The island has a considerable reputation for the manufacture of the woollen tissues interwoven with silk which are known as burnous stuffs; a market for the sale of sponges from the neighboring seas is held from November till March; and a good trade is maintained in the export of dates and other fruits. Gerba is the Lothophagitis or Lotus-eaters' Island of the Greek and Roman geographers, and it may also be identified with the Brachion of Scylax. The modern name appears as early as the 3d century in Aurelius Victor, who, mentioning the births of the emperors Gallus Trebonianus and Volusianus his son, says—"Creati in insula Meninge, quæ nunc Girba dicitur." Meninge or Meninx was the name of one of the two ancient towns in the island, the other being Thoar. A castle erected by the Spaniards in 1284 at Haumt-es-Suk still remains; but the pyramid built of the skulls of the Spaniards under Garcia, who perished in 1516, was removed in 1837.

See Barth, *Wanderungen durch die Küstenl. des Mittelmeres*; and Maltzan, *Reise in Tunis und Tripolis*, Leipsic, 1870.

GERBER, ERNST LUDWIG (1746–1819), author of the well-known dictionary of musicians, was born at Sondershausen 29th September, 1746. His father, Henry Nicolas Gerber (1702–1775), a pupil of J. S. Bach, was an organist and composer of some distinction, and under his direction Ernst Ludwig at an early age had made great progress in his musical studies. In 1765 he went to Leipsic with the view of studying law, but the claims of music, which had gained additional strength from his acquaintanceship with J. A. Hiller, soon came to occupy almost his sole attention. On his return to Sondershausen he was appointed music teacher to the children of the prince, and in 1775 he succeeded his father as court organist. Latterly he devoted much of his time to the study of the literature and history of music, and with this view he made himself master of several of the modern languages. His *Historisch-biographisches Lexikon der Tonkünstler* appeared in 1790 and 1792 in two volumes; and the first volume of what was virtually an improved and corrected edition of this work was published in 1810 under the title *Neues historisch-biographisches Lexikon der Tonkünstler*, followed by other three volumes in 1812, 1813, and 1814. Gerber also contributed a number of papers to musical periodicals, and published several minor musical compositions. He died at Sondershausen 30th June, 1819.

GERBERON, GABRIEL (1628–1711), a Jansenist monk, one of the most diligent students and prolific writers of his century, was born August 12, 1628, at St. Calais, in the department of Sarthe. At the age of twenty he took the vows of the Benedictine order at St. Melaine, Rennes, and after having taught rhetoric and philosophy in the monasteries of Bourgueil (Touraine) and St. Denis, he became sub-prior at Compiègne, whence he was afterwards removed to St. Germain-des-Pres. In the year 1669 he fully and finally committed himself in the Jansenist controversy by the publication of his first work, which was an apology for the abbé Rupert of Tuits. In 1672 he was ordered to Argenteuil and in 1675 to Corbie; but having by this time aroused the most bitter hostility of the entire Jesuit order, he found it necessary to save himself by flight into the Low Countries, where he seems to have lived in various towns during the next twenty-eight years, and where he published a great number of works, including the *Histoire Générale du Jansenisme* (1700), by which he is now best known. Arrested on the 30th of May, 1703, at Brussels, at the instance of the archbishop of Malines, he was sent into France and condemned to imprisonment, from which he was not released till 1710, and even then only after he had consented to abjure the five Jansenist propositions. The first use he made of his freedom was to write a work (which, however, his friends prudently prevented him from publishing) *Le vaine triomphe des Jesuites*, containing a virtual withdrawal of the compulsory recantation. He died at the abbey of St. Denis on the 29th of March, 1711. A full list of his works is given in the *Biographie Générale.*

GERBERT. See Silvester II.

GERBERT, Martin (1720–1793), a Catholic prelate and writer on church music, was a descendant of the Gerberts of Hornau, and was born at Horb on the Neckar, Würtemberg, 12th August, 1720. He received his education at the Jewish school of Freiburg in the Breisgau, at Klingenau in Switzerland, and at the monastery of St. Blaise in the Black Forest. He joined the order of the Benedictines in the monastery of St. Blaise in 1736, became priest in 1744, was soon thereafter appointed professor of theology, and was chosen abbot in 1764. From 1759 to 1762 he travelled in Germany, Italy, and France, chiefly with the view of obtaining access to the old collections of musical literature contained in the libraries of the monasteries. In 1774 he published two volumes *De cantu et musica sacra;* in 1777, *Monumenta veteris liturgiæ Alemannicæ;* and in 1784, in three volumes, *Scriptores ecclesiastici de musica sacra*, a collection of the principal writers on church music from the 3d century till the invention of printing. Although this work contains many textual errors, its publication has nevertheless been of very great importance for the history of music, by preserving writings which otherwise might either have perished or remained unknown. He is also the author of *Codex epistolaris Rudolphi I.*, 1772, and *Historia Nigræ Silvæ*, Cologne, 1783–1788. His interest in music led to his acquaintance with the composer Gluck, who became his intimate friend. He died 3d May, 1793.

GERHARD, Friedrich Wilhelm Eduard (1795–1867), a distinguished German archæologist, was born at Posen, 29th November, 1795. After studying at Breslau and Berlin, he in 1816 took up his residence at the former town. The reputation he acquired by his *Lectiones Apollonianæ*, published in the same year, led soon afterwards to his being appointed professor at the gymnasium of Posen. On resigning that office in 1819, on account of weakness in the eyes, he travelled in Italy, and in 1822 he took up his residence in Rome, where, with the view of prosecuting his archæological studies, he remained for fifteen years. He there contributed to Platner's *Beschreibung der Stadt Rom*, then under the direction of Bunsen, and he was also one of the principal originators of the *Instituto di corrispondenza archeologica*, founded at Rome in 1828, and during his stay in Italy its director. After his return to Germany in 1837, he was appointed archæologist at the Royal Museum of Berlin, and in 1844 he was chosen a member of the Academy of Sciences, and a professor in the university. He died at Berlin 12th May, 1867.

Besides a large number of archæological papers in periodicals, in the *Annali* of the Institute of Rome, and in the Transactions of the Berlin Academy, and several illustrated catalogues of Greek, Roman, and other antiquities in the Berlin, Naples, and Vatican Museums, Gerhard is the author of the following works;—*Antike Bildwerke*, Stuttg., 1827–44; *Auserlesene griech. Vasenbilder*, 1839–58; *Etruskische Spiegel*, 1839–65; *Hyperboreisch-röm Studien*, vol. i., 1833; vol. ii., 1852; *Prodromus mytholog. Kunsterklärung*, Stuttgart and Tübingen, 1828; and *Griech. Mythologie*, 1854–5. His *Gesammelte akademische Abhandlungen und kleine Schriften* were published posthumously in 2 vols., Berlin, 1867.

GERHARD, Johann (1582–1637), one of the ablest and most learned exponents of Lutheran orthodoxy, was born of a good middle-class family in Quedlinburg, 17th October, 1582. In his fifteenth year, during a dangerous illness, he came under the personal influence of Johann Arndt, author of *Das Wahre Christenthum*, and resolved to study for the church. Soon after entering the university of Wittenberg, however, in 1599, he began to waver in this determination, and ultimately gave himself for two years to the study of medicine, but in 1603 resumed his theological reading at Jena, and in the following year received a new impulse from Winkelmann and Mentzer at Marburg. Having graduated and begun to give lectures at Jena in 1605, he in 1606 received and accepted the duke of Coburg's invitation to the superintendency of Heldburg and mastership of the gymnasium; soon afterwards he became general superintendent of the duchy, in which capacity he was much and usefully engaged in the practical work of ecclesiastical organization until 1616, when he found a more congenial sphere in the senior theological chair at Jena, where the remainder of his life was spent. Though still comparatively young, Gerhard had already come to be regarded as the greatest living theologian of Protestant Germany; in the numerous "disputations" which characterized that period he was always protagonist, while on all public and domestic questions touching on religion or morals his advice was eagerly sought on all hands and by every class. It is recorded that during the course of his lifetime he had received repeated calls to almost every university in Germany, as well as to Upsala in Sweden. He died on the 20th August, 1637. Personally he is said to have exhibited a rare combination of all the best elements of the Christian character; the only failing imputed to him by any one decidedly leans to virtue's side—an excessive love of peace.

His writings are very numerous, alike in exegetical, polemical, dogmatic, and practical theology. To the first category belong the *Commentarius in harmoniam historiæ evangelicæ de passione Christi* (1617), the *Comment. super priorem D. Petri Epistolam* (1641), and also his commentaries on Genesis (1637) and on Deuteronomy (1658). Of a controversial character are the *Confessio Catholica* (1634–68), an extensive work which seeks to prove the evangelical and catholic character of the doctrine of the Augsburg Confession from the writings of approved Roman Catholic authors; and the *Loci theologici* (1629), his principal contribution to science, in which Lutheranism is expounded "nervose, solide, et copiose," in fact with a fulness of learning, a force of logic, and a minuteness of detail that had never before been approached. The *Meditationes sacræ* (1621), a work expressly devoted to the uses of Christian edification, has been frequently reprinted in Latin and has been translated into most of the European languages, including Greek. The English translation by R. Winterton (1631) has passed through at least nineteen editions. There is also an edition by W. Papillon in English blank verse (1801). A *Vita Joh. Gerhardi* was published by E. R. Fischer in 1723.

GERHARDT, Charles Frederic, was born at Strasburg, August 21, 1816, and died there August 19, 1856. After his school years spent at home and in Carlsruhe, where his taste for chemistry was awakened, he was sent to Leipsic to learn business, but he attended Erdmann's lectures on chemistry as well. Returning home he very soon found that a commercial life was not to his taste, so, after a sharp dispute with a disappointed father, he enlisted in a cavalry regiment. In a few months a military career also became intolerable, and, being bought off by a friend, he went to Giessen to study under Liebig. There he remained eighteen months, displaying such entire devotion to chemistry that he found himself unable to obtain the customary degree. He again thought of entering trade, but Liebig persuaded him to go to Paris, where he arrived in 1838. His good appearance and address recommended him to Dumas and other chemists, and in a short time along with Cahours, who became his intimate friend, he published an important memoir on essential oils, distinguished especially by the new views it contained. He soon after left Paris and went to Montpellier, where he was professor in the faculty of science till 1848. He then returned to Paris and opened a school for chemistry, which, however, was not commercially a success. From 1848 to 1855 he resided at Paris, and it was during this time that he published the memoirs and carried on the controversies which have been of such importance in the development of scientific chemistry. In 1855 he was appointed professor at Strasburg, his native place; but he had held the office for but a short time when he died, after two days' illness. Gerhardt's contributions to chemistry are less discoveries of new facts, than of new ideas which organized and vitalized an inert accumulation of facts. He developed the notion of types of structure and reaction; he discovered the order of organic compounds, which led him to the doctrine of homologous and other series; and on theoretical grounds he remodelled the whole character of the combining weights upon the two-volume molecular basis. The bare statement, however, of his results gives no idea of the lucidity, the wealth of thought, the grasp of the entire subject which his memoirs and his longer works display. It was by his writings especially that Gerhardt's influence was felt. Although a thorough enthusiast in his subject, clear in his exposition, earnest in his work, weighty in his delivery, he seems to have wanted the qualities of a successful teacher. Nothing is heard of his lectures, or of his influence as a professor,—such influence as drew students round Liebig and other great masters. None the less, however, did he stir the thoughts of other chemists to the very depths; and although the unitary system has had its day, yet, in substance at least, if no longer in name, chemistry is still Gerhardt's, and it is not impossible that chemists may return to some of his views which at present are not acceptable.

GERHARDT, Paul (c. 1606–1676), the greatest hymn-writer of Germany, if not indeed of Europe, was born of a good middle-class family at Gräfenhainichen, a small town on the railway between Halle and Wittenberg, in 1606 or 1607,—some authorities, indeed, give the date March 12, 1607, but neither the year nor the day is accurately known. His education appears to have been retarded by the troubles of the period, the Thirty Years' War having begun about the time he reached his twelfth year. After completing his studies for the church he is known to have lived for some years at Berlin as tutor in the family of an advocate named Berthold, whose daughter he subsequently married, on receiving his first ecclesiastical appointment at Mittelwald (a small town in the neighborhood of Berlin) in 1651. In 1657 he accepted an invitation as "diaconus" to the Nicolaikirche of Berlin; but, in consequence of his uncompromising Lutheranism in refusing to accept the elector Frederick William's "syncretistic" edict of 1664, he was deprived in 1666. Though absolved from submission and restored to office early in the following year, on the petition of the citizens, his conscience did not allow him to retain a post which, as it appeared to him, could only be held on condition of at least a tacit repudiation of the Formula Concordiæ, and for upwards of a year he lived in Berlin without fixed employment. In 1668 he was appointed archdeacon of Lübben in the duchy of Saxe-Merseburg, where, after a somewhat sombre ministry of eight years, he died on the 7th of June, 1676. Many of his best known hymns were originally published in various church hymn-books, as for example in that for Brandenburg which appeared in 1658; others first saw the light in Johann Crüger's *Geistliche Kirchenmelodien* (1649) and *Praxis Pietatis Melica* (1656). The first complete set of them is the *Geistliche Andachten*, published in 1666–67 by Ebeling, music director in Berlin. No hymn by Gerhardt of a later date than 1667 is known to exist.

The life of Gerhardt has been written by Roth (1829), by Langbecker (1841), by Schultz (1842), by Wildenhahn (1845), and by Bachmann (1863); also by Kraft in Ersch u. Gruber's *Allg. Encycl.* (1855). The best modern edition of the hymns, published by Wackernagel in 1843, has often been reprinted. There is an English translation by Kelly (*Paul Gerhardt's Spiritual Songs*, 1867).

GÉRICAULT, Jean Louis André Théodore (1791–1824), French painter, led the inevitable reaction which set in under the empire against the fixed and strictly limited aims of the school of David. He was born at Rouen in 1791. In 1808 he entered the studio of Charles Vernet, from which, in 1810, he passed to that of Guérin, whom he drove to despair by his passion for Rubens, and by the unorthodox manner in which he persisted in interpreting nature. At the Salon of 1812 Géricault attracted attention by his "Officier de Chasseurs à Cheval" (Louvre), a work in which he personified the cavalry in its hour of triumph, and turned to account the solid training received from Guérin in rendering a picturesque point of view which was in itself a protest against the cherished convictions of the pseudo-classical school. Two years later (1814) he re-exhibited this work accompanied with the reverse picture "Cuirassier blessé" (Louvre), and in both subjects called attention to the interest of contemporary aspects of life, treated neglected types of living form, and exhibited that mastery of and delight in the horse which was a feature of his character. Disconcerted by the tempest of contradictory opinion which arose over these two pictures, Géricault gave way to his enthusiasm for horses and soldiers, and enrolled himself in the *mousquetaires*. During the Hundred Days he followed the king to Bethune, but, on his regiment being disbanded, eagerly returned to his profession, left France for Italy in 1816, and at Rome nobly illustrated his favorite animal by his great painting "Course des Chevaux Libres." Returning to Paris, Géricault exhibited at the Salon of 1819 the "Radeau de la Méduse" (Louvre), a subject which not only enabled him to prove his zealous and scientific study of the human form, but contained those elements of the heroic and pathetic, as existing in situations of modern life, to which he had appealed in his earliest productions. Easily depressed or elated, Géricault took to heart the hostility which this work excited, and passed nearly two years in London, where the "Radeau" was exhibited with success, and where he executed many series of admirable lithographs now rare. At the close of 1822 he was again in Paris, and produced a great quantity of projects for vast compositions, models in wax, and a horse *écorché*, as preliminary to the production of an equestrian statue. His health was now completely undermined by various kinds of excess, and on 26th January, 1824, he died at the age of thirty-three. That which he left us is effective only as a protest; his work, like his life, lacked the fixity of conscious purpose necessary to the task of reconstruction. Had he steadied himself and survived the abuse of his powers, he might have played an important part in determining the course of the modern school, for, though no colorist, he was in other respects richly endowed, and was possessed by a rare energy which redeemed even that tendency to undue emphasis which gives a theatrical character to much of the best French work. Géricault's biography, accompanied by a *catalogue raisonné* of his works, was published by M. C. Clément in 1868.

GERIZIM (הַר־גְּרִזִּים, "the desert hill," or, according to others, "the hill of the Gerizzites"[1]), the third highest mountain of Samaria,[2] is situated at the western extremity of the fertile plain of Mochna, and with Mount Ebal, which lies immediately to the north, forms a narrow valley in which lies the ancient town of Sichem or Shechem. As seen from this point Gerizim is distinguished from its tamer neighbor by the boldness of its crags, the richness of its verdure, and the number of its springs. Its southern slope however is much gentler than its northern, and both are almost bare of trees. On the summit stands at present a small Mahometan chapel, and there are besides numerous traces of a fortress and church possibly dating from the time of Justinian. But the spot regarded by the Samaritans as the holiest upon earth is a small level plateau situated somewhat to the south of this. Here it is believed stood the temple built by Manasseh, the son of the Jewish high priest in the days of Nehemiah,[3] and destroyed by John Hyrcanus 300 years afterwards (Jos., *Ant.*, xiii. 9. 1). According to the Samaritans and some modern writers, Gerizim was the scene of the incidents recorded in Genesis xxii. 9–13. Probably as being the hill on the right hand of the spectator who, standing in the valley of Shechem, looks to the sun rising, it was also the hill on which, according to Josh. viii. 33, 34 (comp. Deut. xi. 29, 30, and xxvii. 12–26), after the conquest of Ai, the tribes of Simeon, Levi, Judah, Issachar, Joseph, and Benjamin, stood to pronounce the blessings connected with a faithful observance of the law, while the remaining tribes from Mount Ebal confirmed the curses attached to specified violations of the divine commands. According to Eusebius and Jerome indeed, the Ebal and Gerizim described in Deut. xi. 30 were not the mountains now known by that name, but two smaller hills in the neighborhood of Jericho. This view, however, may now be regarded as universally abandoned (see Stanley, *Sinai and Palestine*, p. 236, note).

GERMAN CATHOLICS (Deutschkatholiken), the name assumed in Germany towards the close of the year 1844 by certain dissentients from the church of Rome. The most prominent leader of the German Catholic movement was Johann Ronge, a Roman Catholic priest, who in October, 1844, made a vigorous attack upon Arnoldi, bishop of Treves, for having made a relic, which he alleged to be the holy seamless coat of Christ, an object of pilgrimage and adoration. On Ronge's excommunication on this account, by the chapter of Breslau in December, 1844, he received a large amount of public sympathy, and a dissenting congregation was almost immediately formed at Breslau with a very simple creed, in which the chief articles were belief in God the Father, creator and ruler of the universe; in Jesus Christ the Saviour, who delivers from the bondage of sin by his life, doctrine, and death; in the operation of the Holy Ghost; in a holy, universal, Christian church; in forgiveness of sins and the life everlasting. Within a very few weeks similar communities had been formed at Leipsic, Dresden, Berlin, Offenbach, Worms, Wiesbaden, and elsewhere; and at a "council" convened at Leipsic in March, 1845, twenty-seven congregations were represented by delegates, of whom however only two or at most three were in clerical orders. Almost contemporaneously with the commencement of the agitation led by Ronge, another movement fundamentally distinct, though in some respects similar, had been originated at Schneidemühl, Posen, under the guidance of Johann Czerski, also a priest, who had come into collision with the church authorities on the then much discussed question of mixed marriages, and also on that of the celibacy of the clergy. The result had been his suspension from office in March, 1844; his public withdrawal, along with twenty-four adherents, from the Roman communion in August; his excommunication immediately thereafter: and the formation, in October, of a "Catholic Apostolic Christian" congregation which, while rejecting various practices of the Roman Church, retained the Nicene theology and the doctrine of the seven sacraments. Czerski had been at some of the sittings of the "German Catholic" council of Leipsic; but when a formula somewhat similar to that of Breslau had been adopted, he refused to adhibit his signature because the divinity of Christ had been ignored, and he and his congregation continued to retain by preference the name of "Catholic Apostolic Christians" which they had originally assumed. Of the German Catholic congregations which had been represented at Leipsic some manifested a preference for the fuller and more positive creed of Schneidemühl, but a great majority continued to accept the comparatively negative theology of the Breslau school. The number of these increased with considerable rapidity, until in June, 1846, in Silesia alone the members of the German Catholic communion were reckoned by thousands, while the congregations scattered over Germany amounted in all to 173. In Austria, however, and ultimately also in Bavaria, the use of the name German Catholics was officially prohibited, that of "Dissidents" being substituted, while in Prussia the adherents of the new creed were laid under various disabilities; these and other circumstances, among which the frequent occurrence of internal dissensions was perhaps the gravest, conspired to check at an early stage the prosperous career of a movement which in its beginnings had been looked upon by many intelligent observers with considerable hopefulness. In 1859 some of the German Catholics entered into a union with the "Free Congregations," when the united body took the title of "The Religious Society of Free Congregations." Before that time many of the congregations which were formed in 1844 and the years immediately following had been dissolved, including that of Schneidemühl itself, which ceased to exist in 1857. No very recent statistics of a trustworthy kind as to the numerical strength of the German Catholics are accessible. Their total in Prussia was 6395 in 1861, and 10,920 in 1867, while in Saxony they numbered 1772 in 1849, and 3015 in 1871. At an early stage the movement attracted the attention of Gervinus, the eminent historian and critic, who in 1846 published a pamphlet entitled *Die Mission des Deutschkatholicismus*, to which, as well as to Kampe's treatise *Das Wesen des Deutschkatholicismus*, reference may be made. See also the article by Schmid in Herzog's *Realencyclopädie* (1878).

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[1] See 1 Sam. xxvii. 8 (Keri).

[2] Josephus (*Ant.*, xi. 8, 2) calls it the highest, but his assertion has been disproved by recent accurate measurement. According to Furrer, Tell 'Azur, Ebal, and Gerizim are 3566, 3375, and 3179 feet respectively above the level of the Mediterranean.

[3] In the days of Alexander the Great, according to Josephus (*Ant.*, xi. 8, 2); but there are good reasons for believing this be inexact. See Neh. xiii. 28, and compare Bertheau on the passage.

GERMANICUS, Cæsar, a distinguished Roman general and provincial governor in the reign of Tiberius, was born 15 B. C., and died 19 A. D. His name Germanicus, the only one by which he is known in history, he inherited from his father Claudius Drusus Nero, the stepson of Augustus, and the most famous of his generals. His mother was the younger Antonia, the daughter of Marcus Antonius and niece of Augustus, and he married Agrippina the granddaughter of the same emperor. It was natural that a prince so intimately allied both by birth and connection with the reigning family should be regarded as a candidate for the purple. Augustus, it would seem, long hesitated whether he should name him as his successor, and as a compromise required Tiberius to adopt him, though Tiberius had a son of his own. When his uncle succeeded to the throne, Germanicus was the only rival that he feared; and the emperor's jealously and suspicion of him not only cut short his career of conquest but embittered the last years of his life, and precipitated, if it did not indirectly cause, his unhappy and premature end.

For the facts of his life our chief and, except a brief notice in Suetonius, almost our sole authority is Tacitus. Germanicus forms the central figure of the first two books of the *Annals*, and in the minute and graphic record of his campaigns, the unravelling of the court intrigues to which he was subject, and the pathetic description of his last hours and of the outburst of grief and indignation which followed the news of his death, the historian has put forth all his powers. But a modern biographer, though compelled to trust to Tacitus for his materials, may yet be allowed to put upon them his own construction, to make allowance for the glamour which surrounded an amiable and ill-starred prince, and to discount the exaggerations of a master of rhetoric who has set his favorite hero in a blaze of light in order to deepen the shadows of his masterpiece Tiberius, the darkest and saddest portrait in all history. The following article will consist of a brief abstract of the life as related by Tacitus, and an estimate of the character as it presents itself to us in the foregoing records.

Of the early years and education of Germanicus little is known. That he possessed considerable literary abilities, and that these were carefully trained, we gather, not only from the speeches which Tacitus puts into his mouth, but from the reputation he left as an orator, as attested by Suetonius and Ovid, and from the fragments of his works which have survived. At the age of twenty he served his apprenticeship in the art of war under his uncle Tiberius, and was rewarded with the triumphal insignia for his services in crushing the revolt in Dalmatia and Pannonia. In 12 A. D. he was made consul, though he had neither attained the legal age nor passed through the grades of prætor and ædile. Soon afterwards he was appointed by Augustus to the important command of the eight legions on the Rhine. The news of the emperor's death found Germanicus at Lugdunum, where he was superintending the census of Gaul. Close upon this came the report that a mutiny had broken out among his legions on the lower Rhine. Germanicus hurried back to the camp, which was now in open insurrection. The tumult was with difficulty quelled, partly by well timed concessions for which the authority of the emperor was forged, but mostly by the help of his personal popularity with the troops. Some of the insurgents actually proposed that he should put himself at their head and secure for himself the empire, but their offer was rejected with righteous horror. In order to calm the excitement and prevent further disaffection, Germanicus determined at once on an active campaign. Crossing the Rhine at the head of 12,000 legionaries and an equal number of allied troops, he attacked and routed the Marsi, and laid waste the valley of the Ems. In the following year he marched against Arminius, the conqueror of Varus, and reached the fatal battlefield in the Teutoburg Forest. The bones of the Roman soldiers still lay bleaching on the ground near the altars where their tribunes had been immolated, and the gibbets where the prisoners had been hanged. Having performed the last rites and erected a barrow to mark the spot, he led his army on, breathing vengeance against the foe. Arminius, however, favored by the marshy ground, was able to hold his own, and it required another campaign before he was finally defeated. A masterly combined movement by land and water enabled Germanicus to concentrate his forces against the main body of the Germans encamped on the Weser, and to crush them in two obstinately contested battles. A monument erected on the field proclaimed that the army of Tiberius had conquered every tribe between the Rhine and the Elbe. Great as the success of the Roman arms had been, it was not such as to justify this boastful inscription. We read of renewed attacks from the barbarians, and plans of a fourth campaign for the next summer.

But no more victories were in store for Germanicus. His success had already stirred the jealousy and fears of Tiberius, and he was reluctantly compelled to obey the imperial summons and repair to Rome. The magnificence of a triumph and the idle honors of a consulship had little attraction for a general in mid-career of conquest, and a man of singularly simple habits and no political ambition. The enthusiasm with which he was welcomed, not only by the populace, which went in crowds to meet him as far as the twentieth milestone, but by the emperor's own prætorians, warned Tiberius that it might be equally dangerous to keep so popular a favorite at Rome, and the earliest pretext was

seized to remove him from the capital. The recent death of Archelaus, king of Cappadocia, and a disputed succession in Parthia and Armenia, afforded a sufficient plea for Roman interference; and, a few months after his return, Germanicus was despatched to the East with extraordinary powers, and started on his mission without waiting to enter on his consulship. At the same time Tiberius took the further precaution of superseding Silanus, a connection of Germanicus, in the government of Syria, and appointing in his stead one of the most violent and ambitious of the old nobility, Cneius Calpurnius Piso, in order to watch his nephew's movements, and if necessary to check his ambition. Germanicus proceeded by easy stages to his province, halting on his way in Dalmatia, where he conferred with Drusus, his brother by adoption, and visiting the battlefield of Actium, Athens, Ilium, and other places of historic interest. At Rhodes he met for the first time his coadjutor Piso, who had followed in his wake, and was seeking everywhere to thwart his policy and asperse his character. When at last he reached his destination, he found little difficulty in effecting the settlement of the disturbed provinces, notwithstanding the violent and persistent opposition of Piso. At Artaxata Zeno, the popular candidate for the throne, was crowned king of Armenia; to the provinces of Cappadocia and Commagena Roman governors were assigned; and Parthia was conciliated by the banishment of the dethroned king Vonones. After wintering in Syria, Germanicus started next year for a tour in Egypt. The chief motive for his journey was love of travel and antiquarian study, and it seems never to have occurred to him, till he was warned by Tiberius, that he was thereby transgressing an unwritten law of the empire forbidding any Roman of rank to set foot in Egypt without express permission. On his return to Syria he found that all his arrangements had been upset by Piso. Violent recriminations followed, the result of which, it would seem, was a promise on the part of Piso to quit the province. But at this juncture Germanicus fell ill. Piso deferred his departure, and, when at length compelled to start, lingered in the neighborhood of Syria, receiving with open exultation the bulletins which told of the prince's rapid decline. Germanicus on his side was fully convinced that he had fallen a victim to the arts of his unscrupulous enemy. He knew that he was dying, and believed that he was dying of poison. Even his gentle nature was stung to madness at the thought, and with his dying words he called on his friends and family to denounce his murderer and avenge his death. Whether these suspicions were true must remain an open question, yet the arguments in favor of a death from natural causes seem to preponderate. It is true that Piso desired his death, and, from what we know of their characters, neither he nor his wife Plancina were likely to stick at any means for procuring it. But a poisoner does not generally let his wishes be publicly known, nor show his exultation when they are attained. The evidence from the appearance of the corpse is still more uncertain. Suetonius indeed avouches that there were livid marks all over the body and foam at the mouth; but he adds as a further proof of poison that on the funeral pyre the heart remained unconsumed, which clearly shows that he was only retailing the vulgar gossip. Tacitus, though inclined to believe the worst of Piso, allows that the report of the symptoms varied with the prepossession of the observers.

The sad tidings of his death cast a gloom over the whole Roman empire. To the provincials he had endeared himself by his simple manners, his affability, his generosity, his justice. The legions mourned their comrade who had always stood their friend at need, their general who had never known a defeat. At Rome there was a universal outburst of sorrow and indignation. The natural grief at the loss of a favorite prince was aggravated by the suspicion of foul play, and by hatred of the emperor who was at least guilty of recklessly exposing him to danger, and who now sullenly refused to join the general mourning. Men recalled the foreboding words which had been whispered at his departure, "Whom the plebs love, die young." Nor was he unworthy of this passionate devotion. He had wiped out a great national disgrace; he had quelled their most formidable foe; he had pacified distant provinces; and in his high estate he had so borne himself that all save one man had loved and honored him. His private life had been stainless, and he possessed in a singular degree the gift of personal attractiveness. And yet an impartial biographer must add that for his fair fame his death was opportune. There were elements of weakness in his character which his short life only half revealed: an almost feminine impetuousness which made him twice threaten to take his own life; a superstitious vein which impelled him to consult oracles and shrink from bad omens; an amiable dilettantism which led him to travel in Egypt while his enemy was plotting his ruin; a want of nerve and resolution which prevented him from coming to an open rupture with Piso till it was too late. His very virtues, his elegant taste, his chivalrous sense of honor, his unsuspecting openness and candor, unfitted him for the stern times in which he lived. He was as little fitted to play the part of Augustus as that of Alexander, to whom Tacitus fondly compares him; and had he lived to succeed to the purple the historian might have been compelled to pronounce on him the epitaph of Galba, that all would have thought him fit to reign if he had not reigned. (F. S.)

GERMAN SILVER, or Nickel Silver, known also under the names of White Copper and Packfong, is an alloy of copper, nickel, and zinc, prepared either by melting the copper and nickel together in a crucible, and adding piece by piece the previously heated zinc, or by heating the finely divided metals under a layer of charcoal, by means of an air furnace of strong draught, and promoting the thorough solution of the nickel by stirring. To destroy its crystalline structure, and so render it fit for working, it is heated to dull redness, and then allowed to cool. German silver is harder than silver; it resembles that metal in color, but is of a greyer tinge. Exposed to the air it tarnishes slightly yellow, and with vinegar affords a crust of verdigris. At a bright red heat it melts, and with access of the atmosphere loses its zinc by oxidation. At a heat above dull redness it becomes exceedingly brittle. German silver is much used in the arts. For the manufacture of imitation silver for knives and forks its composition is—nickel and zinc of each 2 parts, and copper 4 parts; for handles of spoons and forks the proportion of copper in this formula is increased by 1. For rolling, the most suitable alloy is copper 3 parts, zinc 1, nickel 1. Candlesticks, bells, spurs, and other cast articles are made of a German silver containing 2 or 3 per cent. of lead. The addition of 2 to 2½ per cent. of iron, which must first be melted with part of the copper, makes an alloy which is whiter, but also more brittle and harder than ordinary German silver.

See Copper, vol. vi. p. 312, and Watts, *Dict. of Chem.* ii. p. 51. On the electrical conductive capacity of German silver, see Electricity, vol. viii. p. 51.

GERMANY. Part. 1.—Geography and Statistics.—Germany occupies the greater portion of central Europe, and has but few lines of natural boundary. If by the designation Germany is meant the territory inhabited by Germans, this is considerably larger than the German empire constituted in 1871, the former having an area of about 340,000, and the latter of 208,000 English square miles. The present German empire extends from 47° 16′ to 55° 53′ N. lat., and from 5° 52′ to 22° 52′ E. long. The eastern provinces project so far that the extent of the German territory is much greater from S. W. to N. E. than in any other direction. Tilsit is 815 miles from Metz, whereas Hadersleben, in Schleswig, is only 540 miles from the Lake of Constance. The difference in time between the eastern and western points is 1 hour and 8 minutes. The empire is bounded on the S. W. and S. by Austria and Switzerland (for 1170 miles), on the S. W. by France (275 miles), on the W. by Luxembourg, Belgium, and Holland (together 512 miles). The length of German coast on the North Sea or German Ocean is 300 miles, and on the Baltic 830 miles, the intervening land boundary on the north of Schleswig being only 53 miles. The eastern boundary is Russia (725 miles).

The total area of the empire including rivers and lakes but not the "haffs" or lagoons on the Baltic, is 208,427 English square miles,[1] which is about the 18th part of Europe, the 250th part of the whole dry land, and the 853d part of the whole surface of the globe.

PHYSICAL FEATURES.

Coast and Islands.—The length of the coast-line is scarcely the third part of the whole frontier, so that the

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[1] 1 English square mile = 2·5898945 square kilometres, or 0·0470352 German square mile; 1 German square mile = 21·26067 English square miles; 1 sq. kilometre = 0·3861161 English square mile.

Germans must be regarded as less a maritime than an inland people. Unlike the eastern states of Europe, the German empire has not only an inland sea-shore, but is also in direct communication with the great oceans by means of the North Sea. The coasts of Germany are shallow, and deficient in natural ports, except on the east of Schleswig-Holstein, where wide bays encroach upon the land, giving access to the largest vessels, so that a great harbor for men-of-war has been constructed at Kiel. With the exception of those on the east coast of Schleswig-Holstein, all the important trading ports of Germany are river ports, such as Emden, Bremen, Hamburg, Lübeck, Stettin, Dantzic, Königsberg, Memel. A great difference, however, is to be remarked between the coasts of the North Sea and those of the Baltic. On the former, where the sea has broken up the ranges of dunes formed in bygone times, and divided them into separate islands, the mainland has to be protected by massive dikes, while the Frisian Islands are being gradually washed away by the waters. On the coast of East Friesland there are now only seven of these islands, of which, Norderney, a bathing-place, is best known, while of the North Frisian Islands, on the western coast of Schleswig, Sylt is the most considerable. Besides the ordinary waste of the shores, there have been extensive inundations by the sea within the historic period, the gulf of the Dollart having been so caused in the year 1276. Sands surround the whole coast of the North Sea to such an extent that the entrance to the ports is not practicable without the aid of pilots. Heligoland, which has belonged to England since 1814, is a rocky island, but it has also been considerably reduced by the sea. The tides rise to the height of 12 or 13 feet in the Jahde Bay and at Bremerhafen, and 6 or 7 feet at Hamburg. The coast of the Baltic on the other hand possesses few islands, the chief being Alsen and Fehmern off the coast of Schleswig-Holstein, and Rügen off Pomerania. It has no extensive sands, though on the whole very flat. The Baltic has no perceptible tides; and a great part of its coast-line is in winter covered with ice, which also so blocks up the harbors that navigation is interrupted for several months every year. Its three haffs fronting the mouths of the large rivers must be regarded as lagoons or extensions of the river beds, not as bays. The Oder Haff is separated from the sea by two islands, so that the river flows out by three mouths, the middle one (Swine) being the most considerable. The Frische Haff is formed by the Nogat, a branch of the Vistula, and by the Pregel, and communicates with the sea by means of the Pillau Tief. The Kurische Haff receives the Memel, called Niemen in Russia, and has its outlet in the extreme north at Memel. Long narrow alluvial strips called *Nehrungen*, lie between the last two haffs and the Baltic. The Baltic coast is further marked by large indentations, the Gulf of Lübeck, that of Pomerania, east of Rügen, and the semicircular Bay of Dantzic between the promontories of Rixhöft and Brüsterort. The German coasts are now well provided with lighthouses.

Surface and Geology.—In respect of physical structure Germany is divided into two entirely distinct portions, which bear to one another a ratio of about 3 to 4. The northern and larger part may be described as a uniform plain, covered generally by very recent deposits, but with small areas of Tertiary and Secondary formations protruding here and there. South and Central Germany, on the other hand, is very much diversified in scenery and in geological structure. It possesses large plateaus such as that of Bavaria, which stretches away from the foot of the Alps, fertile low plains like that intersected by the Rhine, mountain chains, and isolated groups of mountains, comparatively low in height, and so situated as not seriously to interfere with communication either by road or by railway. Its geological structure corresponds to this diversity of surface. The most ancient rocks of Germany are the gneisses, schists, and granites which form the Bohemian and Bavarian plateau, and extend into Saxony. Another isolated mass of similar rocks rising into the heights of the Vosges and Black Forest has been cut through by the valley of the Rhine. Silurian rocks are but scantily developed in Germany. The Devonian system, however, occupies an extensive area, since it forms the high tableland of the Taunus, Hundsruck, and Eifel, which ranges westward into Belgium. Carboniferous rocks with productive coal-fields cover isolated areas, chiefly in north-western Germany, particularly in Westphalia, at Saarbrück, in Saxony, and in Upper and Lower Silesia (see COAL). Between the Devonian uplands of the Taunus and the crystalline rocks of Bavaria a vast area of western Germany is occupied by the Triassic system, which ranges from Hanover to Basel and from near Metz to Baireuth. The southern half of this vast Triassic basin is bordered by a belt of overlying Jurassic rocks which skirt the Danubian plain in Würtemberg and Bavaria. Cretaceous rocks occur chiefly in north Germany in scattered patches flanking older formations. They evidently underlie the great plain, since they are found rising up here and there to the surface between Westphalia and Denmark. Older Tertiary formations are absent from Germany, save the portion of the Eocene Alps included within the territory of Bavaria. But Miocene deposits extend into numerous detached basins, including those of the Rhine below Bonn, and at Mainz, the country round Magdeburg, and the plains of Bavaria. These strata contain valuable seams of lignite. The vast plains of northern Germany are covered with glacial drift, which rises to heights of 1400 feet above the sea along the edges of the flanking hills. Igneous rocks of different ages have been erupted in many districts, and further diversify the geology. The best known are the Tertiary and post-Tertiary lavas and cones of the Eifel and Siebengebirge; others of more ancient date occur along the southern slopes of the Harz.

Mountains and Plateaus.—Bavaria is the only division of the country that includes within it any part of the Alps, the Austro-Bavarian frontier running along the ridge of the Northern Tyrolese or Bavarian Alps. The loftiest peak of this group, the Zugspitze (57 miles south of Munich), is 9702 feet in height, being the highest summit in the empire. The Upper German plain sloping northwards from the Bavarian Alps is watered by the Lech, the Isar, and the Inn, tributaries of the Danube, all three rising beyond the limits of German territory. This plain is separated on the west from the Swiss plain by the Lake of Constance (Bodensee, 1306 feet above sea-level), and on the east from the undulating grounds of Austria by the Inn. The average height of the plain may be estimated at about 1800 feet, the valley of the Danube on its north border being from 1540 feet (at Ulm) to 920 feet (at Passau). The plain is not very fertile. In the upper part of the plain, towards the Alps, there are several lakes, the largest being the Ammersee, the Würmsee or Starnberg Lake, and the Chiemsee. Many portions of the plain are covered by moors and swamps of large extent, there called *Moose.* The left or northern bank of the Danube, from Regensburg (Ratisbon) downwards presents a series of granitic rocks called the Bavarian Forest (Bayerischer Wald), which must be regarded as a branch of the Bohemian Forest (Böhmischer Wald). The latter is a range of wooded heights on the frontier of Bavaria and Bohemia, occupying the least known and least frequented regions of Germany. The summits of the Bayerischer Wald rise to the height of about 4000 feet, and those of the Bohemian Forest to 4800 feet, Hoher Arber, about 49° N. lat., being 4842 feet. The valley of the Danube above Ratisbon is flanked by Jurassic plateaus sloping gently to the Danube, but precipitous towards the valley of the Neckar. The centre of this elevated tract is the Rauhe Alp, so named on account of the harshness of the climate. The plateau continuing to the north-east and then to the north, under the name of the Franconian Jura, is crossed by the valley of the winding Altmühl, and extends to the Main. To the west extensive undulating grounds or low plateaus occupy the area between the Main and the Neckar.

The south-western corner of the empire contains a series of better defined hill-ranges. Beginning with the Schwarzwald (Black Forest), we find its southern heights decline to the valley of the Rhine, above Basel, and to the Jura. The summits are rounded and covered with wood, the highest being the Feldberg (10 miles S. E. of Freiburg, 4902 feet). Northwards the Black Forest passes into the plateau of the Neckarbergland (average height, 1000 feet). The heights between the lower Neckar and the Main form the Odenwald (about 1700 feet); and the Spessart, which is watered by the Main on three sides, is nothing but a continuation of the Odenwald. West of this range of hills lies the valley of the upper Rhine, extending about 180 miles from south to north, and with a width of only 20 to 25 miles. In the upper parts the Rhine is rapid, and therefore navigable with difficulty; this explains why the towns there are not along the banks of the river, but some 5 to 10 miles off. But from Speyer (Spires) town succeeds town as far down as Düsseldorf. The western boundary of this valley is formed in the first instance by the Vosges, where granite summits rise from under the surrounding red Triassic rocks (Sulzer Belchen, 4700 feet). To the south the range is not continuous with the Swiss Jura, the valley of the Rhine being connected here with the Rhone system by low ground known as the Gate of Mülhausen. The crest of the Vosges is pretty high and unbroken, the first convenient pass being near Zabern, which has been taken advantage of for the railway from Strasburg to Paris. On the northern side the Vosges are connected with the Haardt sandstone plateau (Kalmit, 2230 feet), which rises abruptly from the plain of the Rhine. The mountains south of Mainz (Mayence), which are mostly covered by vineyards, are lower, the Donnersberg, however, raising its head to 2262 feet. These hills are bordered on the west by the high plain of Lorraine and the coal-fields of Saarbrücken, the former being traversed by the river Moselle. The larger half of Lorraine belongs to France, but the German part possesses great mineral wealth in its rich layers of ironstone (siderite), and in the coal-fields of the Saar. The Devonian tract of the Hundsruck, Taunus, and Eifel is an extended plateau, divided into separate sections by the river valleys. Among these the Rhine valley from Bingen to Bonn, and that of the Moselle from Treves to Coblentz, are winding gorges excavated by the rivers. The Eifel presents a sterile, thinly-peopled plateau, covered by extensive moors in several places. It passes westwards imperceptibly into the Ardennes. The hills on the right bank of the Rhine also are in part of a like barren character, without wood; the Westerwald (about 2000 feet), which separates the valleys of the Sieg and Lahn, is particularly so. The northern and southern limit of the Niederrheinisches Gebirge present a striking contrast to the central region. In the south the declivities of the Taunus (2890 feet) are marked by the occurrence of mineral springs, as at Ems on the Lahn, Nauheim, Homburg, Soden, Wiesbaden, etc., and by the vineyards which produce the best Rhine wines. To the north of this Gebirge, on the other hand, lies the great coal basin of Westphalia (the largest in Germany). In the south of the hilly duchy of Hesse rise the isolated mountain groups of the Vogelsberg (2530 feet) and the Rhön (3117 feet), separated by the valley of the Fulda, which uniting further north with the Werra forms the Weser. To the east of Hesse lies Thuringia, a province consisting of the far-stretching wooded ridge of the Thüringer Wald (with three peaks of upwards of 3000 feet high), and an extensive elevated plain to the north. Its rivers are the Saale and Unstrut. This plateau is bounded on the north by the Harz, an isolated group of mountains, rich in minerals, with its highest elevation in the bare summit of the Brocken (3743 feet). To the west of the Harz a series of hilly tracts is comprised under the name of the Weser Mountains, out of which above Minden the river Weser bursts by the Porta Westphalica. A narrow ridge, the Teutoburger Wald (1300 feet), extends between the Weser and the Ems as far as the neighborhood of Osnabrück.

To the east the Thüringer Wald is connected by the plateau of the Frankenwald with the Fichtelgebirge. This group of mountains, occupying what may be regarded as ethnologically the centre of Germany, forms a hydrographical centre, whence the Nab flows southward to the Danube, the Main westward to the Rhine, the Eger eastward to the Elbe, and the Saale northward, also into the Elbe. In the north-east the Fichtelgebirge connects itself directly with the Erzgebirge, which forms the northern boundary of Bohemia. The southern sides of this range are comparatively steep; on the north it slopes gently down to the plains of Leipsic, but is intersected by the deep valleys of the Elster and Mulde. Although by no means fertile, the Erzgebirge is very thickly peopled, as various branches of industry have taken root there in numerous small places. Around Zwickau there is a productive coal-field, and mining for metals is carried on near Freiberg. In the east a tableland of sandstone, called Saxon Switzerland, from the picturesque outlines into which it has been eroded, adjoins the Erzgebirge; one of its most notable features is the deep ravine by which the Elbe escapes from it. Numerous quarries, which supply the North German cities with stone for buildings and monuments, have been opened along the valley. The sandstone range of the Elbe unites in the east with the low Lusatian group, along the east of which runs the best road from Northern Germany to Bohemia. Then comes a range of lesser hills clustering together to form the frontier between Silesia and Bohemia. The most western group is the Isergebirge, and the next the Riesengebirge, a narrow ridge of about 20 miles' length, with bare summits. Excluding the Alps, the Schneekoppe (5266 feet) is the highest peak in Germany; and the southern declivities of this range contain the sources of the Elbe. The hills north and north-east of it are termed the Silesian Mountains. Here one of the minor coal-fields gives employment to a population grouped round a number of comparatively small centres. One of the main roads into Bohemia (the pass of Landshut) runs along the eastern base of the Riesengebirge. Still farther to the east the mountains are grouped around the hollow of Glatz, whence the Neisse forces its way towards the north. This hollow is shut in on the east by the Sudetic group, in which the Altvater rises to almost 4900 feet. The eastern portion of the group called the Gesenke, slopes gently away to the valley of the Oder, which affords an open route for the international traffic, like that through the Mülhausen Gate in Alsace. Geographers style this the Moravian Gate.

The North-German plain presents little variety, yet is not absolutely uniform. A row of low hills runs generally parallel to the mountain ranges already noticed, at a distance of 20 to 30 miles to the north. To these belongs the Upper Silesian coal-basin, which occupies a considerable area in south-eastern Silesia. North of the middle districts of the Elbe country the heights are called the Fläming hills. Westward lies as the last link of this series the Lüneburger Haide or Heath, between the Weser and Elbe, north of Hanover. A second tract, of modern elevation, sweeps around the Baltic, without, however, approaching its shores. This plateau contains a considerable number of lakes, and is divided into three portions by the Vistula and the Oder. The most eastward is the so-called Prussian Seenplatte. Spirdingsee (430 feet above sea-level, and 46 square miles in area) and Mauersee are the largest lakes; they are situated in the centre of the plateau, and give rise to the Pregel. Some peaks near the Russian frontier attain to 1000 feet. The Pomeranian Seenplatte, between the Vistula and the Oder, extends from S. W. to N. E., its greatest elevation being in the neighborhood of Dantzic (Thurmberg, 1096 feet). The Seenplatte of Mecklenburg, on the other hand, stretches from S. E. to N. W., and most of its lakes, of which the Müritzsee is the largest, send their waters towards the Elbe. The finely wooded heights which surround the bays of the east coast of Holstein and Schleswig may be regarded as a continuation of these Baltic elevations. The lowest parts, therefore, of the North-German plain, excluding the sea-coasts, are the central districts from about 52° to 53° N. lat., where the Vistula, Netze, Warthe, Oder, Spree, and Havel form vast swampy low-lands (in German called *Brüche*), which, during the last hundred years, have been considerably reduced by the construction of canals and by cultivation—improvements due in large measure to Frederick the Great. The Spreewald, to the S. E. of Berlin, is one of the most remarkable districts of Germany. As the Spree divides itself there into innumerable branches, enclosing thickly wooded islands, boats form the only means of communication. West of Berlin the Havel widens into what are called the Havel lakes, to which the environs of Potsdam owe their charms. In general the soil of the North-German plain cannot be termed fertile, the cultivation nearly everywhere requiring severe and constant labor. Long stretches of ground are covered by moors, and there turf-cutting forms the principal occupation of the inhabitants. The greatest extent of moorland is found in the westernmost parts of the plain, in Oldenburg and East Frisia. The plain contains, however, a few districts of the utmost fertility, particularly the tracts on the central Elbe, and the marsh lands on the west coast of Holstein and the north coast of Hanover, Oldenburg, and East Frisia, which within the last two centuries, the inhabitants have reclaimed from the sea by means of immense dikes.

Rivers.—Nine independent river-systems may be distinguished; those of the Memel, Pregel, Vistula (Weichsel), Oder, Elbe, Weser, Ems, Rhine, and Danube. Of these the Pregel, Weser, and Ems belong entirely, and the Oder mostly, to the German empire. The Danube has its sources on German soil; but only the fifth part of its course is German. Its total length is 1730 miles, and the Bavarian frontier at Passau, where the Inn joins it, is only 350 miles distant from its sources. It is navigable as far as Ulm, 220 miles above Passau; and its tributaries the Lech, Isar, Inn, and Altmühl are also navigable. The Rhine is the most important river of Germany, although neither its sources nor its mouths are within the limits of the empire. From the Lake of Constance to Basel (122 miles) the Rhine forms the boundary between the German empire and Switzerland; the canton of Schaffhausen, however, is situated on the northern bank of the river. From Basel to below Emmerich the Rhine belongs to the German empire—about 470 miles, or four-sevenths of its whole course. It is navigable all this distance, as are also the Neckar from Esslingen, the Main from Bamberg, the Lahn, the Lippe, the Ruhr, the Moselle from Metz, with its affluents the Saar and Sauer. Vessels sail up the Ems as far as Papenburg, and river craft as far as Greven, and the river is connected with a widely branching system of canals for turf-boats. The Fulda, navigable for 63 miles, and the Werra 38 miles, above the point where they unite, form by their junction the Weser, which has a course of 271 miles, and receives as navigable tributaries the Aller, the Leine from Hanover, and some smaller streams. Large steamers cannot, however, get as far as Bremen, and that commercial emporium has, in consequence, been obliged to form a seaport at Bremenhafen. The Elbe, after a course of 250 miles, enters German territory near Aussig, 482 miles from its mouth. It is navigable above this point to its junction with the Moldau. Hamburg may be reached by vessels of 10 to 11 feet draught. The navigable tributaries of the Elbe are the Saale (below Naumburg), the Havel, Spree, Elde, Sude, and some others. The Oder begins to be navigable almost on the frontier at Ratibor, 480 miles from its mouth, receiving as navigable tributaries the Glatz Neisse and the Warthe. Only the lower course of the Vistula belongs to the German empire, within which it is a broad, navigable stream of considerable volume. On the Pregel ships of 2500 tons reach Königsberg, and river barges reach Insterburg; the Alle, its tributary, may also be navigated. The Memel is navigable in its course of 113 miles from the Russian frontier. Germany is thus a country abounding in natural waterways, the total length of them being estimated at 7000 miles. But it is only the Rhine, in its middle course, that has at all times sufficient volume of water to meet the requirements of a good navigable river.

Lakes.—The regions which abound in lakes have already been pointed out. The Bodensee or Lake of Constance (186 square miles) is on the frontier of the empire—portions of the northern banks belonging severally to Bavaria, Würtemberg, and Baden. The largest lake entirely on German territory is the Chiemsee (75 square miles); the Ammersee and the Würmsee are, however, but little less. A good many smaller lakes are to be found in the Bavarian Alps. The North-German plain is dotted with upwards of 500 lakes, covering an area of about 2500 square miles. The largest of these are the three Haffs—the Oderhaff covering 370 square miles, the Frische Haff 332, and the Kurische Haff 626. The lakes in the Prussian and Pomeranian provinces, in Mecklenburg, and in Holstein, and those of the Havel, have already been mentioned. In the west the only lakes of importance are the Steinhuder Meer, 14 miles north-west of Hanover, and the Dümersee on the southern frontier of Oldenburg.

Climate.—The climate of Germany is to be regarded as intermediate between the oceanic and continental climates of western and eastern Europe respectively. It has nothing in common with the Mediterranean climate of southern Europe, Germany being separated from that region by the lofty barrier of the Alps. Although there are very considerable differences in the range of temperature and the amount of rainfall throughout Germany, these are not so great as they would be were it not that the elevated plateaus and mountain chains are in the south, while the north is occupied by low-lying plains. In the west no chain of hills intercepts the warmer and moister winds which blow from the Atlantic, and these accordingly influence at times even the eastern regions of Germany. The mean annual temperature of south-western Germany, or the Rhine and Danube basins, has in recent years been about 52° to 54°, that of central Germany 48° to 50°, and that of the northern plain 46° to 48°. In Pomerania and West Prussia it is only 44° to 45°, and in East Prussia 42° to 44°. The warmest districts of the German empire are the northern parts of the Rhine plain, from Carlsruhe downwards, especially the Rheinthal; these are scarcely 300 feet above the sea-level, and are protected by mountainous tracts of land. The same holds true of the valleys of the Neckar, Main, and Moselle. Hence the vine is everywhere cultivated in these districts. The mean summer temperature there is 66° and upwards, while the average temperature of January does not descend to the freezing point (32°). The climate of north-western Germany (west of the Elbe) shows a predominating oceanic character, the summers not being too hot (mean summer temperature 60° to 62°), and snow in winter remaining but a short time on the ground. West of the Weser the average temperature of January exceeds 32°; to the east it sinks to 30°, and therefore the Elbe is generally covered with ice for some months of the year, as are also its tributaries. The further one proceeds to the east the greater are the contrasts of summer and winter. While the average summer warmth of Germany is 60° to 62°, the January temperature falls as low as 26° to 28° in West Prussia, Posen, and Silesia, and 22° to 26° in East Prussia and Upper Silesia. The navigation of the rivers is regularly interrupted by frost. Similarly the upper basin of the Danube, or the Bavarian plain, has a rather inclement climate in winter, the average for January being 25° to 26°.

As regards rainfall, Germany belongs to those regions where atmospheric precipitation takes place at all seasons, but chiefly in the form of summer rains. In respect to the quantity of rain the empire takes a middle position between the humidity of north-western Europe and the aridity of the east. There are considerable differences between particular places. The rainfall is greatest in the Bavarian table-land and the hilly regions of western Germany. For the Eifel, Sauerland, Harz, Thüringer Wald, Rhön, Vogelsberg, Spessart, the Black Forest, the Vosges, etc., the annual average may be stated at 34 inches or more, while in the lower terraces of south-western Germany, as in the Erzgebirge and the Sudetic range, it is estimated at 30 to 32 inches only. The same average obtains also on the humid north-west coast of Germany as far as Bremen and Hamburg. In the remaining parts of western Germany, on the shores of Further Pomerania, and in East Prussia, it amounts to upwards of 24 inches. In western Germany there is a district famous for the scarcity of rain, and for producing the best kind of wine: in the valley of the Rhine below Strasburg, in the Palatinate, and also in the valley of the Main, no more than from 16 to 20 inches fall. Mecklenburg, Brandenburg, and Lusatia, Saxony and the plateau of Thuringia, West Prussia, Posen, and Lower Silesia are also to be classed among the more arid regions of Germany, the annual rainfall being 16 to 20 inches.

VEGETATION, ANIMALS, AND AGRICULTURE.

The flora of Germany comprises about 3000 species of phanerogamic and about 4000 cryptogamic plants. The country does not, however, form a single natural region, and cannot be characterized distinctively by any of the principal botanical types.

No uniform returns for the whole empire have been published, furnishing details regarding the distribution of the soil in respect of its cultivation, and thus statistics can only be collected from the official returns and estimates or valuations for separate districts. The following tabular statements must therefore be regarded as only approximately accurate:—

Cultivable and Uncultivable Area.

States or Groups.	Cultivable.		Uncultivable.	
	Square Miles.	Percent. of Total.	Square Miles.	Percent. of Total.
Prussia, including the minor states of North Germany...	134,400	91·7	12,130	8·3
Thuringia................	4,450	93·7	300	6·3
Saxony....................	5,570	96·0	230	4·0
Bavaria..................	27,500	93·8	1,800	6·2
Würtemberg	7,200	95·6	330	4·4
Baden.........	5,200	89·4	620	10·6
Alsace-Lorraine........	5,200	90·9	520	9·1
Hesse	2,850	96·0	120	4·0
Total..................	192,370	92·3	16,050	7·7

Distribution of the Cultivable Area.

States.	Arable.		Meadows and Pasture Grounds.		Woodland.	
	Square Miles.	Per ct. of Total.	Square Miles.	Per ct. of Total.	Square Miles.	Per ct. of Total.
Prussia, etc...	74,150	50·7	26,870	18·3	33,380	22·7
Thuringia......	2,500	52·6	440	9·3	1,510	31·8
Saxony..........	3,200	55·2	770	13·2	1,600	27·6
Bavaria.........	12,350	42·1	5,120	17·5	10,030	34·2
Würtemberg..	3,600	47·8	1,300	17·3	2,300	30·5
Baden...........	2,200	37·9	1,030	17·7	1,970	33·8
Alsace-Lorraine......	2,770	48·5	660	11·6	1,770	30·8
Hesse...........	1,530	51·6	380	12·8	940	31·6
Total.........	102,300	49·0	36,570	17·6	53,500	25·7

From these tables it will be seen that the extent of uncultivable ground in Germany is inconsiderable; and that the arable land, including garden ground and vineyards, amounts to about one-half of the area.

Forests.—The woodlands form about one-fourth of the entire soil, the proportion of forest being far greater than in any other state in the west or south of Europe; the percentage for France is but 17, for Italy 12, for Great Britain about 3. The state forests alone occupy 17,600 square miles; and the greatest attention is paid throughout the empire to forest culture. Speaking generally, northern is not nearly so well wooded as central and southern Germany, where indeed most of the smaller mountains are covered with timber, as is indicated by the frequent use of the termination *wald* affixed to the names of the mountain ranges (as Schwarzwald, Thüringer Wald, etc.). The "Seenplatten" are less wooded than the hill country, but the eastern portion of the northern lowlands is well provided with timber. A narrow strip along the shores of the Baltic is covered with oaks and beeches; further inland coniferous trees are the most prevalent, particularly the Scotch fir; birches are also abundant. The mountain forests consist chiefly of firs, pines, and larches, but contain also silver firs, beeches, and oaks. Chestnuts appear on the terraces of the Rhine valley, and in Swabia and Franconia. The whole north-west of Germany is destitute of wood, but to compensate for this the people have ample supplies of fuel in the extensive stretches of turf.

Agriculture.—The same kinds of cereal crops are cultivated in all parts of the empire, but in the south and west wheat is predominant, and in the north and east rye, oats, and barley. To these in some districts are added spelt, buckwheat, millet, rice-wheat (*Triticum dicoccum*), lesser spelt (*Triticum monococcum*), and maize. In general the soil is remarkably well cultivated. The three years' rotation formerly in use, where autumn and spring-sown grain and fallow succeeded each other, has now been abandoned, except in some districts, where the system has been modified and improved. In South Germany the so-called *Fruchtwechsel* is practised, the fields being sown with grain crops every second year, and with pease or beans, grasses, potatoes, turnips, etc., in the intermediate years. In North Germany the mixed *Koppelwirthschaft* is extending, by which system, after several years of grain crops, the ground is for two or three seasons in pasture. No general statistics on the subject of crops have as yet been published, but, according to private estimates, a fair average season will yield 325 million quarters of rye,[1] oats 300, wheat and spelt 170, barley 100. In good seasons the production has been found sufficient to meet the native demand. Formerly the exports of the produce of the wheat and pulse crops exceeded the imports, but the importation of cereals has now for a number of years been constantly increasing. The potato is largely cultivated, not merely for food, but for distillation into spirits. This manufacture is prosecuted especially in eastern Germany. The Prussian provinces east of the Elbe, including Mecklenburg and Saxony, with a population of about 19 millions, produced 72 million gallons[2] of spirits in 1876, while the rest of Germany (population 24 millions) produced only 25 million gallons. The common beet (*Beta vulgaris*) is largely grown in some districts for the production of sugar, which has greatly increased during the last thirty years. There are two centres of the beet-root sugar production: 231 factories, or more than two-thirds of the whole, are in Prussian Saxony, Hanover, Brunswick, Anhalt, and Thuringia, and there are 71 in Silesia, Brandenburg, and Pomerania, the principal centre of the latter group being Frankfort-on-the-Oder. Flax and hemp are cultivated, though not so much as formerly, for manufacture into linen and canvas, and also for the production of oil. The home supply no longer suffices for the native demand. The cultivation of hops is in a very thriving condition in the southern states of Germany. The soil occupied by hops was estimated in 1873 at 93,680 acres,[3]—a larger area than in any other country of the globe (Great Britain having about 70,000 acres). The total production of hops is 477,000 cwts., and of this 402,000 cwts. are grown in Bavaria, Würtemberg, Baden, and Alsace-Lorraine. Hops thus form one of the standard articles of exportation from Germany, as well as beer. The following table shows the number of breweries in different parts of the country, and the amount of their production :—

Years.	Manufactories.	Beet-root consumed.	Sugar produced.
		Cwts.	Cwts.
1846–47	107	5,600,000	331,000
1856–57	233	27,500,000	1,800,000
1866–67	296	50,700,000	3,900,000
1874–75	333	55,100,000	5,100,000
1875–76	332	83,200,000	7,100,000
1876–77	328	71,000,000	5,800,000

States.	Breweries.	Total.	Per Head.
		Gallons.	Gallons.
Northern Germany......	12,186	448,000,000	14
Bavaria, not including Palatinate.......	6,703	269,000,000	59
Palatinate (estimated)..	....	13,000,000	20
Würtemberg	7,777	85,300,000	46
Baden (estimated)......	1,500	24,200,000	18
Alsace-Lorraine	241	17,600,000	11
Total, about.........	28,500	857,100,000	20

Tobacco forms the most productive and most profitable object of culture in many districts. The total extent under this crop in 1876 was 53,720 acres, no less than 32 per cent. of this being in Baden, 22 in Bavaria, 16 in Alsace-Lorraine, and only 30 per cent. in the rest of Germany. In the north the plant is cultivated principally in Pomerania, Brandenburg, and East and West Prussia. Of late years the production has on the whole diminished, the average amount having been 800,000 cwts. from 1872 to 1876.

The culture of the vine is almost confined to southern and Western Germany, and especially to the Rhine district. The northern limits of its growth extend from Bonn in a north-easterly direction through Cassel to the southern foot of the Harz, crossing 52° N. lat. on the Elbe running then east some miles to the north of that parallel, and finally turning sharply towards the south-west on the Warthe. In the valley of the Saale and Elbe (near Dresden), and in Lower Silesia (between Guben and Grünberg) the number of vineyards is small, and the wines of inferior quality; but along the Rhine from Basel to Coblentz, in Alsace, Baden, the Palatinate, and Hesse, and above all in the province of Nassau, the lower slopes of the hills are literally covered with vines. Here are produced the celebrated Rüdesheimer, Hochheimer, and Johannisberger. The vines of the lower Main, particularly those of Würzburg, are the best kinds; those of the Upper Main and the valley of the Neckar are rather inferior. The Moselle wines are lighter and more acid than those of the Rhine. The total amount produced in Germany is estimated at 1000 million gallons,—Alsace-Lorraine turning out 400 millions, Baden 175, Bavaria, Würtemberg, and Hesse together 300, while the remainder, which though small in quantity is in quality the best, is produced by Prussia.

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[1] 1 quarter = 2·90781 hectolitres; 1 hectolitre = 0·34388 quarter.

[2] 1 gallon = 0·22 litre.

[3] 1 acre = 0·40467 hectare; 1 hectare = 2·4711442 acres.

Live Stock.—The cultivation of grazing lands in Germany has been greatly improved in recent times, and is in a highly prosperous condition. The provinces of Pomerania and Hanover are particularly remarkable in this respect. The best meadow lands of Bavaria are in the outer range of the Alps, those of Saxony in the Erzgebirge. The following table shows the results of a live-stock census in 1873:—

Horses	3,352,231
Cattle	15,776,702
Sheep	24,999,406
Pigs	7,124,088
Goats	2,320,002
Total	53,572,429

The breeding of domestic animals is prosecuted most extensively in Bavaria, and in the maritime provinces. There we find 1000 to 1500 head of the larger kinds (horses, cattle, sheep, goats, swine) for every 1000 inhabitants; in the rest of eastern Germany 600 to 800; and in central and southern Germany only 400 to 600. In the number of horses Germany ranks with Great Britain (about 80 for every 1000 inhabitants); and, although the production cannot satisfy the home demand, the imports being nearly 30,000 in excess of the exports annually, the breeding of horses has attained great perfection. The main centre is in East and West Prussia, where there are more than half a million of horses,—about 30 per English square mile; then follow the marsh districts on the Elbe and Weser, some parts of Westphalia, Saxony, and Upper Silesia, Lower Bavaria, Lower Alsace, and Lorraine. Cattle abound in most South-German states, especially Bavaria and Würtemberg, where there are 180 to 200 head for every square mile. In the northern and north-eastern districts, on the other hand, the numbers are small (in some districts only 30 to 50 head to the square mile), except Schleswig-Holstein and the marsh lands along the shores of the North Sea, whence there is a considerable exportation to England. The aggregate number of sheep in Germany is only exceeded in Europe by that in Great Britain and Russia. The principal sheep districts are Pomerania and Mecklenburg (300 per square mile). As a rule, sheep-farming is resorted to where the soil is of inferior quality and unsuitable for tillage and the breeding of cattle. Far more attention is accordingly given to the rearing of sheep in northern and north-eastern Germany than in Schleswig-Holstein, East Frisia, Westphalia, Rhineland, and South Germany. The exportation of sheep is considerable, amounting in 1871 to 1,460,000 head; in 1875, however, the number was only 1,000,000. At the same time the native demand for wool is not covered by the home production. The largest stock of swine is in central Germany and Saxony, in Westphalia, on the lower Rhine, in Lorraine, Hesse, etc. Central Germany (especially Gotha and Brunswick) exports sausages and hams largely, as well as Westphalia; but the excess of swine imported over the exports for the whole of Germany ranges from 600,000 to 800,000 annually.

Agricultural Population.—In the census returns of 1871 the number of persons entered as agriculturists (including persons engaged in rearing stock, in forestry, and the fisheries) was about 12,210,000, comprising 1,844,202 proprietors (1,690,931 males and 153,271 females), 2,101,005 agricultural laborers, etc., with 6,764,747 members of their families (2,338,174 males and 4,426,573 females), and about 1,500,000 (660,000 males and 840,000 females) engaged in household duties. Agriculture thus supports three-tenths of the population.

Wild Animals.—The number of wild animals in Germany is not very great. Foxes, martens, weasels, badgers, and otters are to be found everywhere; wolves are rare, but they find their way sometimes from French territory to the western provinces, or from Poland to Prussia and Posen. Among the rodents the hamster and the field-mouse are a scourge to agriculture. Of game there are the roe, stag, boar, and hare; the fallow deer and the wild rabbit are less common. The elk is to be found in the forests of East Prussia. The feathered tribes are everywhere abundant in the fields, woods, and marshes. Wild geese and ducks, grouse, partridges, snipes, woodcocks, quails, widgeons, and teal are plentiful all over the country. Geese and ducks are found mostly in the flat districts, where the great abundance of standing water affords ample scope for their increase. Tame geese are bred in large flocks, particularly in Pomerania. The length of time that birds of passage remain in Germany differs considerably with the different species. The stork is seen for about 170 days, the house-swallow 160, the snow-goose 260, the snipe 220. In northern Germany these birds arrive from twenty to thirty days later than in the south.

The waters of Germany abound with fish; but the genera and species are few. Carp and salmon tribes are the most abundant; after them rank the pike, the eel, the shad, the roach, the perch, and the lamprey. In addition to frogs, Germany has few varieties of Amphibia. Of serpents there are only two kind, one of them being poisonous.

The rearing of bees is particularly attended to in the heathy districts of Hanover. The number of bee-hives may be estimated at 2 millions, and the produce of wax and honey at 100,000 cwts. The cultivation of silk-worms has been attempted, but has either entirely failed or had very indifferent success. In 1852–62 an attempt was made to extend the cultivation of the mulberry in the province of Brandenburg; but disease among the silk-worms, which it was found impossible to repress, rendered it unsuccessful.

MINES AND MINERALS.

Germany abounds in useful minerals, and in consequence takes a high place among industrial states. The production falls short, indeed, of that of England, but bears comparison with that of France and of the United States. The last annual report of the imperial statistical office (for the year 1876) classified the mineral produce of Germany under the following heads:—

Mineral Production in 1876.

Minerals.	Quantities.	Value.	Miners.
	Metric Tons.[1]	£	
Coal, including lignite	49,588,050	15,131,000	208,429
Iron ore	3,515,020	1,047,850	24,373
Zinc ore	503,360	650,340	11,680
Lead ore	12,060	1,019,300	16,929
Copper ore	30,450	356,250	7,077
Silver and gold ore	2,311	219,150	7,475
Tin ore	185	6,380	306
Cobalt ore	313	10,000	...
Nickel ore	1,222	5,780	100
Antimony ore	43	580	66
Arsenic ore	1,670	2,510	20
Manganese ore	11,651	28,240	79
Bismuth ore	28	13,650	824
Uranium ore	9	2,210	...
Tungsten ore	3	20	...
Iron pyrites	113,703	107,290	...
Alum ores	35,320	4,400	829
Salt	170,150	60,700	198
Potash, etc	580,900	234,500	2,053
Total, about	55,000,000	18,900,000	280,401

The general value of the production has increased considerably during the ten years ending 1876, as will be seen by the following table:—

		£		£
1867	Not including Lorraine.	10,720,700	1872	20,783,000
1868		11,248,000	1873	26,782,000
1869		12,021,000	1874	25,283,000
1870		12,412,000	1875	20,844,000
1871		15,708,000	1876	18,900,000

The metals extracted from ores in 1876 were thus classified:—

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[1] 1 centner or 50 kilogrammes = 110·23 pounds = 0·9851 cwt. In round numbers the centner is taken as equivalent to the cwt., and the metric ton to the English ton; the exact value of the latter, however, is 19·702 cwts., or 0·9851 tons. £1 sterling = 20·4294 marks. In round numbers £1 is taken as 20 marks; the values given are therefore too large by 2·15 per cent.

Metal Production in 1876.

Metals.		Quantities.	Value.
		Cwts.	£
Iron......	from home ores...	30,410,000	4,920,550
	“ foreign ores.	1,884,000	306,890
Zinc......	“ home ores...	1,582,300	1,655,980
	“ foreign ores.	82,270	84,630
Lead	“ home ores...	1,372,800	1,417,070
	“ foreign ores.	139,100	148,220
Copper...	“ home ores...	165,100	628,170
	“ foreign ores.	3,300	13,520
		Ounces.	
Silver....	“ home ores...	4,347,200	967,820
	“ foreign ores.	587,150	130,650
Gold......	“ home ores...	10,445	26,040
	“ foreign ores.	3,338	13,200
		Cwts.	
Nickel...	“ home ores...	4,050	57,730
	“ foreign ores.	3,380	79,030
Cobalt............................		7,150	58,400
Cadmium............................		36	1,450
Tin............................		3,671	9,540
Bismuth............................		430	12,520
Arsenic products................		17,150	16,540
Sulphur............................		6,800	3,300
Oil of vitriol, etc...............		2,201,400	438,950
Total....................		Cwts. 37,882,937 Oz. 4,948,133	£10,995,100

Coal.—Coal-mining appears to have been first practised in the 14th century, at Zwickau (Saxony), and on the Ruhr. The production, which certainly did not exceed 500,000 tons in 1800, has vastly increased during the last thirty years, as may be seen from the following table (which does not include lignite):—

Coal Production, 1848–1877.

		Quantities.	Value.
		Metric Tons.	£
1848	Lorraine not included.	4,384,000	1,284,000
1853		8,329,000	2,566,000
1857		11,279,000	4,137,000
1862		15,576,000	4,155,000
1867		23,808,000	6,371,000
1871		29,398,000	10,917,000
1872		33,306,000	14,833,000
1873		36,392,000	20,183,000
1874		35,919,000	19,359,000
1875		37,436,000	14,874,000
1876		38,454,000	13,184,000
1877		37,576,000	10,854,000

There are six large coal-fields, occupying an area of about 3600 square miles, of which the most important occupies the basin of the Ruhr, its extent being estimated at 2800 square miles. Here there are more than 60 beds, of a total thickness of 150 to 200 feet of coal; and the amount in the pits has been estimated at 45,000 millions of tons, so that the basin, at the present rate of 17,500,000 tons raised per annum, would not be exhausted in 2000 years. Smaller fields are found near Osnabrück, Ibbenbüren, and Minden, and a larger one near Aix-la-Chapelle. The Saar coal-field, within the area enclosed by the rivers Saar, Nahe, and Blies (460 square miles), is one of great importance. The thickness of 80 beds amounts to 250 feet, and Von Dechen estimates the total mass of coal at 45,400 million tons. The greater part of the basin belongs to Prussia, the rest to Lorraine. A still larger field exists in the Upper Silesian basin, on the border-land between Austria and Poland, containing about 50,000 million tons. Beuthen is the chief centre. The Silesian coal-fields have a second centre in Waldenburg, east of the Riesengebirge. The Saxon coal-fields stretch eastwards for some miles from Zwickau. Deposits of less consequence are found in Upper Bavaria, Upper Franconia, Baden, in the Harz, etc.

Number and Production of Collieries in 1876.

Coal-Fields (Not including Lignite).	Number of Collieries.	Coal produced in 1876.
		Tons.
Ruhr (gov. districts, Arnsberg and Düsseldorf)............	207	17,430,000
Upper Silesia............................	107	8,468,000
Saar............................	33	5,080,000
Zwickau............................	71	3,038,000
Lower Silesia............................	44	2,150,000
Aix-la-Chapelle............................	17	994,000
Osnabrück, Ibbenbüren, etc..........	22	822,000
Minor fields............................	47	472,000
Total............................	548	38,454,000

The above tables do not include lignite, of which numerous beds are scattered over Germany. Extensive strata follow the course of the Oder, and a second group is spread over Lusatia, but the largest and most important deposit is in the Saale districts from Altenburg to the Harz. Smaller fields are situated round Cassel, northward of Frankfort, near Cologne and Aix-la-Chapelle, in the west of Hanover, and in the Upper Palatinate. The total production is stated in the official returns at 11,100,000 tons, representing a value of £1,922,000. Of this 8,780,000 tons are supplied by the fields in the Saale districts (province of Saxony, Anhalt, Brunswick, Saxe-Altenburg, and kingdom of Saxony). In North Germany turf also is of importance as a fuel; the area of the turf moors in Prussia is estimated at 8000 square miles, of which more than 2000 are in the north of Hanover. The coal produced supplies the home demand, although a considerable trade is carried on across the frontier. Through the ports of the North Sea and the Baltic more than 2 million tons of coals are imported annually from England, and nearly 2½ million tons of lignite come from Bohemia. On the other hand, the Ruhr and the Saar basins export nearly 3 million tons of coal to the Netherlands, France, and Switzerland, and the Upper Silesian basin 1⅔ millions to Austria and Russia. The following table gives a comparative view of the quantity supplied by the more important coal-producing countries in 1876:—

	Tons.		Tons.
Great Britain......	135,612,000	France.................	16,889,000
United States......	50,000,000	Belgium	14,329,000
Germany	48,296,000	Austria-Hungary...	13,362,000

Graphite is produced only in Lower Bavaria; the total amount in 1876 was 20,104 cwts., value £2090. *Asphalt* occurs near Hanover, in Brunswick, and in Alsace; total production in 1876, 720,000 cwts., value £15,300. *Petroleum* is found in limited quantity near Lüneburg, and in Alsace.

Iron Ore.—Germany abounds in iron ores, some of which are of superior quality. The production increased rapidly for a time, but in recent years there has been a very great decline.

About 35 per cent. is brown iron ore, 25 per cent. spathic iron, 18 per cent. black band, and 10 per cent. red iron ore. The rest consists of clay-ironstone, bog-iron ore (in the northern lowlands), and magnetic ores. Unfortunately but few mines are found in proximity to coal-pits, and important ore-deposits of great extent are far from coal, as, for instance, the iron districts of Nassau, of the Sieg valley, and of Hesse, Thuringia, Lorraine, Bavaria, and Würtemberg. Ores free of phosphorus, suitable for the manufacture of Bessemer pig-iron, are also very scarce.

Iron Ore Production, 1848–1876.

		Quantities.	Value.
		Tons.	£
1848	Lorraine not included.	694,000	191,000
1853		903,000	250,000
1857		1,962,000	583,000
1867		3,264,000	918,000
1872		5,896,000	2,118,000
1873		6,177,000	2,117,000
1874		5,137,000	1,430,000
1875		4,730,000	1,387,000
1876		4,712,000	1,181,000

The following table shows the number and production of furnaces in blast in 1876:—

Government Districts.	Furnaces in Blast.	Pig-iron made.
		Tons.
Arnsberg	37	337,640
Düsseldorf	21	278,110
Oppeln	32	223,750
Coblentz	27	212,470
Lorraine	18	193,450
Treves	10	103,080
Hildesheim	4	55,750
Osnabrück	4	45,200
Upper Palatinate	10	31,060
Wiesbaden	14	26,550
Cologne	3	25,130
Hesse (grand-duchy)	5	18,150
Würtemberg	5	10,810
Saxe-Meiningen	1	13,840
Other districts	34	37,690
Total	225	1,612,680

The iron manufacture has not been in a thriving condition since 1873; the total number of furnaces in Germany in 1876 was 435,—225 in blast as above, and 210 blown out. The following table shows the progress of pig-iron production, including castings:—

	Quantities.	Value.
	Tons.	£
1848 } about	200,000	1,230,000
1862 } about	640,000	2,630,000
1867 } about	990,000	3,600,000
1871	1,421,000	5,946,000
1873	1,983,000	11,238,900
1874	1,660,000	7,243,000
1875	1,759,000	6,632,900
1876	1,615,000	5,232,000

Since the incorporation of Lorraine with the German empire the pig-iron production of Germany exceeds that of France. The following table shows the comparative increase in those countries, as well as in Great Britain and the United States:—

	Quantities of Pig-Iron.			
		Tons.		Tons.
Great Britain	1866	4,596,000	1876	6,660,000
United States	"	1,225,000	1877	2,351,000
Germany	"	1,000,000	1876	1,615,000
France	"	1,260,000	1877	1,453,000

Iron Industry.—While the produce of pig-iron has thus been advancing, similar progress appears in the iron industry, in some branches of which Germany has already emancipated herself from dependence on England. During the last few years, it is true, this trade has suffered severely from the overproduction of 1872 and 1873, as may be seen from the following table, showing the quantities and values of worked pig-iron in 1872 and 1876:—

Articles.	1872.		1876.	
	Quantities.	Value.	Quantities.	Value.
	Cwts.	£	Cwts.	£
Wrought iron and rolled iron	19,194,000	12,255,000	15,515,000	5,013,000
Iron plate	2,348,000	2,007,000	2,190,000	1,095,000
Iron wire	2,053,000	1,695,000	2,650.000	1,392,000
Raw steel	2,703,000	2,333,000	2,680,000	1,104,000
Cast steel	3,542,000	2,840,000	4,877,000	2,488,000

The greatest advance has been made in the production of steel. In 1863 the quantity was only 1,400,000 cwts., but in 1872 it was about 6,500,000. The greater part of this is produced at the celebrated works of Krupp in Essen and the cast-steel works in Bochum. Many European states have for a considerable time been supplied by Krupp with cast-steel guns. The production of rails not only covers the home demand, but has allowed an annual exportation of 3,000,000 cwts. since 1877. Hardware also, the production of which is centred in Solingen, Heilbronn, Esslingen, etc., is largely exported. Germany stands second to Great Britain in the manufacture of machines and engines. There are in many large cities of North Germany extensive establishments for this purpose, but the industry is not limited to the large cities. It must be admitted that in agricultural machinery Germany cannot as yet compete with England. The locomotives and wagons for the German railways, however, are almost exclusively built in Germany; and Russia, as well as Austria, receives large supplies of railway plant from German works. In shipbuilding likewise Germany is becoming independent of England; and dockyards have been erected on the coast for the construction of large ironclads.

Silver and Gold.—Germany produces more silver than any other European state, and the quantity is annually increasing. Silver and gold are extracted from the ores in the mines of Freiberg (Saxony) and near the Harz; but silver is also refined from lead and copper ores in Upper Silesia, Merseburg, Aix-la-Chapelle, Wiesbaden, and Arnsberg. The gold-mining is of far less importance. The value of silver produced was, in 1867, £791,370; 1873, £1,539,590; 1876, £1,098,470; and that of gold, 1867, £11,750; 1876, £39,234.

Lead.—The quantity of the lead produced allows Germany to export from 300,000 to 400,000 cwts. annually. Nearly half the produce is obtained near Aix-la-Chapelle (651,273 cwts. in 1876); next come Upper Silesia (265,000 cwts.), Harz (176,550 cwts.), Nassau (143,770 cwts.), Saxony, Arnsberg, etc. The value in 1867 was only £898,140; but in 1876, £1,565,280; the quantity was 987,090 cwts. in 1867, and 1,512,000 cwts. in 1876.

Copper.—Although Germany yields more copper than any other European state, the native supply does not meet the demand. In recent years more than 200,000 cwts. have been imported. The Harz mountains and their environs (Mansfeld) alone produce five-sixths of the whole amount, which has been doubled during the ten years ending 1876:—1867, 77,440 cwts., value £312,750; 1876, 168,430 cwts., value £641,750.

Zinc.—About 90 per cent. of the zinc produced in Europe is yielded by Belgium and Germany. The exportation from the latter amounts to more than half a million of cwts. per annum. The production doubled during the period from 1850 (620,000 cwts.) to 1860, but has made only slow progress since that time. In 1867 it was only 1,277,000 cwts., value about £600,000; in 1876, 1,664,500, value £1,740,600. 70 per cent. is produced in Upper Silesia in the neighborhood of Beuthen, the rest in Westphalia and the Rhineland.

Salt.—Germany possesses abundant salt deposits. The actual production not only covers the home consumption, but also allows a yearly increasing exportation, especially to Russia, Austria, and Scandinavia. In 1877–78 there were 77 salt works in operation, 8 of which were mining works for rock-salt. The provinces of Saxony and Hanover, with Thuringia and Anhalt, have 28 works and produce half the whole amount. A large work is found at Strzalkowo (Posen), and smaller ones near Dortmund, Lippstadt, and Minden (Westphalia). In South Germany salt abounds most in Würtemberg (Hall, Heilbronn, Rottweil); the principal Bavarian works are at the foot of the Alps near Freilassing and Rosenheim. Hesse and Baden have 6 salt works; Lorraine and the Upper Palatinate, 6. The total yield now amounts to 8,318,000 cwts. boiled salt, 3,221,000 cwts. rock-salt, and 256,000 cwts. of other kinds. The production has made great advance during the last thirty years, having in 1850 been only 5 million cwts., while in 1877 it was upwards of 11 million cwts.

Chloride of Potash.—A considerable amount of this substance is turned out by 15 works in Anhalt, where only the potash ores are found. The production there in 1876 was 846,000 cwts., value about £250,000.

POPULATION.

Till very recent times no estimate of the population of Germany was precise enough to be of any value. At the beginning of the present century the country was divided into some hundred states, but there was no central agency for instituting an exact census on a uniform plan. Even the formation of the German Confederation in 1815 effected but little change in this respect, and it was left to the different states to arrange in what manner the census should be taken. On the formation, however, of the German Customs Union or Zollverein between certain German states, the necessity for accurate statistics became apparent, since the amounts accruing from the common import duties were to be distributed according to the number of inhabitants in the several states. The Zollverein had its origin in a customs convention between Prussia and the grand-duchy of Hesse in 1828; and other states, as they gradually became convinced of the advantages afforded by a general customs frontier, joined it from time to time during the succeeding forty years. The following table shows the progressive territorial limits of the Zollverein—which may be regarded as the precursor of the present German empire:—

Population of the Zollverein.

Years.	States entering during the various Periods.	Area, Sq. Miles.	Population of the Union States.
1828	Prussia, Hesse (grand-duchy)....	112,000	13,295,254
1831	Hesse-Cassel............	115,300	15,090,075 ('34)
1834	Bavaria, Würtemberg, Saxony, Thuringia, etc.............	163,900	23,478,120
1844	Brunswick, Luxembourg, etc.....	171,900	28,498,136 ('43)
1851	Hanover, Oldenburg.................	191,800	32,559,055 ('52)
1868	Schleswig-Holstein, Lauenburg, Mecklenburg.............	205,500	38,277,939 ('67)
1871	Alsace-Lorraine.......................	209,281	40,677,950

The returns made at different times by the separate states cannot be combined into an aggregate, showing precisely the former population of Germany. An enumeration was made every third year of the number of people that could be held as belonging to the different states comprised in the Zollverein; and it was only from 1867 that the returns gave the actual resident population. The following table gives the area and population of the twenty-six states of Germany as returned at the two last censuses (1871 and 1875):—

Population of the German Empire, 1871 and 1875.

States of the Empire.	Area, English Sq. Miles.	Population.	
		Dec. 3, 1871.	Dec. 1, 1875.
Kingdoms.			
1. Prussia	134,178	24,691,433	25,742,404
2. Bavaria	29,292	4,863,450	5,022,390
3. Saxony......................	5,789	2,556,244	2,760,586
4. Würtemberg	7,531	1,818,539	1,881,505
Grand-Duchies.			
5. Baden	5,824	1,461,562	1,507,179
6. Hesse	2,965	852,894	884,218
7. Mecklenburg-Schwerin	5,137	557,897	553,785
8. Saxe-Weimar	1,404	286,183	292,933
9. Mecklenburg-Strelitz..	1,131	96,982	95,673
10. Oldenburg................	2,471	314,459	319,314
Duchies.			
11. Brunswick.	1,425	311,764	327,493
12. Saxe-Meiningen........	953	187,957	194,494
13. Saxe-Altenburg.........	510	142,122	145,844
14. Saxe-Coburg-Gotha...	760	174,339	182,599
15. Anhalt......................	906	203,437	213,565
Principalities.			
16. Schwarzburg - Rudolstadt	364	75,523	76,676
17. Schwarzburg-Sondershausen........	333	67,191	67,480
18. Waldeck	433	56,224	54,743
19. Reuss-Greiz..............	122	45,094	46,985
20. Reuss-Gera...............	320	89,032	92,375
21. Schaumburg-Lippe....	171	32,059	33,133
22. Lippe......	438	111,135	112,452
Free Towns.			
23. Lübeck.....................	109	52,158	56,912
24. Bremen.....................	97	122,402	142,200
25. Hamburg.................	158	338,974	388,618
Imperial Territory.			
26. Alsace-Lorraine.........	5,603	1,549,738	1,531,804
Total......................	208,424	41,058,792	42,727,360

The following table shows the rate of recent increase, the population of Alsace-Lorraine returned at the French census of 1866 being included in the statement for 1867:—

Years.	Population.	Total increase.	Percentage for the period.	Percentage per annum.
Dec. 3, 1867	40,108,029			
Dec. 3, 1871	41,058,792	950,763	2·4	0·6
Dec. 1, 1875	42,727,360	1,688,568	4·1	1·0

Comparing the census returns of 1871 and 1875, it is found that only Alsace-Lorraine (17,934), the two Mecklenburgs (together 5231), and Waldeck (1481) are decreasing; all other states are increasing, though at very different rates. A comparison cannot here be made, however, between the smaller and the larger states. Hamburg and Bremen, for example, have considerably increased, but these must be regarded as consisting of single large towns, and a similar increase is found in all the great cities of Germany. In southern Germany (Alsace-Lorraine not included), and also in Hanover, the growth of population has been insignificant, whereas the population in the eight old provinces of Prussia and in Saxony shows a marked increase.

It appears from the following table that the inhabitants of Prussia and Saxony have increased 60 to 70 per cent. in 40 to 44 years, and those of the other states only 18 to 23 per cent. And it is to be observed that this increase is not confined to the industrial districts, but that those provinces also which have few large cities and the population of which live for the most part by agriculture, such as Pomerania, Prussia, Posen, have increased by 50 to 60 per cent. This is to be explained by the fact that there has been a very extensive immigration into Prussia since 1815, whereas emigration has been mostly from South Germany. But the surplus of births over deaths also has at all times been greater in the North.

Increase of Population in States.

Provinces or States.	Population.		Total Increase per cent.
	Census 1831-34.	Census 1875.	
Saxony (kingdom)	('34) 1,596,000	2,760,000	73
The eight ancient Prus. provinces	('31) 13,040,000	21,116,000	62
Brandenburg (incl. Berlin)	" 1,612,000	3,126,000	84
Rhineland	" 2,250,000	3,804,000	70
Pomerania	" 910,000	1,462,000	63
Prussia..............	" 2,015,000	3,199,000	59
Silesia	" 2,460,900	3,844,000	56
Westphalia.........	" 1,270,000	1,905,000	52
Saxony	" 1,450,000	2,169,000	50
Posen	" 1,070,000	1,606,000	50
Baden	('34) 1,228,000	1,507,000	23
Hanover	('33) 1,663,000	2,017,000	21
Würtemberg	('34) 1,573,000	1,882,000	20
Bavaria	" 4,245,000	5,022,000	18
Hesse	" 750,000	884,000	18

Vital Statistics.—It is very recently that general registers of births, deaths, and marriages began to be kept for all the German states, but these prove the increase of the excess of births over deaths in recent years to have been considerable. The following table of returns for the whole of Germany during the period 1872–76 brings out a natural addition by births of upwards of half a million yearly:—

	Marriages.	Births (incl. Still-born).	Deaths (incl. Still-born).	Still-born.	Surplus of Births.
1872	423,900	1,692,227	1,260,922	66,190	431,305
1873	416,049	1,715,287	1,241,459	67,166	474,012
1874	400,282	1,752,976	1,191,132	69,536	560,579
1875	386,746	1,798,591	1,246,572	74,179	552,019
1876	366,912	1,831,218	1,207,144	73,517	624,074
Mean..	398,778	1,758,059	1,229,446	70,117	528,398

The numbers of births, deaths, and marriages for every 1000 of the population of Germany during the period 1872–5 were as follows:—

	To 1000 Persons living.			To 1000 Marriageable Persons.
	Births.	Deaths.	Marriages.	Marriages.
1872	41·1	30·5	10·3	39·9
1873	41·3	29·9	10·0	37·8
1874	41·8	28·4	9·5	36·0
1875	42·3	29·3	9·1	34·3
Mean...	41·6	29·5	9·7	37·0

In comparing this with similar tables for England, a great difference is obvious. While the average annual rate of births (41·6) has been much higher than in England (34·0) during recent years, the annual death-rate does not compare favorably with that of England (22·3) or of other states. Only Russia, Finland, Austria-Hungary, Italy, and Servia exhibit greater higher rates.

Sexes.—The numbers of the different sexes in 1871 and 1875 were as follows:—

	Males.	Females.	Excess of Females.	Females for 1000 Males.
1871	20,154,109	20,906,737	752,638	1037
1875	20,986,701	21,740,659	753,958	1036

As in most European states, the surplus of females arises from their lower death-rate, for in Germany as elsewhere more boys are born than girls. The following table shows the numbers of births, including still-born:—

	Boys.	Girls.	Excess of Boys.	Boys for 1000 Girls.
1872	871,438	820,786	50,652	1062
1873	883,017	832,265	50,752	1061
1874	903,148	849,821	53,327	1063
1875	928,397	870,194	58,203	1067
1876	943,433	887,781	55,652	1063
Average	905,887	852,170	53,717	1063

Illegitimacy.—The number of illegitimate births is greater than in any other European state, except Sweden, Denmark, Austria, and Portugal. The rate of illegitimacy is about 9 per cent. of the births, the annual average for 1872–75 being 8·86. In Rhineland the proportion was 2·8 per cent., North-Western Germany, Oppeln, and Posen 5 to 6, South-Western Germany 7 to 9, province of Saxony, Brandenburg (exclusive of Berlin), Pomerania, Schleswig-Holstein 9 to 10, Saxony, Thuringia, and Lower Silesia 12, Berlin 13·5, and Bavaria 14·6 per cent. On the whole, illegitimacy has decreased of late, particularly in Bavaria.

Emigration.—The increase of population would have been still greater if emigration had not for years drained the country of considerable numbers of its inhabitants. The number of emigrants from Germany since 1820 may be estimated at 3,500,000, but this includes many Austrians, and it cannot be stated how many of the emigrants were natives of the German empire, as no authentic statistics of emigration were issued before 1873. The greater part of the emigrants take their passage *via* Bremen and Hamburg. The following statement, therefore, of the numbers of emigrants from these ports may afford a sufficient indication of the total emigration:—

	Emigrants.		Emigrants.
Average.			
1836–44	14,653	1870	79,337
1845–49	36,706	1871	102,740
1850–54	77,165	1872	154,834
1855–59	54,433	1873	132,417
1860–64	41,665	1874	74,076
1865–69	107,672	1875	56,313
1870–74	108,675	1876	50,396
1875–77	49,786	1877	41,749

The following table, on the other hand, gives the number of emigrants from the German empire according to the official returns. The numbers are considerably lower than those of the last table. It will be seen that emigration has decreased greatly during recent years.

1873	103,638	German emigrants.
1874	45,112	"
1875	30,773	"
1876	28,368	"
1877	21,964	"
Total	229,855	"

The greater part of the recent emigration has been from the maritime provinces. Out of 230,000 emigrants in the years 1873–77, 132,350 were from Prussia, Pomerania, Mecklenburg, Schleswig-Holstein, Hanover, Oldenburg, Bremen, and Hamburg. These states, with a total population (1875) of 9,245,000, accordingly lost 1½ per cent., the rest of the country (33,482,000 inhabitants) only 97,500, or 0·3 per cent. It must be added, however, that the emigration from South Germany was formerly much more considerable. Alsace-Lorraine lost only 1193 inhabitants in 1873–77 by emigration to America. The great mass of German emigrants go to the United States,—90·5 per cent. of the whole (207,974) having embarked for that country in 1873–76. According to the official returns of the board of statistics at Washington, more than 2,900,000 immigrants arrived from Germany at American ports during 1820–1877. The rest of the emigrants find their way to Australasia, Brazil, the Cape, etc.

Immigrants and Foreigners.—In comparison with the emigrants, the number of immigrants is inconsiderable. The bulk come from Belgium, Holland, and Russia. The following table shows the number of natives of the empire who after being abroad have re-established themselves at home, and also the number of naturalized foreigners:—

	Re-established.	Naturalized.
1872	897	2296
1873	1284	2381
1874	1514	6532
1875	3735	9604
1876	2007	3643
1877	651	5810
Total...	10,088	30,266

The number of foreign residents has considerably increased during 1871–75. In 1871 there were in the empire 40,852,037 natives and 206,755 foreigners; in 1875, 42,436,561 natives and 290,799 foreigners. The following table gives the native countries of the foreigners for 1871,—the latest date for which these statistics have been published:—

Austria-Hungary	75,702	Belgium	5,097
Switzerland	24,518	Luxembourg	4,828
Holland	22,042	France	4,671
Denmark	15,163	Italy	4,019
Russia	14,535	Turkey	504
Sweden and Norway	12,345	Spain	310
United States	10,698	Greece	192
Great Britain	10,104	Other countries	2,026

Density of Population.—The population is very unequally distributed, and the differences are far greater now than they were formerly. The mean density of the population had increased from about 120 inhabitants per square mile in 1820 to 150 in 1840, and to 205 in 1875. We have already pointed out the great increase of population during the present century in many agricultural provinces of

Classes of Towns.		Number of Towns.	Population.	Per cent. of total.
Large towns of more than 100,000 inhabitants	1871	8	1,968,537	4·8
	1875	12	2,665,914	6·2
Middle-sized towns, from 20,000 to 100,000	1871	75	3,147,272	7·7
	1875	88	3,487,857	8·2
Small towns, from 5000 to 20,000	1871	529	4,588,364	11·1
	1875	592	5,132,971	12·0
Rural towns, from 2000 to 5000	1871	1716	5,086,625	12·4
	1875	1636	4,922,781	11·5
Town population	1871	2328	14,790,798	36·1
	1875	2328	16,209,523	37·9
Rural population	1871	...	26,219,352	63·9
	1875	...	25,517,837	62·1

Prussia. In South Germany, however, the density of population was considerable even at the beginning of the century. But Germany during this period has become an important industrial state, and, as in England, distinct industrial districts have been formed, where the inhabitants cluster in populous centres. Besides, the population of the cities has gone on increasing at the expense of the agricultural districts, so that the natural increase of the inhabitants in these districts by the surplus of births is neutralized by the steady migration of the people into the cities. In the accompanying official statistics all the inhabitants of communes with more than 2000 souls are designated "town population," and the term "rural population" is applied to those of the smaller places. But it must be remarked that in several provinces, such as Westphalia, Rhineland, and Oldenburg, there are many communes consisting of numerous small villages and hamlets which have not the character of a town, and the inhabitants of which are almost exclusively agriculturists. These rank as town population, which accordingly appears in the returns to be a little larger than it really is. The figures exhibit the extremely unequal increase of the different groups from 1871 to 1875.

Increase per cent. of Population, 1871–75.

Large towns	14·83
Middle-sized towns	12·41
Small towns	10·74
Rural towns	5·75
Town population	9·59
Rural population	0·79
Total for the empire	4·19

The following is a list of the 35 towns which had upwards of 50,000 inhabitants at the census of 1875. The first column exhibits the population within the boundaries of the municipal boroughs (Stadtgemeinde). The numbers in the second are not official, but include all suburbs of a really urban character. The latter therefore afford a better indication of the actual size of the several towns.

Population of the Principal Towns in 1875.

Towns.	Within the Municipal Boundaries.	Within the Topograph. Boundaries.
1. Berlin	966,858	1,062,000
2. Hamburg	264,675	348,447
3. Breslau (Silesia)	239,050	239,050
4. Munich (Bavaria)	198,829	212,376
5. Dresden (Saxony)	197,295	197,295
6. Elberfeld Barmen (Rhine)	80,589 86,502	167,091
7. Leipsic (Saxony)	127,387	160,686
8. Cologne (Rhine)	135,371	154,564
9. Frankfort on-Main (Hesse-Nassau)	103,136	134,776
10. Hanover	106,677	127,576
11. Magdeburg (Saxony)	87,925	122,789
12. Königsberg (East Prussia)	122,636	122,636
13. Bremen	102,532	111,039
14. Stuttgart (Würtemberg)	107,273	105,062
15. Dantzic (West Prussia)	97,931	ab. 99,000
16. Nuremberg (Bavaria)	91,108	94,878
17. Strasburg (Alsace)	94,306	92,379
18. Chemnitz (Saxony)	78,209	85,334
19. Altona (Holstein)	84,097	84,097
20. Stettin (Pomerania)	80,972	80,972
21. Düsseldorf (Rhine)	80,695	80,695
22. Aix-la-Chapelle (Rhine)	79,606	79,606
23. Essen (Rhine)	54,790	76,450
24. Posen (Posen)	60,998	66,505
25. Brunswick	65,938	65,938
26. Mülhausen (Alsace)	58,463	65,361
27. Crefeld (Rhine)	62,905	62,905
28. Halle (Prov. Saxony)	60,503	60,503
29. Dortmund (Westphalia)	57,742	57,742
30. Augsburg (Bavaria)	57,213	57,213
31. Cassel (Hesse-Nassau)	53,043	56,745
32. Mainz (Hesse)	56,421	56,421
33. Potsdam (Brandenburg)	45,003	54,186
34. Metz (Lorraine)	45,856	53,151
35. Erfurt (Prov. Saxony)	48,030	50,477
Total	4,340,564	4,745,945

The inhabitants of these 35 towns amount to 10·1 or 11 per cent. of the entire population of the empire, according as we reckon by the municipal or the topographical boundaries. A similar proportion appears in France and Belgium; but the towns of England and Wales of 50,000 inhabitants and upwards have nearly 9½ million inhabitants, or 44 per cent. of the whole population.

Density of Population.—The town population amounts in some districts, such as Gumbinnen (East Prussia) and Lower Bavaria, to only 11 to 12 per cent.; in others, as Zwickau, Leipsic, Düsseldorf, it reaches 50 to 66 per cent. Arranging Germany in 13 large divisions, we get the following table, the divisions being named after their principal provinces:—

Divisions.	Population, 1875.	Per Sq. Mile.	Proportion per cent of	
			Town. Popul.	Rural Popul.
1. Prussia (East and West)	3,199,171	132	23·8	76·2
2. Pomerania, Schleswig-Holstein, Mecklenburg, etc	3,665,289	144	42·3	57·7
3. Brandenburg (not including Berlin) and Posen	3,765,637	142	30·0	70·0
4. Hanover, Münster, Oldenburg, etc	2,437,476	137	35·0	65·0
5. Bavaria (not including Palatinate)	4,381,136	163	25·0	75·0
6. Prov. of Saxony, Anhalt, Brunswick, etc	3,123,643	228	40·8	59·2
7. Silesia	3,843,699	247	33·0	67·0
8. Hesse, Hesse-Nassau, Minden, Lippe	3,033,856	250	33·6	66·4
9. Würtemberg, Baden	3,455,150	250	33·9	66·1
10. Alsace-Lorraine, Palatinate	2,173,058	274	35·9	64.1
11. Rhineland, Arnsberg	4,823,215	355	60·2	39·8
12. Saxony and Thuringia	3,859,972	365	40·8	59·2
13. Berlin	966,858	...	100	...
Total	42,728,160	205	37·9	62·1

The most thinly peopled territories are found, not as might be expected in the mountain regions, but in some parts of the plains. There are not more than 50 persons to the square mile (about the same proportion as in the Scotch Highlands) on the moors of the Isar north of Munich, on the East-Frisian moors, and on the Lüneburg Heath. There are 50 to 100 inhabitants to the square mile on the Seenplatten of Pomerania and Mecklenburg, on the middle ridges of Schleswig-Holstein, in the northern districts of Hanover, in the Spreewald, etc. Leaving out of account the small centres, Germany may be roughly divided into two thinly and two densely peopled parts. In the former division has to be classed all the North German plain; there it is only in the valleys of the larger navigable rivers, and on the southern border of the plain, that the density reaches 150 to 200 inhabitants per square mile. In some places indeed it is far greater: at the mouths of the Elbe and the Weser, in East Holstein, in the delta of the Memel, 250 to 300, and in the environs of Hamburg even 400, inhabitants are found to the square mile. This region is bordered on the south by a very densely inhabited district, the northern boundary of which may be defined by a line from Breslau to Hanover, and its southern by a line from Coburg *via* Cassel to Münster. Here the density rises from 150 to 570 per square mile, for in this part of Germany there are not only very fertile districts, such as the "Goldene Aue" in Thuringia, but also centres of industry. The population is thickest in Upper Silesia around Beuthen (coal-fields), round Ratibor, Neisse, and Waldenburg (coal-fields), round Zittau (Saxony), in the Elbe valley around Dresden, in the districts of Zwickau and Leipsic as far as the Saale, in the Goldene Aue, on the northern slopes of the Harz, and around Bielefeld in Westphalia. In all these places the density is greater than 350 inhabitants to the square mile, and in Saxony it exceeds 500. The third division of Germany comprises the basin of the Danube and Franconia (the Upper Main system), and sweeps to the north-west between the valleys of the Werra and the tributaries of the Rhine as far as Sauerland. The population of Franconia rises a little above that of the rest of this region, the density in the valley of the Regnitz between Nuremberg and Bamberg, and in the Main valley round Würzburg, reaching about 200 to 240 inhabitants per square mile. The fourth division embraces the valleys of the Rhine and the Neckar. In the latter and in the Upper Rhine plain agriculture has reached a high degree of perfection, and the soil is so fertile as to support a population of 400 per square mile. North of the Niederrheinisches Schiefergebirge, again, are rich coal-fields,—making this the most important industrial district in Germany. Here indeed, in the governmental district of Düsseldorf, the population amounts to 700 per square mile,—about the same proportion as in the West Riding of Yorkshire; but no such density as exists in Lancashire (1500 to the square mile) is found anywhere in Germany. West of the Rhine a thickly peopled district is grouped round the coal-field of the Saar basin, but there is only a scattered population in the surrounding country. On the Eifel there are scarcely 100 inhabitants to the square mile.

Houses.—The number of houses was estimated in 1871 at 5,330,000, so that the average number of inhabitants per house is from 7 to 8. In England and Wales it is only 5·3 (1871). The greatest proportion of dwelling-houses to the population is in Alsace (5·1 persons to one house) and in Swabia (5·4). All the larger cities of Germany consist largely of houses in which a number of families live together. In Berlin the proportion per house is 57 persons, while in London it is only 8. This marks one important point of difference in the habits of the two countries.

Occupations.—The census of 1871 distinguishes 8 principal classes of occupation, but does not subdivide these. The official returns give for each class the number of persons engaged in the several occupations comprised in that class, with the number of attendants and other members of the families of those so occupied. The following table presents an abstract of the returns. In the case of Alsace-Lorraine the attendants are not given in the separate classes, but are all returned under class D.

Occupations.		Engaged in the several occupations.	Attendants and other members of families.	Total.
A. Agricultural class	males..	2,968,738	2,986,556	12,179,307
	females	976,669	5,247,344	
B. Industrial class	males..	4,498,739	2,462,937	13,407,793
	females	1,086,071	5,360,046	
C. Commercial class	males..	1,023,260	322,249	3,256,605
	females	201,641	1,709,455	
D. Domestic class (and general laborers	males..	1,777,118	2,344,235	9,569,658
	females	936,901	4,511,404	
E. Army and Navy	males..	430,800	20,654	508,413
	females	....	56,959	
G. Other occupations	males..	506,734	318,238	1,751,976
	females	98,974	828,030	
H. Persons not returned under any occupation	males..	414,284	255,322	1,985,162
	females	620,881	694,685	
I. Not stated, poor, etc.	males..	....	....	437,968
	females	....	....	
Total		15,540,610	25,080,214	41,058,792

This table does not admit of comparison with the census returns of England and Wales, the mode of classification being different. It will be seen that more persons belong to the industrial than to the agricultural class.

INDUSTRIES.

Some account of different industries has already been given in connection with the productions of the empire. The principal textile manufactures have still to be noticed.

Cotton Manufacture.—Before 1871 the production of cotton fabrics in France exceeded that in Germany; but as the cotton manufacture is pursued largely in Alsace, more than 2 million spindles being employed there, the balance is now against the former country. In 1873 there were about 5 million spindles in Germany and 4,611,000 in France. From the subjoined table of imports and exports (gross weight, the net weight being about 4 per cent. less) of the raw material, it will be seen that this industry has not improved since 1873:—

	Total imports of Raw Cotton.	Total exports of Raw Cotton.	Excess of Imports.
	Cwts.	Cwts.	Cwts.
1873	3,609,000	1,153,000	2,456,000
1874	3,490,000	848,000	2,642,000
1875	3,199,000	819,000	2,380,000
1876	3,518,000	705,000	2,813,000
1877	3,262,000	831,000	2,431,000
1878	3,289,000	973,000	2,313,000

Cotton spinning and weaving are not confined to one district, but are prosecuted in Upper Alsace (Mülhausen, Gebweiler, Colmar), in Saxony (Zwickau, Chemnitz, Annaberg), in Silesia (Breslau, Liegnitz), in the Rhine province (Düsseldorf, Münster, Cologne), in Erfurt and Hanover, in Würtemberg (Reutlingen, Cannstadt), in Baden, Bavaria (Augsburg, Bamberg, Baireuth), and in the Palatinate. The number of hands occupied in the mills in 1875 was 68,555 (34,385 males, 34,170 females) and in the weaving establishments 186,496 (124,732 males and 61,764 females). Of these 98,188 were in Saxony. The production of cotton yarn is not sufficient for the home demand, and for some years back the imports of the article have exceeded the exports by about 200,000 cwts., till 1878, when the excess was only 117,000 cwts.

Woollen and Worsted.—In this class of manufactures Germany is far behind France. First of all, the home production of wool is not sufficient. In 1873–75 the imports of wool exceeded the exports by 300,000 cwts. per annum, and in 1876–78 the excess amounted to 800,000 cwts. In 1875 there were about 1,200,000 spindles for carded woollen yarn,—about 700,000 of them in Prussia, and 320,000 in Saxony. For worsted spinning there were 450,000 spindles,—Upper Alsace having 180,000, and Saxony 110,000; nevertheless the production falls short of the demand, and from 150,000 to 250,000 cwts. must be obtained from foreign countries. The manufacture of woollen cloth is well developed, and is prosecuted for exportation. The cloth is valued as being well woven, durable, and cheap. The centres of its manufacture are the Rhine province, Brandenburg, Lower Silesia, Magdeburg, Thuringia, Saxony, Würtemberg, and Alsace. In 1875 there were altogether 192,452 persons engaged in the woollen industry.

Linen, Hemp, and Jute.—Germany, although linen was formerly one of her most important articles of manufacture, is now left far behind in this industry, not only by Great Britain and France, but also by Austria-Hungary. In 1874 there were 326,538 spindles at work in Germany for flax, hemp, and jute spinning, while there were 415,000 in Austria, 663,000 in France, and 1,670,000 in Great Britain. About 300,000 cwts. of linen yarn are imported into Germany annually, whereas Austria exports about 100,000 cwts. Hand-loom weaving is practised all over Germany, but centres principally in Saxony, Silesia, and Westphalia. In recent times also power-loom weaving has been extending. In 1873 there were 68 establishments in Germany, principally at Elberfeld and Barmen, with 3473 power-looms, including 7 factories, with 546 power-looms, for jute. The linen industry employed 187,793 persons in 1875. The demand for linen is nearly covered by the home production.

Silk.—Raw silk can scarcely be ranked among the products of the empire, and the annual demand has thus to be provided for by importation. It amounts to about 50,000 cwts., there being some superior silk-weaving establishments. The main centre of the silk industry is Crefeld and its neighborhood; then come Elberfeld and Barmen, Aix-la-Chapelle, as well as Berlin, Potsdam, Chemnitz and Annaberg, Munich, Stuttgart, Saargemünd, etc. The exports of silk stuffs always exceed the imports.

General Census of Industries.—In 1875 a census of industrial occupations was taken in Germany. The following table gives the numbers of the different establishments and of the persons engaged in them:—

Classes.	Establishments.	Persons engaged.
1. Horticulturists	13,072	24,893
2. Fishermen	15,636	19,623
3. Miners	7,893	433,109
4. Workers in stone, clay, glass	51,235	265,139
5. Workers in metal	164,328	420,445
6. Workers in machines, instruments, etc	83,635	307,705
7. Chemical industry	8,640	51,739
8. Workers in lighting materials, soap, resins, etc	8,947	42,318
9. Textile industry	380,918	925,457
10. Workers in paper and leather	56,614	187,174
11. Workers in wood	245,703	463,533
12. Workers in food and drink	241,694	693,278
13. Workers in dress and washing	755,616	1,049,470
14. Workers in building	234,334	485,997
15. Polygraphic industry	8,108	55,852
16. Artistic industry	5,534	13,183
17. Persons in mercantile business	420,129	659,988
18. Persons engaged in conveyance	74,655	233,819
19. Lodging and boarding	159,881	234,848
Total	2,936,572	6,567,570

Roads, Railways, and Canals.

Roads.—The construction of good highways has been well attended to in Germany only since the Napoleonic wars. The separation of the empire into small states was favorable to road-making, inasmuch as it was principally the smaller Governments that expended large sums for their network of roads. Thirty years ago the best roads were found in Hanover and Thuringia; the Thüringer Wald has been almost transformed into a park by its splendid roads. But some districts suffer even still from the want of good highways. The introduction of railways for a time diverted attention from road-making, but this neglect has of late been to some extent remedied. In Prussia the circles (*Kreise*) have now themselves undertaken the charge of the construction of the roads; but they receive a subsidy from the public funds of the several provinces. The total length of the public roads is now estimated at 72,000 miles.

Railways.—The period of railway construction was inaugurated in Germany by the opening of the line from Nuremberg to Fürth in 1835, but the development of the system was slow. The want of a central government operated injuriously here, for it frequently happened that intricate negotiations and solemn treaties between several sovereign states were required before a line could be constructed; and moreover the course it was to take was often determined less by the general exigencies of commerce than by many trifling interests or desires of neighboring states. The state which was most self-seeking in its railway politics was Hanover, which separated the eastern and western parts of the kingdom of Prussia. The difficulties arising to Prussia from this source were experienced in a still greater degree by the seaports of Bremen and Hamburg. Until 1866 there was no railway from Bremen into the interior of Germany, while now there are four. Prior to 1865 the construction of railways advanced pretty uniformly, the average construction during the years from 1840 to 1865 having been from 340 to 370 miles per annum. Germany was at that time far outstripped in the extent of its railway system by England, Belgium, and Switzerland, and even by France. A new period of railway construction begins with the year 1866, and is closely connected with the economical and political progress of Germany. Numerous great undertakings were then set on foot, partly to remedy the defects of the existing system. Everywhere it became a primary object to establish the most direct lines of communication between important places of industry and commerce. As a consequence the German railway system was immensely enlarged, and from 1865–75 it has nearly been doubled. In 1872, 2000 miles were opened, the average from 1869 to 1877 being 1080 miles annually, so that Germany now owns a greater length of railways than any other state in Europe. On the 31st December, 1877, Germany had 18,830 miles, Great Britain and Ireland 17,092, France 14,785. As regards proportion to the area and population, however, Belgium, Great Britain, and Switzerland are still in advance. In 1877 Belgium had 320 miles of railways to every 1000 square miles, Great Britain 273, Switzerland 155, and Germany 147. The following table exhibits the development of the German railways, including those of Alsace-Lorraine:—

Years. Dec. 31.	Length of Lines open for traffic.	Of which double Lines.	Cost of Construction.
	Miles.	Miles.	£
1840	304		
1850	3,753		
1860	7,195		
1865	8,887		
1870	11,457	3,699	207,608,000
1875	17,061	5,622	339,225,000
1876	18,080	5,735	373,558,000
1877	18,830		

In recent years the multiplication of competing railways has greatly reduced the receipts of the older lines. The total amount of capital sunk in railway construction is estimated for the year 1876 at £373,558,000, or just about half the capital invested for the same purpose in Great Britain (£741,800,000). From the subjoined table it will be seen that the working expenses have considerably advanced during late years, and dividends accordingly have experienced a great decline. Railways formerly paying 15 to 18 per cent. have gone down to 5 to 6; the average dividend, which in 1870 was still 6 per cent., in 1876 had fallen to 4·4 per cent.

	Total Receipts.	Total Working Expenditure.	Net Receipts.	Proportion of Expenditure to total Receipts.
	£	£	£	Per cent.
1870	25,312,000	12,770,000	12,543,000	50·5
1875	42,151,000	26,534,000	15,617,000	63·0
1876	42,862,000	26,559,000	16,303,000	62·0

The making of railways has from the outset been regarded by some German states as exclusively a function of the Government. The South German states, for example, possess only state railways. In Prussia numerous companies have in the first instance constructed their systems, and the state has contented itself for the most part with laying lines in such districts only as were not likely to attract private capital. Yet, in order to establish a preponderating influence over the administration, of all German railways, the Government has for some time been buying up private lines. Saxony not long ago purchased all the Saxon railways belonging to private companies. The following table gives the proportion of state and private railways at 31st December, 1877, the minor North German states being classed along with Prussia. Of these Oldenburg alone possesses a greater length of railways belonging to the state than of those in the hands of private companies. The railways of Alsace-Lorraine are the property of the empire. The number of independent managements in 1878 was 67.

States.	State Railways.	Private Railways worked by State.	Private Railways.	Total.
	Miles.	Miles.	Miles.	Miles.
Prussia and minor German States...	3,285	2,060	6,857	12,202
Bavaria..................	2,241	169	371	2,781
Saxony	1,035	23	170	1,228
Würtemberg............	761	...	10	771
Baden.....................	651	77	4	732
Hesse	179	...	270	449
Alsace-Lorraine.......	660	...	7	667
Total.....	8,812	2,329	7,689	18,830

Canals.—Germany cannot be said to be rich in canals. In South Germany the Ludwigs-canal was until the annexation of Alsace-Lorraine the only one of importance. It was constructed by King Ludwig of Bavaria in order to unite the German Ocean and the Black Sea, and extends from the Main at Bamberg to Kelheim on the Danube. Alsace-Lorraine had canals for connecting the Rhine with the Rhone and the Marne; the coals of the Saar valley were conveyed by canals to Lorraine. The North German plain has several canals, of which only the more important need be named. In the east a canal by which Russian grain is conveyed to Königsberg joins the Pregel to the Memel. The Netze canal unites the Vistula and Oder. The upper Silesian coal-field is in communication with the Oder by means of a canal. The greatest number of canals is found around Berlin; they serve to join the Spree to the Oder and Elbe. Smaller canals are found also in the northwest. The Meuse and the Rhine are also connected by a canal. The 70 canals in Germany have a total length of only 1250 miles, a very small extent when the other canal systems of western Europe are compared with it.

Posts and Telegraphs.

With the exception of Bavaria and Würtemberg, which have administrations of their own, all the German states belong to the system of the reichspost. Since 1874 the postal and telegraphic departments have been combined. Both branches of administration have undergone a surprising development during the last 10 years, especially since the reduction of the postal rates. Germany, including Bavaria and Würtemberg, constitutes with Austria-Hungary a special postal union (Deutsch-Oesterreichischer Postverband), besides forming a part of the international postal union. There are no statistics of posts and telegraphs before 1867, for it was only when the North German union was formed that the lesser states resigned their right of carrying mails in favor of the central authority. Formerly the prince of Thurn-and-Taxis was postmaster-general of Germany, but only some of the central states belonged to his postal territory. The seat of management was Frankfort. Of late years the number of post-offices has increased considerably, as will be seen from the following figures, in which the statistics of the Bavarian and Würtemberg post-offices are included, as well as those of the reichspost. In 1872 there were 7400 post-offices; in 1877, 8600. In the latter year therefore there was one post-office for every 23 square miles. In 1877 there were 3194 imperial post-and-telegraph offices, and 3746 imperial post-offices, while the Bavarian post-offices numbered 1243, and those of Würtemberg 499. The following table shows the increase of letter circulation from 1872 to 1877:—

	Letters Imperial Post.	Total in German Empire.	Average Number to each person.
	Millions.	Millions.	
1872	352·0	407·8	10
1873	429·0	492·4	12
1874	456·6	521·9	13
1875	498·2	576·0	14
1876	516·4	596·3	14
1877	521·5	604·2	14

The average number of letters to each person is thus a little greater in Germany than it is in Ireland, whereas it is 26 in Scotland, and 35 in England. The number of post-cards has increased from 26·5 millions in 1872 to 99·3 millions in 1877. The following table shows the general postal circulation during the three years 1875–77:

	1875.	1876.	1877.
	Millions.	Millions.	Millions.
Letters	576·0	596·3	604·2
Post-cards	64·7	82·7	99·3
Printed papers	93·0	101·0	112·4
Newspapers	392·8	414·2	433·5
Samples	9·3	9·0	9·8
Money orders	33·5	39·8	...
Total amount of money orders and remittances	£840	£793	£784
Parcels	78·4	80·3	82·3
Total weight of parcels	℔ 559	℔ 583	℔ 915

Telegraphs.—By combining the postal and telegraphic departments Germany has been saved a large number of officials; but great sums are still spent annually on the extension of the telegraph system. Since 1876 important localities have been brought into communication with Berlin by subterranean wires. This plan is expensive, but under it a considerable saving is anticipated in repairs. The number of telegraph offices in 1877 was 7251, of which about 4600 belonged to the state, and the rest to private railways. The following table shows the progress of the telegraphic system between 1872 and 1877, and the number of messages in these two years:—

Telegraph Service.	1872.	1877.
	Miles.	Miles.
Length of line	23,350	33,660
Length of wire	77,870	121,810
Number of offices	4,038	7,251
Number of messages—		
Home service	8,478,000	8,994,000
International (includ. in transit)	4,945,000	5,203,000

The increase of messages is insignificant, a circumstance which must be attributed to the recent dulness of trade. On the whole the telegraph is not as yet used to a very great extent in Germany. The number of messages for every 100 inhabitants in 1877 was 33, as compared with 47 in Norway, 49 in Denmark, 54 in Belgium, 58 in the Netherlands, 64 in Great Britain, and 100 in Switzerland.

SHIPPING.

The German mercantile marine has always been distinguished by the excellence of its personnel. The seamen of Frisia are acknowledged to be among the best in the world, and the shipping of Bremen and Hamburg had won an everywhere respected name long before a German mercantile marine, properly so-called, was heard of. Many Hamburg vessels sailed under charter of English and other houses in foreign waters, especially in the Chinese. Since 1868 all German ships have carried a common flag—black, white, red—but formerly Oldenburg, Hanover, Bremen, Hamburg, Lübeck, Mecklenburg, and Prussia had each its own flag, and Schleswig-Holstein vessels sailed under the Danish flag. It is but lately that a uniform mode of measuring the hold tonnage of German ships has been introduced, and accordingly it is only since 1871 that it has been possible to give an exact statement of the position of German shipping. The official returns show that the marine is on the increase. The following table gives its position on the 1st of January in the years 1872–78. The tonnage is reckoned according to the English register ton.

	Sailing Vessels.		Steamers.		Total.	
	Number.	Tons.	Number.	Tons.	Number.	Tons.
1872	4,354	892,000	175	97,000	4,529	988,000
1873	4,311	869,000	216	130,000	4,527	999,000
1874	4,242	866,000	253	168,000	4,495	1,034,000
1875	4,303	878,000	299	190,000	4,602	1,068,000
1876	4,426	901,000	319	184,000	4,745	1,084,000
1877	4,491	923,000	318	181,000	4,809	1,104,000
1878	4,469	935,000	336	183,000	4,805	1,118,000

The lowest tonnage of vessels included in this return is 16 tons for sailing vessels and 11 tons for steamers. On comparing the state of the German marine with that of other countries we find that Germany ranks fourth in the list of maritime nations. Great Britain and the United States have considerably larger fleets. That of Norway also was even in 1871 greater than that of Germany, and it has increased much more rapidly than the other since that time; but on the other hand the mercantile marines of France and Italy, which in 1871 were larger than the German, are both now less. The following table shows the proportion of the mercantile shipping of Germany belonging to each of the maritime states on the 1st of January, 1878. It must be borne in mind that Bremen and Hamburg properly consist only of one port each, whereas Prussia has hundreds of miles of coast-line both on the North Sea and on the Baltic.

States.	Number of Ports.	Sailing Vessels.	Steamers.	Total.
		Tons.	Tons.	Tons.
Prussia	243	464.477	31,573	496,050
Hamburg	2	137,347	84,127	221,474
Bremen	2	158,677	57,377	216,054
Mecklenburg	2	108,521	3,812	112,333
Oldenburg	21	61,774	27	61,801
Lübeck	1	3,760	6,463	10,223
Total	271	934,556	183,379	1,117,935
North Sea Ports	62	419,698	38,699	458,397·
Baltic Ports	209	514,858	144,680	659,538

The number and the tonnage of steamers have, as in other countries, increased greatly, while those of sailing vessels have remained almost stationary. The aggregate horse-power of the steamers in 1871 was 23,287; in 1877 it was 50,603. The number of seamen employed in 1878 was 40,832, and of those 8173 served on board steamers.

In 1876 165 sailing vessels of 35,439 tons, and 14 steamers of 6200 tons, were built in Germany; and 8 sailing vessels of 3862 tons, and 1 steamer of 1910 tons, were built abroad. There were besides 50 ships with a total tonnage of 21,755 which had been bought in America, Holland, and Great Britain.

The shipping returns of German ports have lately fluctuated but little. The total amount was 13,311,000 tons in 1876. A striking difference will be observed in the following table in the returns between the numbers entering and clearing in ballast:—

Total Tonnage of Ships, 1876.

	With Cargo.	In Ballast.	Not for Trade.	Total.
	Tons.	Tons.	Tons.	Tons.
Entered...	6,072,000	505,000	130,000	6,585,000
Cleared ...	4,100,000	2,619,000	128,000	6,726,000

Only 44 per cent. of the ships that trade with German ports sail under the German flag. British ships have a very considerable trade in German ports. They constitute 32 per cent. of the total tonnage, and as much as 47 per cent. of the tonnage of steam vessels. Denmark follows next with 7·2 per cent., Sweden 4·8, Norway 4·6, Russia 2·3, Holland 2·1, France 1·2, United States 1·2, Italy 0·5, other countries 0·4. The number of voyages in all made by German ships in 1876 was 45,492, of which 12,963 were made between German ports. Much more considerable, however, is the trade of German ships between the home ports and foreign countries, as the subjoined table will show, while no fewer than 9777 voyages were made in 1876 by German vessels without calling at any home port:—

	Number of Ships with Cargo.	Tonnage of Ships with Cargo.	Number of Ships in Ballast.	Tonnage of Ships in Ballast.
Home trade (average of entered and cleared ships)	12,963	577,000	5,194	220,000
Foreign trade entered into German ports...............	8,002	1,984,000	710	79,000
Foreign trade cleared from German ports.......	5,449	1,552,000	3,397	602,000
Voyages of German ships between foreign ports...	6,950	3,314,000	2,827	880,000
Total.........	33,364	7,427,000	12,128	1,782,000

There were 5544 voyages made between non-German ports in Europe, the greater number being between one English port and another. Many German vessels also run between the Baltic ports of Russia and Sweden. From European ports 993 vessels sailed for non-European ports, and 869 returned thence to Europe. Here also the greater number ran from Great Britain to the United States, the West Indies, and South America. 2371 ships made their voyages without touching at European ports. Most of these were engaged in the coasting trade in the Chinese Seas, on the South American coasts, and in the West Indies.

As regards the shipping of the most important German ports, the following table will show the total tonnage of ships entered and cleared in 1876:—

Ports.	Tonnage.	Ports.	Tonnage.
Hamburg....	4,406,000	Kiel..................	608,000
Bremerhafen......	1,300,000	Pillau..............	440,000
Stettin..............	1,144,000	Königsberg.......	418,000
Neufahrwasser (Dantzic)....	780,000	Geestemünde......	378,000
		Memel..............	352,000
Lübeck............	646,000	Swinemünde......	332,000

COMMERCE.

Statistics relating to the foreign trade of the empire are necessarily confined to very recent times. The quantities of such imported articles as are liable to duty have indeed been known for many years; and some years ago an attempt was also made to compile official tables showing the value both of imports and of exports. But when the results of these tables proved the importation to be very much greater than the exportation, the conviction arose that the valuation of the exports was erroneous, and below the reality. There is no compulsory declaration of such goods, and consequently the attempt to compute statistics of this nature has been abandoned since 1875. It must at the outset be observed that the customs frontier does not coincide with the political frontier of Germany, for it does not take in the free-port territories of Hamburg and Cuxhaven, Bremen, Bremerhafen and Geestemünde, etc. (in all, 129 square miles with 593,040 inhabitants, in 1875), besides some communes in Baden adjoining the Lake of Constance (22 square miles, 5236 inhabitants). On the other hand the grand-duchy of Luxembourg (998 square miles, with 205,158 inhabitants in 1875) and the small Austrian commune of Jungholz (206 inhabitants), near Füssen, belong to the German Zollverein. The collection of duties is a function of the empire. The following table shows the results of the official calculations of the imports into Germany for 1872–76, and also the values of the exports, but in the case of these it is only the figures for the years 1872–74 that are official. The numbers for 1875 and 1876 are those published by Professor Laspeyres in the *Economiste Français.*

Years.	Imports.	Exports.	Transit.
1872	£173,400,000	£124,700,000	£54,700,000
1873	212,800,000	124,400,000	61,700,000
1874	183,700,000	121,600,000	
1875	176,500,000	127,400,000	
1876	190,200,000	127,600,000	
Average...	187,100,000	125,200,000	

The extremely slight variation which this table shows in the exports of the several years from 1872 to 1876 appears so improbable that we can hardly venture to make it a basis of calculation, or to draw a conclusion so unfavorable to the trading balance of Germany as the figures would suggest. The proportion per head of population is, as regards imports and exports respectively, about £4, 10s. and 3£, whereas the proportion in Great Britain in 1876 amounted in the one case to £11, 10s. and in the other to £6, thus showing the German trade to be less than half that of England. The statistical tables do not specify the several foreign markets for imports and exports; they only give the value of imports on the different frontiers.

Frontiers.	Total Value of Imports.	
	1875.	1876.
	Millions.	Millions.
North Sea line, including Bremen and Hamburg..........................	£56·6	£62·4
Denmark..	1·0	1·0
Russia..	19·0	19·2
Austria.......	32·2	36·3
Switzerland................................	8·0	9·2
France..	11·3	12·1
Belgium..................	16·3	16·3
Holland..	27·1	28·8
By post, or frontier not stated..........	5·0	4·9
Total..............	176·5	190·2

According to the official trade returns of Great Britain, France, and other countries, the trade between Germany and these countries is very considerable. By the English tables the importation from Germany to British ports was in 1875–76 between £21,000,000 and £22,000,000; the exportation to Germany in 1875 was £23,300,000, and in 1876, £20,100,000. The movement of trade is shown in the following tables of the principal articles imported and exported. We begin with articles of consumption:—

Articles.		1872.		1877.	
		Imports.	Exports.	Imports.	Exports.
Animals, except horses...............	No.	1,490,000	1,719,000	2,443,000	1,848,000
Grain and flour.....	Cwts.	28,800,000	21,860,000	73,070,000	39,600,000
Herrings..........	Barrels	691,000	...	667,000	...
Coffee....................	Cwts.	1,855,000	...	1,916,000	...
Sugar..........	"	879,000	264,000	155,000	1,802,000
Wine......................	"	817,000	400,000	1,182,000	380,000
Beer......................	"	100,000	590,000	300,000	1,280,000
Hops......................	"	25,000	142,000	36,000	162,000
Tobacco................	"	1,128,000	140,000	1,043,000	120,000

The weights are stated in hundredweights (cwts.) net throughout (see *Statistical Abstract* published by the English Board of Trade, No. V., 1878). This table shows that of late years Germany has had to order considerable quantities of grain from abroad. The value of the importation, estimated at £14,000,000 in 1872, was nearly £36,000,000 in 1877. Similarly the value of the imported animals advanced from £4,400,000 in 1872 to £9,500,000 in 1877.

The following table gives the imports and exports of the principal raw materials:—

Articles.	1872.		1877.	
	Imports.	Exports.	Imports.	Exports.
Coal, lignite, etc....Cwts.	71,600,000	76,395,000	95,000,000	100,184,000
Ores..................... “	8,200,000	5,300,000	6,855,000	16,140,000
Iron, pig............... “	12,395,000	3,616,000	10,536,000	9,119,000
Lead, pig............... “	163,000	433,000	60,000	649,000
Cotton, raw........... “	2,830,000	614,000	3,130,000	798,000
Flax..................... “	786,000	667,000	1,380,000	1,010,000
Hemp.................... “	500,000	248,000	930,000	469,000
Wool, raw .... “	1,070,000	357,000	1,370,000	445,000
Silk, raw cocoons .. “	61,300	16,000	63,000	20,000
Hides .... “	1,181,000	290,000	857,000	295,000
Guano................... “	1,400,000	190,000	2,440,000	127,000
Linseed, etc.......... “	1,110,000	670,000	1,116,000	1,354,000
Grease.................. “	578,000	40,000	725,000	75,000
Petroleum .... “	3,320,000	907,000	6,810,000	1,810,000
Wood............... Cwts.	49,400,000	30,200,000	36,800,000	21,400,000
Wood............... Pieces.	5,600,000	79,000	3,800,000	...

With regard to the proper products of industry, the exports, with few exceptions, such as yarn, exceed the imports in every case, as is shown in the table below. The total value of all fabrics imported is estimated at about £30,000,000, that of those exported at from £42,000,000 to £45,000,000. But, even supposing the last figures to be too low, the difference between the German and the British trade is still very great, since the value of all the industrial products exported by Great Britain may be stated at £170,000,000 for the year 1875 (see *Almanach de Gotha*, 1877). The difference is greatest in the textile industries,—the value of tissues exported from England in 1875 being estimated at £100,000,000, while that of Germany did not rank higher than from £20,000,000 to £25,000,000. Articles of hardware are showing a great decrease of imports and a considerable increase of exports.

Industrial Products—Imports and Exports.

Articles.	1872.		1877.	
	Imports.	Exports.	Imports.	Exports.
	Cwts.	Cwts.	Cwts.	Cwts.
Manufactures of cotton..	48,000	166,000	45,000	216,000
“ “ silk......	?	31,000	16,000	33,000
“ “ wool....	163,000	285,000	114,000	238,000
Yarns........................	1,088,000	243,000	892,000	334,000
Leather......................	130,000	158,000	150,000	166,000
Glass and glass wares....	250,000	627,000	150,000	832,000
Metal wares............	2,633,000	1,330,000	1,121,000	2,530,000
Machinery, exclusive of boilers, ..	563,000	596,000	729,000	801,000
Rails...........................	234,000	1,414,000	1,521,000	4,497.000
Musical instruments......	8,000	53,000	10,000	69,100

The principal ports of import and export are Hamburg and Bremen, and in these places the annual amount of shipping business has advanced step by step with the general development of German trade. As to the total value of goods entering Hamburg we have accurate statistics for several decades.

Imports of Hamburg.

		Total Imports, exclud. Bullion.		Total Imports, exclud. Bullion.
		Millions.		Millions.
Average.	1846–50	£20·5	1873	£85·3
	1851–60	33·5	1874	84·3
	1861–70	49·8	1875	85·1
	1871	77·3	1876	85·2
	1872	85·6	1877	88·8

The stagnation in the development of trade during the period 1871–77 is obvious; and with Bremen the case is the same. The following table states the total imports of Bremen by sea and from the interior. The importation from Germany or the Zollverein territory represents about one-third of the total amount. Bremen trades principally with the United States; Hamburg more with England, South America, etc.

Imports of Bremen.

		Total Imports.		Total Imports.
		Millions.		Millions.
Average.	1847–51	£5·3	1873	£26·5
	1857–61	11·1	1874	24·9
	1867–71	17·1	1875	21·9
	1871	23·3	1876	22·1
	1872	24·8	1877	22·1

GOVERNMENT.

The German empire is a union of 25 sovereign states,—4 kingdoms, 6 grand-duchies, 5 duchies, 7 principalities, 3 free towns. Alsace-Lorraine, ceded by France at the peace concluded 10th May, 1871, forms a twenty-sixth constituent of the confederation, but it is administered by the central authority. The supreme direction of the military and political affairs of the empire has, by the vote of the reichstag or diet of the North German confederation, been vested in the king of Prussia, who accordingly bears the title of German Emperor (Deutscher Kaiser).

The imperial dignity is hereditary in the line of Hohenzollern, and follows the law of primogeniture. The emperor exercises the imperial power in the name of the confederated states. In his office he is assisted by a federal council or bundesrath, which represents the governments of the individual states of Germany. The members of this council, 59 in number, are appointed for each session by the governments of the individual states. The legislative functions of the empire are vested in the emperor, the bundesrath, and the reichstag or diet. The members of the latter, 397 in number, are elected for a space of three years by universal suffrage. Vote is by ballot, and one member is elected by (approximately) every 100,000 inhabitants.

As regards its legislative functions, the empire has supreme and independent control in matters relating to military affairs and the navy, to the imperial finances, to German commerce, to posts and telegraphs, and also to railways, in so far as these affect the common defence of the country. Bavaria and Würtemberg, however, have preserved their own postal and telegraphic administration. The legislative power of the empire also takes precedence of that of the separate states in the regulation of matters affecting freedom of migration (Freizügigkeit), domicile, settlement, and the rights of German subjects generally, as well as in all that relates to banking, patents, protection of intellectual property, navigation of rivers and canals, civil and criminal legislation, judicial procedure, sanitary police, and control of the press and of associations.

The executive power is in the emperor's hands. He represents the empire internationally, and can declare war if defensive, and make peace as well as enter into treaties with other nations; he also appoints and receives ambassadors. For declaring offensive war the consent of the federal council must be obtained. The separate states have the privilege of sending ambassadors to the other courts; but all consuls abroad are officials of the empire, and are named by the emperor.

Both the federal council and the reichstag meet in annual sessions convoked by the emperor, who has the right of proroguing and dissolving the diet; but the prorogation must not exceed 60 days, and in case of dissolution new elections must be ordered within 60 days, and the new session opened within 90 days. All laws for the regulation of the empire must, in order to pass, receive the votes of an absolute majority of the federal council and the reichstag. The annexed table gives the number of votes which the separate states have in the federal council. Each state may appoint as many members to the federal council as it has votes. The table also gives the number of the deputies in the reichstag. The official order of precedence of the 26 states is given in a former table (see p. 409); here they are arranged in the order of the number of their inhabitants.

The federal council is presided over by the chancellor of the empire (Reichskanzler). Imperial measures, after passing the federal council and the reichstag, must obtain the sanction of the emperor in order to become law, and must be countersigned, when promulgated, by the chancellor of the empire. All members of the federal council are entitled to be present at the deliberations of the reichstag. The federal council, acting under the direction of the chancellor of the empire, is also a supreme administrative and consultative board, and as such it has nine standing committees, viz.:—for army and fortresses; for naval purposes; for tariffs, excise, and taxes; for trade and commerce; for railways, posts, and telegraphs; for civil and criminal law; for financial accounts; for foreign affairs; and for Alsace-Lorraine. Each committee includes representatives of at least four states of the empire.

Representation in Federal Council and Reichstag.

States of the Empire in order of their Population.	Population 1875.	Votes in the Federal Council.	Deputies in the Reichstag.
1. Prussia	25,742,404	17	236
2. Bavaria	5,022,390	6	48
3. Saxony	2,760,586	4	23
4. Würtemberg	1,881,505	4	17
5. Alsace-Lorraine	1,531,804	0	15
6. Baden	1,507,179	3	14
7. Hesse	884,218	3	9
8. Mecklenburg-Schwerin	553,785	2	6
9. Hamburg	388,618	1	3
10. Brunswick	327,493	2	3
11. Oldenburg	319,314	1	3
12. Saxe-Weimar	292,933	1	3
13. Anhalt	213,565	1	2
14. Saxe-Meiningen	194,494	1	2
15. Saxe-Coburg-Gotha	182,599	1	2
16. Saxe-Altenburg	145,844	1	1
17. Bremen	142,200	1	1
18. Lippe	112,452	1	1
19. Mecklenburg-Strelitz	95,673	1	1
20. Reuss-Gera	92,375	1	1
21. Schwarzburg - Rudolstadt	76,676	1	1
22. Schwarzburg - Sondershausen	67,480	1	1
23. Lübeck	56,912	1	1
24. Waldeck	54,743	1	1
25. Reuss-Greiz	46,985	1	1
26. Schaumburg-Lippe	33,133	1	1
Total	42,727,360	58	397

For the several branches of administration a considerable number of imperial offices have been gradually created. All of them, however, either are under the immediate authority of the chancellor of the empire, or are separately managed under his responsibility. The most important are the chancery office, the foreign office, and the general post and telegraph office. But the heads of these do not form a cabinet.

By the electoral law of 31st May, 1869, every German of twenty-one years of age is entitled to be an elector, and every one who has completed his twenty-fifth year, and has resided for a year in one of the federal states, is eligible for election. The deputies are unsalaried, but during the session they have the right of travelling free by rail. The following table shows the political composition of the reichstag after the four elections from 1871 to 1878:—

Parties.	1871.	1874.	1877.	1878.
Conservatives	50	21	40	61
Deutsche Reichs-partei (Liberal-Conservatives)	38	31	38	51
National Liberals	116	150	126	111
Fortschritts-partei (Progressists)	44	49	33	25
Social Democrats	2	9	12	9
Centrum (Clerical)	57	94	96	99
Poles	13	13	14	14
Other parties	62	30	38	27
Total	382	397	397	397

All the German states are constitutional, except Alsace-Lorraine and the two grand-duchies of Mecklenburg. The six larger states have adopted the two-chamber system, but in the composition of the houses great differences are found. The following table gives analyses of the membership for the sessions of 1878. As regards the lower house, 60,000 inhabitants elect one deputy in Prussia, 33,000 in Bavaria, 35,000 in Saxony, 20,000 in Würtemberg, 24,000 in Baden, 18,000 in Hesse.

	Prussia.	Bavaria.	Saxony.	Würtemberg.	Baden.	Hesse.
Members of Upper Houses.						
Royal princes of age, heads of the mediatized princely houses, etc.	64	53	7	36	10	22
Higher clergy, Catholic and Protestant	4	4	3	...	2	2
Delegates of the nobility and rich landowers	100	...	22	...	8	2
Representatives of university chapters	11	...	3	...	2	1
Burgomasters of large towns	38	...	8	...	...	...
Members nominated by the king or prince for life	85	15	5	9	7	11
Total for Upper Houses	302	72	48	45	29	38
Members of Lower Houses.						
General representation	434	156	...	...	...	...
Delegates of nobility and landowners.	...	...	...	13	...	6
Representatives of large towns	...	...	35	7	22	10
Representatives of rural districts	...	...	45	63	41	34
Higher clergy	...	...	...	9	...	...
Universities	...	...	...	1	...	...
Total for Lower Houses	434	156	80	93	63	50

The lesser states also have chambers of representatives numbering from 12 members (in Reuss) to 46 members (in Brunswick), and in most states the different classes, as well as the cities and the rural districts, are separately represented. The free towns have legislative assemblies, numbering from 120 to 200 members. In the so-called landtagen (diets) of Mecklenburg, which have but few privileges, 684 rittergüter (allodial estates) are represented and only 40 towns.

Finance.

The most important expenses which the budget of the German empire has annually to meet are those of the central administration, the army and navy, posts and telegraphs, the high court of justice, the foreign office, and some smaller items. For defraying these, all customs receipts and the net amount of certain excise duties are paid into the imperial treasury (reichskasse). Of the excise duties those on beet-root sugar, salt, and tobacco are common to all the states; but the imperial malt tax is not imposed in Bavaria, Würtemberg, Baden, or Alsace-Lorraine. The three first-named states are likewise exempt from the imperial excise on spirits. Additional receipts are derived from the duty on bill stamps, from posts and telegraphs (excluding Bavaria and Würtemberg), from the railways in Alsace-Lorraine, etc. These receipts are, however, insufficient to meet the expenses of the administration, and for that reason the separate states have to make contributions to the revenues of the empire, varying in proportion to their population. Bavaria, Baden, Würtemberg, and Alsace-Lorraine pay proportionally higher direct contributions, because they impose taxes on their own account on malt and spirits; so also do Bremen and Hamburg, because they are situated outside the customs territory. For the last few years the average contributions have ranged from £3,000,000 to £4,000,000; but they are increasing with the diminution of the funds available from the French war indemnity. These contributions press heavily upon the minor states.

The imperial budget is voted every year by the reichstag. The ordinary and extraordinary expenses for the financial year ending March 31, 1879, were distributed as follows:—

Expenditure, 1878–79.

	Ordinary.	Extra-ordinary.
Imperial chancery	£226,799	£116,516
Reichstag	6,100	1,500
Foreign office	305,233	26,350
Army	16,125,914	1,368,927
Navy	1,205,526	1,729,008
Invalid fund	1,602,658	...
Military pensions	829,072	...
Civil pensions	48,586	...
Imperial judicature	40,309	1,750
Carry forward	20,390,197	3,244,051

	Ordinary.	Extra-ordinary.
Brought forward	£20,390,197	£3,244,051
Imperial court of railway affairs	13,637	505,117
Posts and telegraphs	...	664,967
Imperial audit	22,526	500
Interest of debt of the empire	339,075	...
Mintage of imperial coins	...	1,135,000
Expenditure in remission of war taxes	...	499,766
Total	20,765,435	6,049,401

Revenue, 1878–79.

1. Customs, net		£5,327,524
2. Excise, net		6,951,768
Common duties. Beet-root sugar	£2,368,336	
Common duties. Salt	1,699,009	
Common duties. Tobacco	47,075	
Special duties. Spirits	2,040,070	
Special duties. Malt	797,278	
3. Contributions by territories outside the Zollverein		237,050
4. Stamps		332,655
5. Posts and telegraphs (gross revenue £6,443,000), net		764,420
6. Railways in Alsace-Lorraine (gross £1,908,600), net		567,800
7. Imperial printing-office, net.		8,716
8. Imperial bank (share of profits)		100,500
9. Various revenues		381,509
10. Invalid fund		1,602,658
11. Interest of imperial funds		366,210
Total direct revenue		16,640,810
Extraordinary supply (loans, various funds)		5,826,753
Contributions of states to revenue		4,357,276
Total revenue to cover expenditure		26,824,839

The direct contributions of the principal states of the empire to the revenue for 1878–79 were as follows:—

Prussia	£2,074,730	Saxony	£228,786
Bavaria	984,137	Alsace-Lorraine	103,020
Würtemberg	340,330	Hesse	71,125
Baden	241,828	Mecklenburg	40,602

Customs Revenue.—The revenue from the customs duties has increased but little since 1872. In that year it was £5,534,000, and in 1873, £6,131,000; but in 1877–78 it was only £5,768,000. No export duties have been raised in Germany for many years. On the other hand, all imported goods were taxed till 1865, with very few exceptions. Since then free trade has been more in favor, and a considerable reduction has taken place in the number of taxed articles. There are still, however, according to the official lists, about 148 articles on which customs duties are levied under 43 divisions. Raw materials are duty free. Four-fifths of the receipts (£4,323,000) are derived from articles of consumption, coffee being the principal item, after which come tobacco, wine, spirits, etc. The subjoined table shows the customs receipts, in round numbers, from the following items in 1878:—

Coffee	£1,838,000	Herrings	£108,000
Tobacco	821,000	Pork	103,000
Wine and spirits	517,000	Sugar and molasses	101,000
Salt	259,000	Rice	83,000
Fruit	258,000	Miscellaneous	235,000

The preceding table shows great differences when compared with the corresponding list for Britain. The consumption of coffee is considerably larger,—Germany having imported 2,128,000 cwts. in 1876, Great Britain only 1,361,000. The duty is at the same time much higher than in England, where the revenue from coffee was only £200,000. On the other hand, tea yields only £36,000 duty in Germany, but in England £3,700,000; wine and spirits, in Germany £517,000, in England £7,500,000; tobacco, in Germany £821,000, in England £7,800,000.

The German customs tariff serves as a protective duty for several industrial products, although in general a free-trade policy has prevailed in Germany during the last ten years. In 1873 the duties on iron were abolished; still its importation, owing to the stagnation of trade, has not increased. The following is a statement of the produce of the duties on specific manufactured articles in 1878:—

Textile fabrics	£604,000	Furniture, etc	£23,000
Glass and earthenwares	50,000	Copper-wares	16,000
Oil	147,000	Iron-wares	10,000
Leather and leather-wares	62,000	Paper	12,500

In 1879, however, Germany has suddenly returned to an extreme protective system. The present import duties are much increased, and duties are imposed on many articles hitherto duty free. The Government hopes to make a gross revenue of about £8,000,000 by the new customs.

Excise—The excise duties on articles of consumption have for the most part been considerably increased since 1872, especially the duty on sugar. The tax on tobacco is, however, still trifling (in 1877, £47,000). Bavaria, Würtemberg, and Baden are exempt from the duties both on spirits and on malt, Alsace-Lorraine from that on spirits.

Receipts from Excise Duties.

	Beetroot Sugar.	Spirits.	Salt.	Malt.
	£	£	£	£
1872	1,726,000	1,631,000	1,644,000	601,000
1874	2,578,000	1,902,000	1,704,000	766,000
1877–78	3,274,000	2,632,000	1,786,000	922,000

Funds of the Empire.—The extraordinary funds, from which very large sums appear annually in the budget, were created after the French war. Part of the indemnity was invested for fixed purposes. The largest of these investments served for paying the pensions of the invalided, and amounted originally to £28,000,000. Every year not only the interest, but also part of the capital of this fund is expended in paying these pensions. Another fund, of about £5,200,000, serves for the construction and armament of fortresses; a third for building new houses of parliament; a fourth for the construction of railways in Alsace-Lorraine. Further the empire has put aside £6,000,000 as a Reichs-Kriegs-Schatz, or imperial war reserve fund, which is not laid out at interest, but exists in coined gold and bullion at Spandau. The railways in Alsace-Lorraine are also the property of the empire—France having paid an allowance to the Eastern Railway Company of £13,000,000 for the railways brought under the control of Germany. The following table shows the state of the imperial funds at 1st March, 1878:—

Invalid fund	£27,870,700
Fund for armament of fortresses	6,515,800
War reserve fund	6,000,000
Parliament House building fund	1,455,400

Imperial Debts.—The loans contracted by the North German Confederation for the war with France have long since been paid off. The extraordinary expenditure of the empire was for several years paid out of the French indemnity, but that resource is now exhausted. Accordingly, for defraying the expenses of the army and navy, the extension of the subterranean telegraphs, etc., two new loans had to be raised in 1877 and 1878, amounting to £8,760,800. There exists, besides, an unfunded debt. The law allows the imperial chancellor to effect an issue of bills of exchequer for short terms to the extent of £7,500,000, and these are destined partly for the expenses of administration, and partly for the completion of the monetary reform. Since 1874 also a debt bearing no interest has been created in imperial treasury bills (Reichscassenscheine), which are to be substituted for the paper currency issued by the separate states. At that date only four states—Lippe, Lübeck, Hamburg, and Bremen—had no paper currency. Prussia had in 1872 only £3,000,000 of paper currency, or 2s. 6d. a head, but in the minor states the proportion was higher,—reaching in Saxe-Coburg-Gotha 10·3s. a head, in Anhalt 14s. in Mecklenburg-Strelitz 24·7s., and in Schaumburg-Lippe the very high figure of 34·8s. This inconvenience was remedied by an imperial law, ordering the states to call in their paper currency, and replacing it by the issue of imperial treasury bills, amounting to £6,000,000. For many of the smaller states this sudden withdrawal of their paper currency was too severe an ordeal. Accordingly, to these a further sum was advanced for a term of years in treasury bills; £8,338,000 was thus in circulation on the 30th of September, 1878.

Reform of the Currency.—The German empire adopted a gold currency by the law of the 4th December, 1871. Subsequently the old local coinages (*Landesmünzen*) began to be called in and replaced by new gold and silver coins. The old gold coins, amounting to £4,550,000, had been called in as early as 1873; and the old silver coins have also been successively put out of circulation, so that none actually now remain as legal tenders but the thaler (3s.). Silver currency to the amount of £52,000,000 had been withdrawn up to the 30th September, 1878, and copper coins to £157,600. To replace these there were coined up till the 30th September, 1878—gold pieces, £81,900,000; silver coins, £21,330,000; nickel and copper, £2,237,800. The currency reform was at first facilitated by the French indemnity, a great part of which was paid in gold. But later on that metal became scarcer; the London gold prices ran higher and higher, while silver declined. The average rate per ounce of standard silver in 1866–70 was 60⅝d., in January, 1875, only 57½d., in July, 1876, as low as 49d. It rose in January, 1877, to 57½d., but again declined, and in September, 1878, it was 50⅝d. While, therefore, the proportion of like weights of fine gold and fine silver in 1866–70 averaged 1 to 15·55, it was 1 to 17·79 in 1876, and 1 to 17·18 in 1877, and the difference again increased in 1878.

Banking.—A new banking law was promulgated for the whole empire on the 14th March, 1875. Before that date there existed 32 banks with the privilege of issuing notes, and on the 31st December, 1872, £67,100,000 in all was in circulation, £25,100,000 of that sum being uncovered. The banking law was designed to reduce this circulation of notes; £19,250,000 was fixed as an aggregate maximum of uncovered notes of the banks. The private banks were at the same time obliged to erect branch offices in Berlin or Frankford for the payment of their notes. In consequence of this regulation 13 banks resigned the privilege of issuing notes, so that at present there are in Germany but 19 note-issuing banks of which 5 belong to South Germany (Frankfort included). The Imperial Bank (Reichsbank) ranks far above the others in importance. It took the place of the Prussian Bank in 1876, and is under the superintendence and management of the empire, which shares in the profits. Its head office is in Berlin, and it is entitled to erect branch offices in any part of the empire. It has a capital of £6,000,000 in shares of £150. The following table exhibits the position of the German Reichsbank as compared with the other 18 banks at the 30th September, 1878:

Banks.	Notes in Circulation.	Bullion.	Excess of Notes.
	£	£	£
Reichsbank............	33,551,350	23,452,150	10,099,200
18 private banks......	9,395,850	7,209,450	2,186,400
Total............	42,947,200	30,661,600	12,285,600

Subjoined is a comparison with the great banks of England, France, and Austria at the same date:—

Banks.	Notes in Circulation.	Bullion.	Excess of Notes.
	£	£	£
Bank of England................	26,592,000	23,846,000	2,742,000
Bank of France.................	91,250,000	86,114,000	5,126,000
German Reichsbank.....	33,551,000	23,452,000	10,099,000
Austrian National Bank.....	29,698,000	13,836,000	15,862,000

Finances of the separate States. — The budgets of the different German states are so variously arranged that it is difficult to group them on uniform principles. We extract the following particulars from the scheme published by Prof. H. Wagner in the *Almanach de Gotha* for 1874. The expenses and receipts of the empire and those of the separate states are in the two tables taken together. The first table contains the net expenses for 1872–73, the charges of collection being deducted:—

Net Expenditure of German States, including the Empire.

1. Civil list and annuities to the princely families...	£1,750,000
2. Diets	112,500
3. Civil service.....	20,200,000
4. Interest and management of the public debts.....	19,000,000
5. Army and navy..	17,360,000
Total..................	58,422,500

Professor Wagner's second table gives the principal items of revenue:—

Revenue.	Gross Revenue.	Net Revenue.
I. *Revenue from public property and establishments managed by state.*	£	£
1. Crown land and state forests..........	......	5,300,000
2. Interest on consolidated funds, profits of issue, etc........................	......	3,075,000
3. State lotteries	. ....	375,000
4. Produce of public mines and salt works	......	1,445,000
5. Various state establishments...........	......	353,000
6. Post-office, telegraph service, state railways, canals...........................	......	6,285,000
II. *Taxes.*		
1. Direct taxes....................................	11,175,000	10,680,000
2. Excise—		
Spirits and malt...........	4,865,000	8,800,000
Beetroot sugar.................	2,170,000	
Salt	1,665,000	
Tobacco	96,500	
Other articles of consumption.......	1,100,000	
3. Customs	6,075,000	5,500,000
4. Stamps of all kinds and fees...........	5,700,000	5,385,000
5. Tolls, tonnages, etc.........................	......	450,000
Total	......	47,648,000

In the absence of trustworthy statistics the local taxes have not been taken into consideration in the above table. These, however, are very considerable in many cities in Germany, in consequence of recent expenditure on schoolhouses, sewage-works, etc.

A comparison of the foregoing tables with the corresponding statistics for the United Kingdom (1874) gives the following result. The payments on account of the national debt in Great Britain formed 42·2 per cent. of the total expenditure after deducting the charges of collection; in Germany only 18·14 per cent. The army and navy in England absorb 39·3 per cent. of the expenditure (or 68·0 per cent. after deducting the charges of debt), in Germany 35·6 per cent. (or 43·7). The expenses of the national debt in England are about 17s. a head, in Germany about 5s. The expenses of the army and navy in England are about 16s. a head, in Germany 9s. The public property in domains and forests is greater in Germany than in any other state of Europe, the area of the state forests being no less than 17,600 square miles. Many of the smaller states defray more than one-half of their expenditure by the revenue from domains and forests. From this source Germany is able to meet nearly one-fifth of her expenditure (17·3 per cent.), whereas in England only 0·6 per cent. is thus obtained. On the other hand, the expenses incurred by Germany for the civil lists and for annuities to the princely families are very considerable. Germany pays 3·6 per cent. of the national income to her princes, Great Britain only 1·04 per cent. In the minor states the princely households absorb 10 to 12 per cent. of the expenditure. The proceeds of establishments managed by the state cover 17·5 per cent. of the whole expenditure in Germany, but only 2·5 in England. The proportion of direct to indirect taxes is in England as 17 to 83, in Germany as 31 to 69. But on the whole the English are taxed twice as heavily as the Germans. The gross revenue in England was, in 1874, 42s. a head, in Germany 16·2s.; of these sums 13·2s. came, in England, from customs duties, and 13·3s. from excise on spirits and malt (apart from the customs duties), while in Germany the corresponding figures were only 3s. and 2·4s.

A considerable part of the public debt of the separate state was paid off by them after the war. In 1873 the total amount of all debts of the German states was only about £171,000,000. In this sum was included £9,500,000 of currency. The greater part of this liability has been incurred for productive purposes, particularly for the construction of railways. The railway debts (which are not directly charged on the population) were in 1873 about £96,500,000. Since then some states have gone on reducing their debts still further; Prussia, for example, has done so by more than £11,000,000. Others again, such as Bavaria, Saxony, Würtemberg, and Baden have contracted new loans for constructing railways, or, as Saxony, for purchasing them. The entire debt of all the German states, including the imperial debt, at 31st December, 1877, may be estimated at £220,000,000, of which sum, however, more than £140,000,000 consists of railway debt. The average sum per head will accordingly be £5, whereas in Great Britain it is £23 to £24. When the railway debts are deducted the proportion is less than £2 a head in Germany.

Army and Navy.

By the constitution of 16th April, 1871, every German is liable to service (wehrpflichtig) and no substitution is allowed (art. 57). Every German capable of bearing arms (wehrfähig) has to serve in the standing army for seven years—as a rule from the end of the twentieth till the commencement of the twenty-eighth year of his age. Three of these seven years he must spend in active service, and the remainder in the reserve; after quitting the latter he forms part of the landwehr for five years more—the full time of military service thus being twelve years. The strength of the army on a peace footing (friedensfuss) was fixed in the army bill of 1874 at 401,659 (or say 1 per cent. of the population at the census of 1871) for a term of seven years ending the 31st December, 1881. The number of recruits levied annually is 145,000 men. All young men who reach a certain fixed standard of higher school training, however, are obliged to serve only for one year in the active army, and these are not included in the effective strength of the army on a peace footing. Collaterally with the army there has existed since 1875 the landsturm, to which all men liable to service and capable of bearing arms, between the ages of seventeen and forty-two, belong, if they are neither in the line, the reserve, the landwehr, nor the marine. The landsturm is only called to arms in the event of a hostile invasion of the imperial territory being threatened or effected.

By the articles of the constitution the whole of the land forces of the empire form a united army in war and peace under the orders of the emperor. The sovereigns of the chief states are entitled to nominate the lower grades of officers, and the king of Bavaria has reserved to himself the special privilege of superintending the general administration of the two Bavarian corps d'armée; but all appointments are made subject to the emperor's approval. The 64th article of the constitution enacts that all German troops are bound to obey unconditionally the orders of the emperor, and to take the oath of allegiance accordingly. The emperor is empowered to erect fortresses in any part of the empire.

Organization of the Army.—The imperial army consists of 18 army corps, viz., the Prussian garde-du-corps, 13 Prussian corps (including the troops of the minor states in military convention with Prussia—Nos. 1 to 11 being Prussian, while Nos. 14 and 15 are the Baden and Alsace-Lorraine corps respectively), the Saxon corps (No. 12), the Würtemberg corps (No. 13), and the 2 Bavarian corps. One army "inspection" comprises from 3 to 4 corps. Generally 1 army corps consists of 2 divisions, each of which includes 1 horse and 2 foot brigades. As a rule the infantry brigade consists of 2 infantry regiments and 2 landwehr regiments, the cavalry brigade of from 2 to 3 cavalry regiments. An infantry regiment consists of 3 battalions of 4 companies each; a cavalry regiment has 5 squadrons. There are many exceptions, however, to these rules, *e. g.*, the garde-du-corps and the Saxon corps d'armée consist each of 1 cavalry and 2 infantry divisions, the 11th contains 3 divisions, etc. Some divisions also are stronger than others. Altogether the German army numbers 40 divisions, of which 6 are infantry, 3 cavalry, and 31 both combined. There are in all 74 infantry and 38 cavalry brigades, and 148 infantry and 93 cavalry regiments.

Strength of the Imperial Army.

Peace-footing.	Officers.	Rank and File.	Horses.
1. Staff	1,987	4	...
2. Infantry, 763 battalions—			
Infantry, 148 regiments or 444 battalions	8,740	255,679	...
Jäger (light infantry), 26 battalions	534	14,454	...
Depôts of landwehr, 293 battalions	348	4,633	...
3. Cavalry, 93 regiments, 465 squadrons	2,357	64,709	62,591
4. Artillery—			
Field artillery, 301 batteries	1,629	30,733	14,845
Fort artillery, 29 battalions	683	15,167	...
5. Engineers, 20 battalions	394	10,324	...
6. Train, 18 battalions	200	4,998	2,457
7. Special troops	311	958	...
Total	17,183	401,659	79,893

War-footing.	Officers.	Rank and File.	Horses.
a. Field Army.			
Staff	863	5,170	5,070
Infantry, 443 battalions	10,190	455,620	17,908
Jäger, 26 battalions	572	26,676	1,046
Cavalry, 372 squadrons	2,144	59,814	65,608
Artillery, 300 batteries, 1800 guns	2,286	78,120	79,432
Engineers, 54 companies	555	20,917	9,647
Train, 295 columns	484	38,451	46,017
Administration department	216	2,856	10,864
Total field army	17,310	687,624	235,592
b. Reserve.			
Staff	375	1,836	322
Infantry, 148 battalions	2,812	179,524	1,036
Jäger, 26 companies	104	8,008	26
Cavalry, 93 squadrons	465	23,994	19,716
Artillery, 71 batteries, 426 guns	340	13,261	5507
Engineers, 20 companies	90	4.950	20
Train, 37 companies	240	11,522	3,903
Total reserve	4,426	243,095	30,530
c. Garrison Troops.			
Administration	850	10,000	1,850
Infantry, 293 landwehr battalions	6,424	250,244	2,044
Jäger, 26 landwehr companies	104	6,500	26
Cavalry, 144 squadrons	828	22,768	25,380
Artillery, 54 batteries, 324 guns	1,370	54,852	8,114
Engineers, 48 companies	531	8,538	...
Total garrison troops	10,107	352,902	37,414
Grand total	31,843	1,283,621	303,536

Besides the troops above named, each army corps generally includes (*a*) 1 jäger or light battalion (the Bavarian army has, however, 10 of them); (*b*) 1 field artillery brigade; (*c*) 1 foot artillery regiment; (*d*) 1 engineer battalion; (*e*) 1 train battalion. The garde-du-corps has, in addition, two railway battalions, 1 instruction infantry battalion (Lehrbataillon), etc. The several field artillery brigades are not uniformly constituted, but in 12 of the 18 army corps the brigade consists of 2 artillery regiments. One of these with 8 batteries is attached to the division, while the other remains under the orders of the corps commander. This latter consists of two sections (Abtheilungen) of 3 batteries each, and a mounted division of 3 batteries. Each battery has as a rule 4 guns. A foot artillery regiment has 2 battalions of 4 companies each. There are in all 36 field artillery regiments with 301 batteries and 1206 guns, and 13 foot artillery regiments. In war time several corps are combined as "armies," the entire military force consisting then of the field or battle army, the reserve or supplementary troops (Ersatztruppen), and the garrison troops (Besatzungstruppen).

The preceding tables exhibit the strength of the German army on a peace footing and on a war footing respectively.

There are other 25,975 men who are not included in the latter sum-total but whose cost is defrayed by army grants. They include 4653 physicians, 838 veterinary surgeons, 1600 paymasters, etc. Nor does the table take account of the troops of the field reserve and of the landsturm, regarding the organization of which no details have been published; the former, which is drawn from the landwehr, is estimated at 250,000 men. It is calculated that Germany may put in arms at any given time two millions and a half of armed men without having recourse to the last reserves. The maximum strength of the army in the war with France was 1,350,787 men and 263,753 horses.

Fortresses.—Since the Franco-German war the fortress system has been entirely remodelled. A number of old and useless fortresses have been dismantled; several new ones have been erected along the sea-coast; and most of those flanking the land frontiers have been enlarged. The empire is divided into nine fortress districts, each including a certain number of fortified places. The Baltic coast fortresses are Memel, Pillau, Dantzic (first-class fortress), Colberg, Swinemünde, Stralsund, Travemünde, Kiel, Friedrichsort, Sonderburg-Düppel. On the North Sea are Wilhelmshaven and the fortresses by which the mouths of the Elbe, Weser, and Ems are guarded. The eastern frontier is protected by the first-class fortresses of Königsberg, Dantzic, Thorn, and Posen; and by the secondary ones of Marienburg and Dirschau on the Vistula, and of Glogau on the Oder, which are especially intended for the protection of the railways. For the southern frontier there exist only the fortresses of Neisse, Glatz, and Königstein on the Elbe. The old inland fortresses have been abolished, except the first-class ones of Küstrin, Magdeburg, Spandau, and (for railway protection) Torgau on the Elbe. Ulm and Ingolstadt on the Danube, both first-class fortresses, are also maintained. On the western frontier Strasburg and Metz have been fortified by a wide range of outer fortifications, and there is besides an outer line of smaller fortified places, consisting of New Breisach, Bitsch, Saarlouis, and Thionville. A second line runs along the Rhine, where there are large fortresses serving as encampments at Rastadt, Mainz, Coblentz, and Cologne, and smaller ones for the protection of the Rhine bridges at Germersheim, Ehrenbreitstein opposite Coblentz, Düsseldorf, and Wesel. The empire thus possesses 16 fortified places of the first class serving as camps, and 27 other fortresses.

Navy.—The German navy is but of recent origin. In 1848 the German people urged the construction of a fleet. Money was collected, and a few men-of-war were fitted out; but these were subsequently sold, the German bundestag (federal council) not being in sympathy with the aspirations of the nation. Prussia, however, began laying the foundations of a small navy. To meet the difficulty arising from the want of good harbors in the Baltic, a small extent of territory near Jahde Bay was bought from Oldenburg in 1854, for the purpose of establishing a war-port there. Its construction is now practically completed, although at enormous expense, and it was opened for ships by the emperor in June, 1869, under the name of Wilhelmshaven. In 1864 Prussia, by annexing Holstein, obtained possession of the excellent port of Kiel, which has since been strongly fortified. From the time of the formation of the North German confederation the navy has belonged to the common federal interest. Since 1st October, 1867, all its ships have carried the same flag—black, white, red, with the Prussian eagle and the iron cross.

From 1848 to 1868 the increase of the navy was slow. In 1851 it consisted of 51 ships with 188 guns (among which there were, however, 36 small gunboats of 2 guns each), and with 1180 hands in all. In 1868 it consisted of 89 vessels of 563 guns, among which number there were

2 ironclads, and 43 other steamers. Since then a definite plan for the development of the navy has been set on foot, and great activity has been displayed in fitting out ships and in augmenting the personnel.

The following table shows the increase that has occurred in the navy budget since 1868:—

	Ordinary.	Extra-ordinary.		Ordinary.	Extra-ordinary.
	£	£		£	£
1868	351,000	394,000	1874	692,000	1,976,000
1869	385,000	897,000	1875	902,000	454,000
1870	470,000	630,000	1876	1,053,000	238,000
1871	539,000	660,000	1877	1,083,000	1,428,000
1872	666,000	685,000	1878–79	1,205,000	1,729,000
1873	688,000	730,000			

The personnel of the navy consisted in 1878 of 965 officers and 9265 men. There are two sailors' divisions (Matrosendivisionen) of 79 officers and 6029 seamen and boys, a shipboys' department (Abtheilung) of 400 hands, 2 dockyard divisions (Werftdivisionen) with 148 officers and 1718 men, and 1 battalion of marines with 1035 men. The sailors and marines are levied by conscription from among the seafaring population, which is on this account exempt from service in the army. The total sea-going population of Germany is estimated at 80,000, 48,000 of whom serve in the merchant marine at home, and about 6000 in foreign service. Great inducements to enter the navy are held out to able seamen. The following table gives the state of the navy in August, 1878:—

Ships.	Number.	Guns.	Tonnage.	Horse-power.
Armor-clad ships—				
Frigates	7	85	3,400 to 5,900	3,500 to 8,000
Corvettes	3	20	2,400 to 5,000	3,000 to 5,600
Floating batteries	7	12	780 to 1,200	700 to 1,200
Non-armor-clad ships—				
Floating battery	1	23	3,300	3,000
Decked corvettes	11	166	1,700 to 2,800	1,500 to 4,800
Corvettes	7	62	1,000 to 1,600	800 to 2,400
Despatch vessels	5	6	330 to 1,500	350 to 3,000
Gunboats	12	30	600 to 1,200	600 to 1,100
Torpedo ships	11	...	24 to 900	80 to 2,300
Transportsteamer	1	...	425	320
Sailing vessels	4	28	2,800	..
Total	69	432	91,500	110,000

RELIGION.

In the official census it has been usual to return the religious creed of the inhabitants, though a few states, such as Prussia and Hamburg, omitted this particular in 1875. Official estimates indeed have been made of the religious profession of the people in these states for 1875 also, but only the census of 1867 and that of 1871 can be accurately compared. The number of persons styling themselves of no religion, or refusing to state their religion, is very small. The following table gives the results of the three last enumerations:—

Creeds.	1867 Census.	1871 Census.	1875 Partly estimated.
Protestants	24,921,000	25,581,623	26,718,823
Roman Catholics	14,564,000	14,867,600	15,371,227
Dissenters	117,000	82,156	100,608
Jews	499,000	512,160	520,575
Other creeds	6,000	176	16,127
Religion not stated		16,980	
Total	40,107,000	41,060,695	42,727,360

Almost two-thirds of the population belong to the Evangelical Church, and rather more than a third to the Church of Rome. The dissenters are very inferior in numbers, amounting to only about 100,000 souls, but the Jewish element, represented by half a million (1¼ per cent.), is more considerable than in any other state of West, North, or South Europe. The following table gives the proportion of Protestants, Catholics, and Jews in every 1000 inhabitants:—

	Rate to 1000 Inhabitants.		
	Protestants.	Catholics.	Jews.
1867	621	363	12·4
1871	623	362	12·5
1875	625	360	12·2

The Protestants have increased in number by 0·4 per cent. of the population since 1867. This increase, however, must not be attributed to conversions, but rather to the greater increase of population in the Protestant provinces of Germany as compared with the Catholic ones; though at the same time the official returns of Prussia prove that conversion to the rival communion is much more frequent with Catholics than with Protestants. Three states in Germany have a decidedly predominant Catholic population, viz., Alsace-Lorraine, Bavaria, and Baden; and in four states the Protestant element prevails, but with 23 to 33 per cent. of Catholics, viz., Prussia, Würtemberg, Hesse, and Oldenburg. In Saxony and eighteen minor states the Catholics number only from ·1 to 3·3 per cent. of the population. The following table gives the respective numbers of Protestants and Catholics according to the census of 1871:—

States.	Protestants.	Roman Catholics.	Rate per 1000 of Population.	
			Prot.	Cath.
Alsace-Lorraine	270,699	1,235,097	175	797
Bavaria	1,342,592	3,464,364	276	712
Baden	491,008	942,560	336	645
Prussia	16,041,215	8,268,309	650	335
Würtemberg	1,248,860	553,542	687	304
Hesse	585,399	238,080	686	279
Oldenburg	240,962	71,027	766	226
Saxony and minor states	5,360,808	94,621	978	17
Total	25,581,543	14,867,600	623	362

From the above figures little can be inferred as to the geographical distribution of the two confessions. On this point it must be borne in mind that the population of the larger towns, on account of the greater mobility of the population since the introduction of railways and the abolition of restrictions upon free settlement, has become more mixed,—Berlin, Leipsic, Hamburg, etc., showing proportionally more Catholics, and Cologne, Frankfort, Munich, etc., more Protestants than formerly. Otherwise the geographical limits of the confessions have been but little altered since the Thirty Years' War. In the mixed territories those places which formerly belonged to Catholic princes are Catholic still, and *vice versa*. Hence a religious map of South Germany looks like an historical map of the 17th century. The number of localities where the two confessions exist side by side is small. Generally speaking, South Germany is predominantly Catholic. Some districts along the Danube (province of Bavaria, Upper Palatinate, Swabia), in southern Würtemberg and Baden, and in Alsace-Lorraine are entirely so. These territories are bordered by a broad stretch of country on the north, where Protestantism has maintained its hold since the time of the Reformation, including Baireuth or eastern Upper Franconia, Middle Franconia, the northern half of Würtemberg and Baden, with Hesse and the Palatinate. Here the average proportion of Protestants to Catholics is two to one. The basin of the Main is again Catholic from Bamberg to Aschaffenburg (western Upper Franconia and Lower Franconia). In Prussia the western and south-eastern provinces are mostly Catholic, especially the Rhine province, together with the government districts of Münster and Arnsberg. The territories of the former principality of Cleves and of the countship of Mark (comprising very nearly the basin of the Ruhr), which went to Brandenburg in 1609, must, however, be excepted. North of Münster, Catholicism is still prevalent in the territory of the former bishopric of Osnabrück. In the east, East Prussia (Ermland excepted) is purely Protestant. Catholicism was predominant a hundred years ago in all the frontier provinces acquired by Prussia in the days of Frederick the Great, but since then the German immigrants have widely propagated the Protestant faith in these districts. A prevailingly Catholic population is still found in the district of Oppeln (89 per cent.) and the countship of Glatz, in the province of Posen (64 per cent.), in the Polish-speaking "circles" of West Prussia, and in Ermland (East Prussia). In all the remaining territory the Catholic creed is professed only in the Eichsfeld on the southern border of the province of Hanover, and around Hildesheim.

Protestant Church.—The adherents of Protestantism are divided by their confessions into Reformed and Lutheran. To unite these the "church union" has been introduced in several Protestant states, as for example in Prussia and Nassau in 1817, in the Palatinate in 1818, and in Baden in 1822. Since 1817 the distinction has accordingly been ignored in Prussia, and Christians are there enumerated only as Evangelical or Catholic. The union, however, has not remained wholly unopposed,—a section of the more rigid Lutherans who separated themselves from the state church being now known as Old Lutherans. In 1866 Prussia annexed Hanover and Schleswig-Holstein, where the Protestants were Lutherans, and Hesse, where the Reformed Church had the preponderance. The inhabitants of these countries opposed the introduction of the union, but could not prevent their being subordinated to the Prussian oberkirchenrath (high-church council), the supreme court of the state church. Subsequently the official returns have been thus classified:—

		1875.
(*a*) Members of the Evangelical State Church		16,636,990
United	13,266,620	
Lutherans	2,905,250	
Reformed	465,120	
(*b*) Separatist Lutherans (Old L.)		40,630
(*c*) Separatist Reformed		35,080

The separatists are thus not numbered among dissenters. A synodal constitution for the Evangelical State Church was introduced in Prussia in 1875. The oberkirchenrath retains the right of supreme management. The ecclesiastical affairs of the several provinces are directed by consistorial boards. The parishes (*pfarreien*) are grouped into dioceses (*sprengel*), presided over by superintendents, who are subordinate to the superintendent-general of the province. Prussia has sixteen superintendents-general. The ecclesiastical administration is similarly regulated in the other countries of the Protestant creed. Regarding the number of churches and chapels Germany has no exact statistics, but in 1867 it was estimated that there were 12,959 places of worship in Prussia.

Roman Catholic Church.—There are six archbishoprics within the German empire:—Breslau (where the archbishop has the title of prince-bishop), Gnesen-Posen, Cologne, Freiburg (Baden), Munich-Freising, and Bamberg. The eighteen bishoprics are—Ermland (see at Frauenburg, East Prussia), Kulm (see at Pelplin, West Prussia), Fulda, Hildesheim, Osnabrück, Paderborn, Münster, Limburg, Treves, Metz, Strasburg, Spires, Würzburg, Ratisbon, Passau, Eichstädt, Augsburg, Rottenburg (Würtemberg). An apostolic vicariate exists in Dresden. In recent years numerous convents, especially in Prussia, have been suppressed. The order of the Jesuits is interdicted in Germany.

Old Catholics.—After the infallibility of the pope had been proclaimed as a dogma by the Vatican council in 1871, several communities as well as individuals declared their secession from the Roman Church. They are called Old Catholics, and they have selected a bishop who has been acknowledged by most of the states. At the 1st of January, 1877, the denomination had 121 congregations with 56 clergymen and 16,557 adult male adherents, so that we may fairly estimate the total number of Old Catholics at a little more than 50,000.

The number of Greek Catholics was 2660 in 1871.

Dissenters.—There is no uniformity in the state returns of the several denominations, and detailed statements are wanting for Würtemberg, Alsace-Lorraine, and eight of the lesser states. In the sixteen remaining states there were in 1875 21,000 Mennonites (particularly in East and West Prussia and the Palatinate), 10,451 Baptists, 3000 Irvingites, 4000 Herrnhuter (Moravian brethren), and 1600 members of the Church of England. The Mennonites had increased from 14,000 in 1871. Besides these there were about 6800 German Catholics, 3600 Freethinkers, and more than twenty-five sects represented by from 100 to 500 members.

Jews.—It is in the towns that the Jewish element is chiefly to be found. They belong principally to the mercantile class, and are to a very large extent dealers in money. Within the last thirty years their wealth has grown to an extraordinary degree. They are increasingly numerous in Hamburg, Berlin, Frankfort, Breslau, Königsberg, and Fürth. Though still, in fact at least, if not also by law, excluded from many public offices, especially from commands in the army, they nevertheless are very powerful in Germany, the press being for the most part in their hands. Some towns of the Marienwerder and Posen districts contain from 20 to 30 per cent. of Jews. By far the greater number are found among the Slavs in the east: in the west they appear chiefly in Hesse, Baden, and Alsace.

LANGUAGES.

The German-speaking nations in their various branches and dialects are found to extend in a compact mass along the shores of the Baltic and of the North Sea, from Memel in the east to a point between Gravelines and Calais near the Straits of Dover. On this northern line the Germans come in contact with the Danes who inhabit the northern parts of Schleswig within the limits of the German empire. A line from opposite Sonderburg in the isle of Alsen to Tondern in the west will nearly form the boundary between the two idioms. The German-French frontier traverses Belgium from west to east, touching the towns of St. Omer, Courtrai, and Maastricht. Near Eupen, south of Aix-la-Chapelle, it turns southward, and near Arlon south-east as far as the crest of the Vosges mountains, which it follows up to Belfort, traversing there the watershed of the Rhine and the Doubs. In the Swiss territory the line of demarcation passes through Biel, Freiburg, Saanen, Leuk, and Monte Rosa. In the south the Germans come into contact with Rhæto-Romans and Italians, the former inhabiting the valley of the Vorder-Rhein and the Engadine, while the latter have settled on the southern slopes of the Alps and are continually advancing up the valley of the Adige. Carinthia and Styria are inhabited by German people, except the valley of the Drave towards Klagenfurt. Their eastern neighbors there are first the Magyars, then the northern Slavs and the Poles. The whole eastern frontier is very much broken, and cannot be described in a few words. Besides detached German colonies in Hungary, the western parts of that country are held by Germans. The river March is the frontier north of the Danube from Presburg as far as Brünn, to the north of which the German regions begin near Olmütz,—the interior of Bohemia and Moravia being occupied by Czechs and Moravians. In the Prussian provinces of Silesia and Posen the eastern parts are mixed territories, the German language progressing slowly among the Poles. In Bromberg and Thorn, in the valley of the Vistula, German is prevalent. In West Prussia some parts of the interior, and in East Prussia a small region along the Russian frontier, are occupied by Poles (Kassubians in West Prussia, Masurians in East Prussia). The German tongue is also fast invading the Lithuanian territory, and in a short time no people speaking that idiom will be found to the left of the river Memel. The total number of German-speaking people, within the boundaries wherein they constitute the compact mass of the population, may be estimated, if the Dutch and the Flemings be included, at 56 millions.

The geographical limits of the German language thus do not quite coincide with the German frontiers. The empire contains about 3½ millions of persons who do not make use of German in everyday life, not counting the 290,000 resident foreigners. The non-German languages have their representatives only in Prussia, Saxony, and Alsace-Lorraine. No census since 1861 has given the statistics of the different languages spoken in the first mentioned country; and, in regard to Alsace-Lorraine also, the figures are based upon estimates only. The following table gives the results of semi-official estimates for 1875:—

Languages.	Persons.	Proportion to 1000 Persons.
German	39,100,000	921
Polish	2,600,000	66
Wendic	140,000	
Czech	50,000	
Lithuanian	150,000	4
Danish	150,000	4
French	250,000	6
Total—Natives	42,440,000	
Foreigners	290,000	

From this it will be observed that the Poles form a considerable part of the population,—about 60·1 per cent. in the district of Oppeln, 59·3 in Posen, 49·6 in Bromberg, 37·8 in Marienwerder, 27·3 in Dantzic, 21·9 in Gumbinnen, 17·1 in Königsberg, and 4·3 in Breslau. The Wends, who inhabit Lusatia, are decreasing in number,—in the Saxon district there were 52,097 in 1871, and in 1875 only 50,737. The Lithuanians are likewise diminishing on the eastern border of East Prussia. Czechs are found only in Silesia on the confines of Bohemia. The French are represented in Lorraine and Upper Alsace, and on the Belgian frontier.

EDUCATION.

In point of intellectual culture Germany ranks high. Much is done by the Government for the promotion both of primary and of secondary education; there are no exact statistics, however, of the educational establishments, or of the expenditure incurred in connection with them. In regard to the latter the sums which figure in the Government budgets are not the only contributions which must be considered; for in most of the states the several locals communities provide from their own resources for primary instruction and for many of the higher schools, while many of the superior institutes have funds of their own not included in the budget. School instruction is obligatory on the whole people, but in many districts there is still a scarcity of teachers and some want of efficient control. The total number of primary schools is estimated at 60,000, and that of pupils at 6,500,000 or 150 pupils to every 1000 inhabitants. Some provinces exhibit a larger proportion; in Saxony, Thuringia, Brunswick, Rhineland, and Westphalia, there are from 165 to 175 pupils to every 1000 inhabitants. In Bavaria, Posen, East and West Prussia, Brandenburg, on the other hand, there are only from 120 to 130. A good criterion of the school instruction is to be found in the statistics of the annual levies of recruits. The following table shows the number of recruits during the years 1876–78 who were unable to read and write:—

	Number of levied Recruits able to write and read.		Number of levied Recruits unable to write and read.	
	In German Language.	In other Languages only.	Number.	Rate to 10,000 Recruits.
1875–76	130,176	6,368	3,311	237
1876–77	130,939	6,283	2,975	212
1877–78	134,189	6,292	2,476	173

It will be seen from the above that the number of illiterate recruits has considerably decreased during the last three years. The figures given compare very favorably with those of other European countries. In 1872 the number of illiterates was 4·6 per cent. in the army, and 2·3 in the navy, the corresponding numbers in France being 23 and 14 per cent. In England 23 per cent. of the marines could neither read nor write in 1865, 4 per cent. could only read, and 37 per cent. could write but imperfectly. In Austria only 28 per cent. of the recruits could write, and in Russia scarcely 10 per cent. had any school education. But the provinces of Germany differ much from one another in this respect. Education is very inferior in the eastern Polish districts. During the three years from 1875–78 in the districts of Posen, Bromberg, and Oppeln there were in all 10·7, 9·24, 8·02 per cent. of illiterates among the recruits, in the provinces of West and East Prussia 8·77, 8·66, 7·80. After these the rate takes a long leap to 3·18, 3·17, 1·94 in Alsace-Lorraine and the Palatinate. In 1877–78 there was no considerable district in Germany which sent so many as 1 per cent. of illiterates. The most satisfactory state of matters is to be found in Saxony, Thuringia, Baden, and Würtemberg, and especially in the last two. Würtemberg had only one recruit among 6000 that was unable to read.

Unremitting attention is being paid to the improvement of primary schools (*volksschulen*), although many of the eastern districts are still destitute of these in the rural localities. Not long ago the position of teachers of primary schools was very unsatisfactory; and the supply of masters was unequal to the demand. In recent years much has been done in all the states to effect a reform on this state of matters. In 1875 there were 170 seminaries in Germany for the training of schoolmasters. But this number is insufficient, for it may be estimated that 5000 to 6000 new appointments are required annually, if one master is not to have charge of more than 60 children. Saxony has the greatest number of institutions of this kind (15). Within the last few years many municipalities have begun to found schools of a somewhat higher rank for the lower classes of the town population, called middle schools.

The census in Prussia in 1871 proves primary school instruction to be much better among the Protestants than among the Catholics, as will be seen in the following table:—

Illiterates of 10 Y'rs. and under.	Males.	Females.	Percentage of corresponding Population.		
			Males.	Fem.	Total.
Protestants........	390,117	693,400	4·9	8·3	6·7
Catholics...........	464,755	685,535	11·3	16·4	13·2
Jews.................	7,976	15,648	4·9	9·4	7·2
Others................	995	2,846	3·7	9·4	5·2
Total......	863,843	1,397,429	7·1	11·1	9·2

There are four different kinds of schools for the higher branches of education. The gymnasia supply preparatory training for the universities, the foremost place in the course of instruction being assigned to the classical languages; but French, English, and mathematics are also taught, and some attention is given to natural science, history, and geography. Their constitution dates back to very remote times, and but few and slight alterations have been made in their schemes of study since the beginning of the present century. Officials, judges, clergymen, teachers, and physicians for the most part receive their early education at the gymnasia. In 1878 there were 360 gymnasia in Germany, or 1 for every 600 square miles and every 117,000 inhabitants. Central Germany has the largest proportion, 1 for every 75,000 inhabitants. To these must be added the progymnasia, about 90 in number. The same studies are prosecuted in these, but the highest classes of a gymnasium are wanting. Of more recent growth is the system of *realschulen*, where Latin is the only ancient language taught, the other branches being modern languages, especially French and English, mathematics and natural philosophy, geography, and modern history. These schools have long enjoyed great popularity. They are classified as of the first and of the second order. In the former a pupil remains generally for nine or ten years, as in the gymnasia; and those who pass the highest examination are allowed to enter the universities, but only to study the modern languages, mathematics, and natural sciences. In 1878 there were 129 realschulen of the first order, mainly in Saxony, Rhineland, Berlin, and Hanover. The realschulen of the second order prepare pupils for those professions which do not require a university course. On the average a pupil leaves school in the seventeenth year of his age. Besides these institutions, which are increasing every year, there is a considerable number of technical schools (gewerbeschulen). Their purpose is purely industrial; drawing, mechanics, mathematics, physics, and chemistry are among the subjects of instruction, languages being excluded. There are, moreover, schools of commerce, navigation, and agriculture in different towns. The military law relating to the one year's volunteers has had an important influence on the attendance at all these institutions. In 1879 there were 878 schools with the privilege of furnishing pass certificates to such volunteers; of these 360 were gymnasia, 129 were realschulen, and about 40 were private schools. Exact and uniform statistics of the higher schools do not as yet exist. Many of the last-mentioned institutions are maintained partly or entirely at the expense of the municipalities, and by far the greater number are denominational, Protestant ones prevailing. The following table shows the number of Prussian schools in 1875 maintained severally by the Government, by the municipalities, and by other funds:—

Denominat'n.	Number of Middle Schools in Prussia maintained by		
	Government.	Municipalities.	Private Funds.
Protestant..	100	199	16
Mixed.......	18	38	...
Catholic.....	43	31	2
Jewish.......	...	...	2
Total....	161	268	20

Universities and Higher Technical Schools.—Germany owes its large number of universities, and its widely diffused higher education to its former subdivision into many separate states. Only a few of the universities date their existence from the present century; the majority of them are very much older. Each of the larger provinces, except Posen, has at least one university, the entire number at present being 21. All have four faculties except Münster, which has no faculties of law and medicine. As regards theology, Bonn, Breslau, and Tübingen have both a Protestant and a Catholic faculty; Freiburg, Munich, Münster, and Würzburg are exclusively Catholic; and all the rest are Protestant. The following table gives the names of the 21 universities, the dates of their respective foundations, the number of their professors and other teachers, and of the students attending their lectures during the summer session 1878, arranged according to the numbers in attendance:—[1]

Universities.	Dates of Foundation.	No. of Professors and Teachers.	No. of Students.
1. Berlin, Prussia...	1810	215	4,331
2. Leipsic, Saxony................	1409	160	2,948
3. Munich, Bavaria..............	1826	136	1,396
4. Breslau, Prussia (1702)......	1811	106	1,250
5. Tübingen, Würtemberg......	1477	88	1,144
6. Bonn, Prussia..................	1818	100	1,075
7. Göttingen, Prussia............	1737	120	1,009
8. Würzburg, Bavaria...........	1402	66	960
9. Halle, Prussia..................	1697	107	944
10. Heidelberg, Baden...........	1386	110	808
11. Strasburg, Alsace-Lorraine.	1872	90	736
12. Königsberg, Prussia..........	1544	89	671
13. Jena, Thuringian states.....	1558	78	570
14. Greifswald, Prussia...........	1456	61	534
15. Marburg, Prussia..............	1527	71	458
16. Freiburg, Baden..............	1457	57	454
17. Erlangen, Bavaria............	1743	64	415
18. Giessen, Hesse................	1607	55	347
19. Münster, Prussia..............	1780	30	332
20. Kiel, Prussia....................	1665	69	264
21. Rostock, Mecklenburg.......	1419	41	157
Total..	....	1,913	20,803

A number of technical high schools rank along with the universities; they all took their rise in the course of the present century, and usually bear the name of Polytechnicum. To the number of these belong the academies of industry (founded 1821) and of architecture (1798) in Berlin, and the Polytechnica at Hanover, Brunswick, Aix-la-Chapelle, Darmstadt, Carlsruhe, Stuttgart, Munich, and Dresden.

Among the remaining higher technical schools may be mentioned the mining academies of Freiberg in Saxony, of Berlin, and of Clausthal in the Harz, and the academies of forestry at Neustadt-Eberswalde, Münden on the Weser, Tharand near Dresden, and Hohenheim near Stuttgart, and at Brunswick, Eisenach, Giessen, and Carlsruhe. Schools of agriculture have also been attached to several universities, the most important being at Berlin, Halle, Göttingen, Königsberg, Jena, Poppelsdorf near Bonn, Munich, and Leipsic.

Libraries.—Mental culture and a general diffusion of knowledge are extensively promoted by means of numerous public libraries established in the capitals, the university towns, and other places. The most celebrated public libraries are those of Berlin (800,000 volumes), Munich (800,000 volumes and 22,000 manuscripts), Göttingen, Dresden, Stuttgart, Hamburg, Strasburg, Frankfort-on-the-Main, Breslau, Gotha, and Wolfenbüttel.

Societies.—There are also numerous societies and unions, some being of an exclusively scientific character, and others being designed for the popular diffusion of useful knowledge. The academies of science in Berlin, Munich, Göttingen, and Leipsic are Government institutions. Ample provision is made for scientific collections of all kinds in almost all places of any importance, either at the public expense or through private beneficence.

Observatories.—These have in recent years been considerably augmented. There are 22 observatories in the empire, viz., at Altona, Berlin, Bonn, Bothkamp in Schleswig, Breslau, Dantzic, Düsseldorf, Gotha, Göttingen, Hamburg, Kiel, Königsberg, Leipsic, Lübeck, Mannheim, Marburg, Munich, Potsdam, Schwerin, Spires, Strasburg, and Wilhelmshaven.

Book Trade.—This branch of industry, from the important position it has gradually acquired since the time of the Reformation, is to be regarded as at once a cause and a result of the mental culture of Germany. Leipsic is the centre of the trade. The number of booksellers in Germany was not less than 5196 in 1878, among whom were 1546 publishers. The following table will show the recent progress of German literary production, and its proportion to that of other European states:—

	Number of Published Works.			
	Germany.	France.	Gt. Britain.	Italy.
1868	10,563	11,267	4,439	4,084
1870	10,058	8,831	5,082	4,318
1872	11,127	10,559	4,812	6,429
1877	13,925			
1878	13,912			

Newspapers.—While in England a few important newspapers have an immense circulation, the newspapers of Germany are much more numerous, but individually command a far more limited sale. Leaving out of account insignificant local papers, Germany in 1878 possessed 600 newspapers published daily, or two to three times a week; of these only 90 were published in South Germany. Berlin alone produces 44 newspapers. Most readers receive their newspapers through the post-office or at their clubs, which may help to explain the smaller number of copies sold. Only 50 of the 600 daily newspapers print more than 10,000 copies, and only 20 more than 20,000.

Fine Arts.—There are many academies which have for their object the promotion of a taste for painting, sculpture, architecture, and music, and the improvement of the technique of art. The largest academy is now that of Berlin. The three schools of painting (*malerschulen*) are represented by the Academies of Berlin, Munich, and Düsseldorf. Other academies for painting are to be found in Dresden, Carlsruhe, Weimar, and Königsberg. The chief musical academy is at Leipsic. Numerous museums of art and collections of pictures exist in the country, but there is no concentration of these as in London or Paris. Although the collections in Berlin have of late years been considerably enriched they do not equal in their number of celebrated originals the galleries of Dresden, Munich, and Cassel. An archæological institute is maintained by the imperial Government at Rome and at Athens, and recently Germany has done much for the advancement of archæology by the part she has taken in the excavations at Olympia.

Bibliography.

Maps.—The topographical maps of Prussia and of some North German states (scale 1 : 100,000) are not yet quite completed. The South German states have for the greater part finished their topographical maps, scale 1 : 50,000. Other good special maps, though not quite completed, are—the maps of Central Europe by Reymann (1 : 200,000) and by Liebenow (1 : 300,000), and of Germany by Stieler (1 : 750,000) and by Ravenstein (1 : 800,000).

Physical Geography.—There is still wanting a sufficiently detailed work on the physical geography of Germany as a whole, although there are some excellent descriptions of the separate provinces. For general information we may mention —Cotta, *Deutschland's Boden*, 2 vols., 1853; Daniel, *Deutschland*, 1878; Kutzen, *Das deutsche Land;* Von Klöden, *Geographisches Handbuch*, vol. ii., 1875; Neumann, *Das deutsch Reich*, 2 vols., 1874; Peschel and Andree, *Atlas der deutschen Reiches*, 2 parts, 1876–78.

Statistics.—Since the year 1871 there has been established in Berlin an imperial office for statistics which does excellent work. Most of the figures in the foregoing article have been derived from these official returns. From 1871 to 1878 the same office has published 30 volumes in 4to, under the title of

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[1] The teaching staff was classified as follows: ordinary professors 957, extraordinary professors 403, honorary professors 41, private teachers (privat-docenten) 438, language and exercise masters 39. The following table gives the number of the students in the different faculties for 1878:—

1.	Students of Protestant theology..	1,738
2.	“ Roman Catholic theology..............................	689
3.	“ law, politics, and forestry.............................	5,156
4.	“ medicine, surgery, and pharmacy..................	3,727
5.	“ philosophy, philology, history, geography, mathematics, and natural science...............	7,237
6.	Unmatriculated students (chiefly at Berlin)....................	2,285

Statistik des deutschen Reiches und Monatshefte der Statistik des deutschen Reiches. But the returns do not give statistics under all the heads in which the separate states collect them. Much valuable geographical, statistical, and topographical information is given in Neumann's *Das deutsche Reich.* The most recent summaries are to be found year by year in the *Almanach de Gotha.*

Topography.—Rudolph's *Vollständiges Ortslexicon von Deutschland,* 2 vols., 1870, is exact and very ample. The separate states have published lists of all places (towns, villages, hamlets, farms), according to the census of 1871. *Das Reichs-Postgebiet,* issued by the General Post-Office, 1878, containing about 7000 places, exclusive of Würtemberg and Bavaria, forms an excellent topographical and statistical handbook.

(H. WA.)

PART II.—HISTORY OF GERMANY.

By JAMES SIME.

Entered according to Act of Parliament of Canada, in the year 1879, by ADAM & CHARLES BLACK, *Edinburgh, Scotland, in the office of the Minister of Agriculture.*

Ancient Times.

The people whom we call "the Germans," and who call themselves "die Deutschen," are a branch of the Teutonic race, which, again, belongs to the great Aryan family. At what time the Teutons broke away from their Aryan kinsfolk we have no means of knowing. In the 4th century B. C., when they are first mentioned, they were settled along the shores of the Baltic Sea; but long before that time the race must have scattered itself far and wide over the countries now known as Scandinavia and Germany, and the Scandinavians and the Germans were gradually marked off from each other by important differences in language, in customs, and in institutions.

Tribes.

At the time of Tacitus, whose *Germania* is our chief authority as to the condition of ancient Germany, central Europe was in the possession of a large number of German tribes. These tribes did not call themselves by a common name. The word "German" is of Celtic origin, meaning, according to some philologers, "shouters," according to others, "neighbors." It seems to have been applied by the Gauls in the first instance to a particular German tribe with which they were in conflict, and afterwards to the whole people. The word "Deutsch" (Goth., *Thiuda,* the people) does not occur till the 9th century, and was not used in the sense now given to it for some time later. Although without a common name, the ancient Germans believed that they had a common origin, all of them regarding as their forefather Mannus, the first man, the son of the god Tuisco. Mannus was supposed to have had three sons, from whom had sprung the Istævones, the Ingævones, and the Herminones. These groups were without political significance, but they seem to have marked real distinctions. The Istævones were the tribes with whom the Romans were brought most into contact, occupying, as they did, both banks of the Rhine. The lands held by those of them on the left bank were divided by the Romans into "Germania Superior" and "Germania Inferior," the chief tribe of the latter being the Ubii, who had an important settlement on the site of what is now Cologne. On the right bank, from the Lippe to the Ruhr, were the Usipetes and Tencteri, and to the north of them the Sicambri and the Bructeri; the land now called Hesse appears to have been inhabited by the Chatti. On the island formed by the Meuse and an arm of the Rhine were the Batavi. The second great group, the Ingævones, among whom were the Frisii, the Chauci, and the Cherusci, were settled along the shores of the North Sea, and inland along the banks of the Weser and the Ems. The Herminones were much more numerous than either of the two other groups; they held the greater part of central and eastern Germany, reaching as far as the Vistula and the Carpathians. Most prominent among them were the Suevi, a great confederation of tribes which included the Marcomanni, the dwellers in what is now Bohemia, and the Semnones, who held what is now Lusatia and Brandenburg. Other Herminones were the Hermunduri, in and around the Thuringian forest; the Lombards, at the mouth of the Elbe; the Vandals, at the upper parts of the same river; the Heruli, to the west of the Vistula; and the Quadi, in what is now Moravia.

Character of people.

The ancient Germans were a tall and vigorous race, with long fair hair and what Tacitus calls "fiercely blue eyes." They wore mantles of fur or of coarse woollen stuff, thrown over the shoulders and fastened by a thorn or a pin. Their dwellings were wooden huts of slight construction, the inner walls of which they roughly colored, and in which cattle were sometimes accommodated with the family. War and the chase were the favorite occupations of the men; and when engaged neither in fighting nor in hunting they often lay idly by the hearth, leaving peaceful work to women and to males incapable of bearing arms. They liked social gatherings, but after a time conversation usually gave place to drunkenness, quarrelling, or excessive gambling. Although violent and cruel in moments of excitement, they were rarely treacherous, and in the ordinary intercourse of life they appear to have been kindly and considerate. They cherished the memory of illustrious ancestors, and listened often and with delight to songs celebrating their famous deeds.

Social relations.

The bulk of the people were freemen, who alone exercised political rights. They inherited their position, and the sign of their dignity was that they always carried arms. A limited class of freemen were nobles, whose sole privilege seems to have been that they were more respected on account of their birth than their neighbors, and more easily acquired a leading place in public life. Each freeman had slaves, who were chiefly prisoners of war and their offspring, and persons condemned to slavery for crime. They had no legal rights as against their owners, but in practice they were well treated. The Liti, composed mostly of freedmen, stood between freemen and slaves. A freeman necessarily either possessed land or was a member of a family that did; the Liti could only hold land of a superior with whom they shared the produce. If any one killed a noble, a freeman, or one of the Liti, he had to pay to the relatives a fine called afterwards the wergeld, and the amount was determined by the class to which the murdered man belonged.

Great importance was attributed to family relations. Instead of the bridegroom looking for a dowry, he was expected to present his bride with a valuable gift which should remain her property throughout life. The wife was completely subject to her husband, and if she proved unfaithful, custom allowed him to cut off her hair and to whip her through the village in which she lived; but this punishment had seldom to be inflicted, the German women being famous for their chastity. They were treated as friends by their husbands, who had a high respect for their judgment, and whom they often accompanied in distant expeditions. The children, over whom the father had absolute control, were hardily trained, boys being early taught the use of weapons, and girls devoting themselves to domestic duties. Relatives were held in great esteem, and, when the head of a household died, it was considered their duty to guard the interests of his family.

Political constitution.

Many freemen lived apart from all others with their families and dependants, but the majority were grouped in villages. The land around a village—its "mark"—originally belonged to the community, and was periodically divided among the inhabitants. About the beginning of the Christian era, however, the arable land was mostly in the possession of individual freemen, the forests and waste places being almost the only common property. A number of villages made a hundred, and the "gau," if the word existed so early, may have been a higher division, although it was more probably the name for the whole land of the tribe. Each village had its chief, elected by the freemen, but the important chiefs were the heads of the hundreds and the head of the tribe, whom the freemen also appointed. Some tribes had kings, but their power had no other source than that of other chiefs, nor was it more extensive; their only distinction was that they were chosen from particular noble families supposed to have sprung from the gods. The chiefs of the hundreds and of the tribes had the right of gathering around them bands of followers; and they never failed to exercise it, vying with each other in the number and quality of the young men whom they attracted to their service. These young men were generally eager for active duty, and if the tribe was at peace an adventurous chief would often give them an opportunity of distinguishing themselves by taking part in the wars of other communities. They swore to be faithful to him, and he in return supplied them with horses, with armor, and with food. The authority of the chief was extremely limited, the constitution of ancient German society being essentially democratic. Every village, hundred, and tribe had its periodical assembly, and these assemblies were attended by all freemen, no one of whom had higher rights than his fellows. Before the meeting of the assembly of the tribe, the king or other supreme chief would consult with the chiefs of the hundreds, who formed his council; but the final decision rested with the freemen, whom they could influence only by persuasion. At this assembly the chiefs were elected; and in its presence freemen clad their sons in the armor which indicated that they had attained the rights of citizenship. It declared war and made peace, permitted the chiefs with their followers to undertake warlike expeditions, and settled all disputed cases of justice.

Army. The army was not a distinct institution; it was made up of the whole body of freemen, all of whom were liable at any moment to be called to service. Each had a long shield and spear, the cavalry having no other armor. The infantry were provided also with missile weapons, of which they made dexterous use, and occasionally wielded clubs and battle-axes. The men of each hundred kept together in war, and were commanded by their chief, the supreme command being undertaken by the head of the tribe, or entrusted to a "herzog" appointed by the army. In the event of several tribes uniting, a herzog was chosen by the chiefs of the allied communities. The Germans rushed upon their enemies with fury, shouting or chanting as they did so, and adding to the noise by putting their shields to their mouths. To throw away the shield in panic was perhaps the worst crime of a German; and most persons guilty of it committed suicide in an agony of remorse and shame.

Religion. The religion of the ancient Germans was essentially the same as that of their Scandinavian kinsmen, but our sources of information respecting it are few and imperfect. The highest place among the gods was held by Wuotan or Wodan, the Scandinavian Odin. The Romans identified him with Mercury, and the mediæval German writers, in referring to him, follow their example. He was the god of the air and of the sky, and was looked upon as the giver of the fruits of the earth. He delighted in battle and in the chase, and was represented as an imposing figure in a large white mantle, riding upon a white horse. Along with him the Germans worshipped Donar, the Scandinavian Thor, to whom Tacitus seems to refer in speaking of Hercules as a German divinity. He was the god of thunder and of the weather, and was armed with a hammer or thunderbolt. In later times the Germans supposed him to be Jupiter. He presided over marriage, and controlled the operations of agriculture; and to him were sacred the oak and the mountain ash, the bear and the ram. Another great divinity was Ziu or Tiu, the Scandinavian Tyr, the god of war, whom Tacitus speaks of as Mars, and whose symbol was the sword. Tacitus says that a powerful goddess called Nerthus was worshipped on the shores of the Baltic; he also mentions Isis as a goddess of the Suevic tribes. Both names evidently refer to the same divinity. On the coasts her symbol was a ship; inland, it was a wagon; in some districts she was represented with the plough. Like Donar, she presided over marriage; she also watched over the house and the fields, was the giver and protector of children, and ruled the world of the dead. At a later time she was known to the Saxons as Fria or Frigg, to the Franks as Holda, to the Bavarians as Perchta—the first name indicating her freedom of manner, the second her kindness, the third her splendor. In the Scandinavian mythology Frigg is the wife of Odin; and to this day, it is said, the peasants in certain parts of Low Germany speak of Fru Fricke, the wife of the wild hunter Wod. The mythology of the Germans, like that of the Scandinavians, included the three sisters of fate, two of whom were fair and good, the third dark and evil. Beneath the gods were giants, elves, and dwarfs. After death, it was believed, good men were received into Walhalla; and by good men were meant warriors who never shrank in battle—above all, warriors who died fighting. The Germans were profoundly influenced by their religious faith, and both in daily life and on special occasions attended scrupulously to the duties and precautions it was supposed to involve. Each god and goddess had his and her own festival, and their images were preserved in sacred groves. Sacrifices were offered to them, and their will was discovered by means of lots, the neighing of wild horses, and the flight of birds. Priests, without dominating the whole of life, exercised considerable influence, especially when the freemen met in public assembly, and when they were advancing against an enemy.

Roman Period.

The Cimbri and the Teutones, who appear to have wandered from the northern coasts of Germany, were the first German tribes with whom the Romans came into contact. In rather less than half a century after their final defeat by Marius, Ariovistus, a bold and powerful Suevic chief, crossed into Gaul with his followers to aid the Sequani against the Ædui. The latter were defeated, and, in reward for his services, he received from the Sequani a third of their best lands. It soon became obvious that his friendship was dangerous, and in 58 B. C. his terrified allies appealed for aid to the new proconsul, Julius Cæsar, who had just inflicted a crushing defeat on the Helvetii. When Cæsar sent to him proposing a personal interview, the barbarian haughtily answered that he himself had better come, which Cæsar quickly did. And the issue was that the army of Ariovistus was utterly beaten, and that he escaped with difficulty, severely wounded, across the Rhine, and soon afterwards died. Cæsar crossed the Rhine twice, but left no permanent mark of his invasions. He thoroughly subdued the Germans on the left bank, and from this time the whole people began to be powerfully affected by their mighty neighbors, many of them taking service in the Roman army.

The first serious attempt to conquer Germany was made by Augustus, who, after he rose to supreme power, wanted occupation for his legions. He began by conquering Rhætia and Noricum, Celtic countries along the southern borders of Germany, extending northwards through what is now German Austria and Bavaria to the Danube. Drusus, who, with Tiberius, executed this conquest in the summer of 15 B. C., was then entrusted with the task of subduing Germany. Deciding to reach the interior of the country by means of the sea and the northern rivers, he cut a canal between the Yssel and the Rhine; and for the protection of Gaul he built no fewer than fifty forts along the latter river. Many of the tribes were at enmity with one another, and in his first expedition in 12 B. C. he was able to form an alliance with the Frisii against the Chauci and the Bructeri. In three different expeditions in the immediately following years he found other native allies, and with their help mastered so many positions that the conquest of the whole country must have seemed quite certain. After the death of Drusus in 9 B. C., Tiberius conquered the Tencteri and Usipetes; and at a later time he not only subdued the Sicambri, but settled 40,000 of them at the mouth of the Rhine, where they lived under Roman rule. A good many of the Istævones were now overcome, while others entered into a more or less compulsory alliance with Rome; and it is probable that, if great generals had represented the empire, Germany would soon have shared the fate of Gaul. Quinctilius Varus, who, in 6 A. D., was placed at the head of the Roman troops in Germany, lost all the advantages gained by his predecessors. He had held office in Syria, where he had ruled with great harshness; and fancying that he might act in the same way towards the fierce tribes of the north, he roused among them a bitter hatred of the Romans. They found in Arminius, a son of the chief of the Cherusci, a leader of extraordinary bravery and resource. He had been a Roman soldier, and had so distinguished himself—perhaps in wars against his countrymen—that he was made a citizen and knight. He formed the design of freeing his people, and soon came to a secret understanding with influential Cheruscan and other chiefs. In the year 9, in the month of September, Varus, who had been told that a northern tribe was in revolt, was led at the head of his legions into the Teutoburg Forest. Here the Germans were lying in wait for him; and everything was in their favor, the narrow defiles having caused disorder among the troops, and the ground having been made muddy by heavy rains. The battle which ensued lasted three days, during which the Romans were altogether destroyed, and Varus, in despair, killed himself by falling upon his sword.

Arminius.

The despairing cry of Augustus—"Varus, Varus, give me back my legions!"—testifies to the consternation which this defeat caused at Rome, where it was expected that the barbarians would take a terrible revenge for the wrongs they supposed themselves to have suffered. The Germans, however, were too much occupied with internal disputes to think of any enterprise beyond their own country; and in the year 14, after Tiberius had become emperor, Rome again assumed the offensive. Germanicus, the son of Drusus, crossed the Rhine, and defeated the Marsi. He returned in the year 15, when he was joined by the Chauci and other tribes, who fought for him as zealously as his own soldiers. Thusnelda, the wife of Arminius, fell into the hands of Germanicus, and was sent as a prisoner to Rome. This intensified the hostility of the young chief, who now exerted to the utmost his vast influence to stir up against the invaders his tribe and its allies. The Teutoburg Forest was again selected as the scene of an attack; and although Arminius was not victorious, he so far injured his enemy that Germanicus was forced to retreat. The struggle was resumed in the year 16, when Germanicus gained two victories. He gained them, however, at so great a cost that he and his army had to take refuge in their ships, the greater number of which were lost in a storm.

Maroboduus.

No sooner had the Romans been driven off than Arminius had to protect his people against an internal danger. Maroboduus, the chief of the Marcomanni, a man of great ambition, had by treachery or by open fighting made himself master of several neighboring tribes. Arminius began to fear his designs, and after the defeat of Varus warned him of his peril by sending him the Roman general's head. When Germanicus finally left the country, Arminius declared war against Maroboduus, broke up his kingdom, and drove him from Germany. It is possible that Arminius himself may afterwards have wished to found a great state. At any rate, a number of chiefs combined against him, and in the year 21, at the age of thirty-seven, he was killed.

Claudius Civilis.

Although the Romans did not again attempt on a large scale the conquest of Germany, they acquired great influence throughout the country, and they gradually obtained considerable possessions to the east of the Rhine and to the south of the Main. Among the tribes whom they forced to become their allies were the Frisians and the Batavians; and in the year 69 a formidable conspiracy against them was headed by a Batavian chief, Claudius Civilis, who, like Arminius, had been a Roman soldier. Having been embittered by ill-usage from the emperor Nero, he stirred up his countrymen, and he found a large number of allies on both banks of the Rhine. He struggled valiantly for a time, supported by the mysterious utterances of Velleda, a prophetess who lived in a tower in the land of the Bructeri, and excited popular enthusiasm on behalf of the enemy of Rome. At last he was overcome by the Roman general Cerealis, and the Batavians were thenceforth compelled to send recruits to the Roman army.

Roman towns in Germany.

About a hundred years after this time the relations of the Romans and the Germans began to be reversed, the latter being the aggressors. In the Marcomannic war Marcus Aurelius opposed for thirteen years a vast host of Germans who sought to push southward into Roman territory. Meanwhile the Romans had profoundly influenced large parts of the country. They built many fortresses along their frontier, and some of these were connected by a great wall, of which there are still remnants in southern Germany. Around the fortresses grew up towns, which became the centres of civilization over pretty wide districts. In Rhætia, which reached from the Lake of Constance along the Danube as far as the Inn, there were important settlements at Augsburg and Regensburg (Ratisbon); Noricum, which stretched far to the east of Rhætia, possessed, among other towns, Vienna, Salzburg, and Wels. Germania Superior and Germania Inferior, on the left bank of the Rhine, included Strasburg, Mainz (Mayence), Worms, Cologne, and Bonn. In the province of Belgium, which was at least partly German, was the great city of Treves, one of the most splendid in the Roman empire, and often the residence of the emperors.

Confederations of Tribes.

The experience of the Germans in contending with the Romans taught them the necessity of some measure of union; and from the third century we hear no longer of the individual tribes which had before been famous, but of groups or confederations, each forming, for purpose of attack and defence, a single state. The Goths were one of the most important of these groups. They included many of the tribes in the eastern and north-eastern parts of Germany, such as the Vandals, the Burgundians, and the Heruli. Next to them, in the order in which they appear in history, were the Alemanni, a confederation made up of several Suevic tribes. They held the Rhine country in the neighborhood of the Main, and were continually pushing southwards and eastwards in the hope of securing Roman lands and towns. To the north of them, on both banks of the Rhine as far as the sea, were the Franks; and to the east of the Franks, the Frisians and Saxons. The Thuringians, descendants of the Hermunduri, inhabited the Thuringian Forest and the surrounding country.

Migrations.

The Goths were the first of these confederations to found a great kingdom; in the 4th century their lands stretched from the Baltic to the Black Sea. This vast state was broken up by the Huns, who poured in immense hordes from the Asiatic steppes into Europe. Urged forward by so tremendous a force, the Burgundians, the Vandals, and many of the Suevi wandered westwards early in the 5th century in search of new homes; and the Burgundians soon conquered from the Romans the whole of the valley of the Rhone, in which they thenceforth settled. The Vandals and the Suevi went on to Spain, the latter remaining there, but the former crossing over to Africa, where they maintained an independent kingdom for upwards of a century. Meanwhile, in a portion of Rhætia a new confederation had been forming itself, the Bavarians, who were probably in part descendants of the Marcomanni and also included some of the bands which had been driven westwards by the Huns. When the latter had settled themselves in the Gothic lands, the East Goths continued subject to them; but the West Goths crossed the Danube into Roman territory, and afterwards, under their bold chief Alaric, penetrated into Italy and seized Rome itself. In the 5th century they conquered the southern part of Gaul, and nearly the whole of Spain, shutting up the Suevi, who had preceded them, in the small part of the peninsula which now forms Portugal. In the great battle with Attila, in which the destinies of civilization were decided, they fought by the side of the Romans; and it was chiefly owing to their valor that he was forced to retreat. After his fall and the consequent disruption of his kingdom, Odoacer, the chief of the Heruli, became lord of Italy, and his authority was recognized beyond the Alps as far as Bavaria. Theodoric, the East Goth, displaced him; and to Theodoric, too, the Bavarians yielded some kind of submission. None of the German kings who planted themselves on Roman soil displayed higher statesmanship than this great sovereign; but his kingdom was built on too narrow foundations, and after his death soon gave way. The Lombards, who succeeded the East Goths in Italy, were not so brilliantly successful, but their power was more enduring.

Changes in Germany.

While these migrations were going on, great changes took place in the mother country. The Slavs, the last of the Aryan family to enter Europe, and at that time a listless and indolent race, having been stirred up by the terrific onslaughts of the Huns, had followed the general impulse towards the west. Finding many German lands vacant they took possession of them; and so numerous were their incursions that in the 5th century the Elbe and the Saale became the eastern boundaries of Germany. Within Germany itself the confederations had greatly extended their lands. The Alemanni held both banks of the Rhine at the points where it is joined by the Moselle and the Main, and reached far into what is now Switzerland. The Thuringians had pushed down as far as the Danube, and penetrated northwards and westwards along the Elbe and towards the Weser. The basins of the Elbe and the Weser were in the hands of the Saxons, and the Bavarians steadily advanced in and around the valley of the Inn.

Franks.

More important than any of these groups were the Franks, whose destiny it was to found the German and the French kingdoms. They were remarkable for the comparatively friendly terms on which they lived with the Romans, in whose armies many of them served, and by whose side they fought the Alemanni, the West Goths, and the Burgundians. This alliance did not, however, prevent them from enriching themselves, whenever they had an opportunity, at the expense of the Romans, who were repeatedly compelled to turn against them and drive them back. The Franks who lived to the east and the

Salic Code.

west of the Rhine were called Ripuarians; those at the mouth of the Rhine and along the western shores of the North Sea were known as Salians,—both of them names whose origin is still uncertain. One consequence of the relation of the Franks to the Romans was that the kingly authority soon became higher among them than among other Germans. The Salic code, which probably belongs to the middle of the 5th century, shows us the Salian king as in all respects the centre of his state. He was not then elected, but inherited his rights; and the only nobility which existed was that belonging to his officers and followers. The state was divided into "gaus," presided over by grafs or counts, whose duty was to administer the laws emanating from him, and to execute the sentences of his tribunal. There were still, however, popular assemblies, without whose sanction the king could not undertake any national enterprise.

Early Mediæval Period.

Early Frankish kings.

The first Salian king of whom we know anything is Chlodio, who reigned about the middle of the 5th century, and whose kingdom reached to the Somme. His successor, Merwig, or Merovæus, who gave his name to the first great Frankish dynasty, fought beside the Romans and the West Goths against Attila. Childeric I., the son of Merovæus, offended his people, and appears to have fled from them and taken refuge for a time among the Thuringians. During his absence the Salians placed themselves under the Roman commander-in-chief, Ægidius, not as the representative of Rome, but as a personal ruler in whom they had confidence. His representative governed so badly that they were glad to welcome Childeric back. In a great battle Childeric overcame Ægidius, and made himself master of Cologne and Treves; but afterwards he was reconciled to the Romans, and before his death he ruled in their name in Paris.

Chlodwig.

When he died in 481, his son and successor, Chlodwig (Clovis), was a boy of fifteen, but a boy of high spirit, daring and aggressive. From him, in 486, came, in the battle of Soissons, the blow which made an end of Roman rule in Gaul. In a few years he conquered the greater part of the country, and many of his warriors scattered themselves over it, seizing much of its most fruitful land. He turned also against men of his own race. The Alemanni having made war on the Ripuarian Franks, the latter appealed for help to Chlodwig, who gladly responded to their summons, and defeated the invaders in the battle of Zülpich. It was in this battle that he vowed, according to tradition, to become a member of the Catholic Church if the God of the Christians gave him the victory. Whether or not the tale be true, it is certain that to his baptism he owed the greater part of his amazing success; for the West Goths and the Burgundians were Arians, and the Gallic clergy, who exercised unlimited power over the popular mind, welcomed into their country an orthodox believer. As for the Alemanni, he would have annexed their whole territory, but Theodoric, the East Goth, who was interested in them, and whom he did not dare offend, warned him that he must not treat them with undue severity. He must, however, have taken the part of their territory in the neighborhood of the Main and the Neckar, for it was henceforth known as Franconia. At a somewhat later date the whole of Alemannia was added to his kingdom. Being as unscrupulous as he was ambitious, he put to death all who had any claim to independent authority among the Franks; so that he became their sole king, and they quickly acquired the proud feeling of being the centre of a vast and growing state.

Division of Frankish kingdom.

Chlodwig died in Paris, his capital, in 511, leaving four sons. They did not destroy the unity of the kingdom, which in its relation to the outer world continued to be regarded as a single power. But each, as a king of the Franks, received a separate territory. The East or Rhenish Franks, with the Alemanni subject to them, were placed under Theodoric, the eldest. He was as valiant as his father, and not less deceitful and cruel. The great Thuringian kingdom was in his time ruled by three brothers, Hermanfried, Berthar, and Baderich. The former of these was married to a niece of Theodoric the East Goth, Amalaberga, a kind of Thuringian Lady Macbeth. Consumed by a vehement ambition, she persuaded her husband to murder Berthar; and she would have caused the death of Baderich also; but that he knew her design and rose against the guilty pair. Hermanfried sent to Theodoric, the East Frankish king, and offered to reward him if he would form an alliance against Baderich. The offer was gladly accepted, and in a battle which followed Baderich was slain. No reward, however, was given, and Theodoric, indignant at being thus treated, vowed to be avenged. He allied himself with the northern neighbors of the Thuringians—the Saxons; and with their united forces they completely subdued the country. Theodoric himself murdered Hermanfried by pushing him off the wall of Zülpich, where they were carrying on an apparently friendly conversation, the Thuringian king having received an assurance that he would be treated with honor. Thereupon the murderer divided between himself and the Saxons the territory of the Thuringians, annexing the southern half to the Frankish kingdom. His son, Theudebert, not only maintained this conquest but added to it, after the downfall of the Gothic kingdom in Italy, that of Bavaria. The Alemanni were also made altogether subject to his rule. Thus the Saxons and the Frisians alone retained their independence.

Merovingian kings.

The rights of the Franks in Germany were at first vigorously asserted; but a change soon came. The Merovingian kings carried on so many fierce wars with each other that they had little time to look after their subjects in the remote east; moreover, the rise of a great new aristocracy steadily undermined the royal power. This aristocracy was made up of the class directly associated with the king by military or court duties. They were rewarded by immense grants of land, which they held in the first instance subject to the condition of rendering faithful service, but the possession of which, in most cases, became in the end absolute and hereditary. Nowhere was the new aristocracy so powerful as in Austrasia, the eastern division of the Frankish monarchy. In Neustria, the western division, where the sovereign had to deal for the most part with a race which for five centuries had been accustomed to the despotic government of Rome, he had little difficulty in maintaining his supremacy; for the Franks settled in different districts could not but be more or less influenced by the feeling of the native population. Besides, they lived at great distances from one another, so that it was difficult to hold popular assemblies of any kind, and the powers which belonged to them were naturally transferred to the head of the state. Hence, even when the Merovingian kings of Neustria were driven into the background, and the mayors of the palace governed, the latter had high authority, and exercised it, as a rule, in the interests of the crown. In Austrasia the conditions were wholly different. There the Franks were the predominant element; and the distances were not so great but that an assembly could be rapidly summoned on every occasion of real need. Thus the important landowners of Austrasia were able to hold together, and to limit the powers of the sovereign on the one hand and of the ordinary freemen on the other. And the mayor of the palace, who was their nominee, and could at any moment be dismissed if he displeased them, usually acted as their representative and leader.

Kings under the authority of an aristocracy of this kind are not likely to be troublesome to unruly subjects; especially kings of such feeble personal character as those who, from the first half of the 7th century, nominally held the sceptre of the mighty Chlodwig. The German confederations which he and his immediate descendants had conquered soon became virtually free. They continued to acknowledge Frankish supremacy; but the acknowledgment was only formal. At the head of each confederation was its own herzog or duke. These rulers were at first appointed by the Frankish kings, or received their sanction; but in course of time the office became hereditary in particular families. This was the case, longer than anywhere else, in Bavaria, where the ancient Agilolfing family held the ducal dignity from the earliest days of Frankish authority down to the time of Charles the Great. The dukes were far from being absolute sovereigns, for in Germany the freemen had retained many of their primeval rights. The assemblies of the hundred and of the confederation still exercised great authority. As among the Austrasian Franks, however, although in a less degree, the leading landowners constantly encroached upon the powers both of the poorer freemen and of the head of the state.

Frankish dukes.

In the time of the great dukes of the Franks, who arose to infuse new life into the decaying monarchy, there was another profound change in the position of the Germans. After the battle of Testri, in 687, in which Pippin of Heristal decided that the Frankish kingdom should not then fall to pieces, and that, in the reunited state, the Austrasian Franks should have the supremacy, the German dukes began to find that they were likely again to have a master. He made war on them, and forced them to some extent to return to the allegiance which they had all but forgotten. His successor, Charles Martel, asserted his rights with not less vigor, and added East Friesland for the first time to the monarchy. The high importance of the efforts of these two illustrious rulers was seen in the struggle of Charles Martel with the Arabs. Had the Frankish kingdom been dissolved, they would have had little difficulty in overrunning Europe; but having under him a state more or less organized, Charles was able to rally around him powerful warriors from all the districts he governed, Germany among the rest. And so, at the memorable battle of Poitiers, he saved Christendom. Other favorable results of the policy of Charles and his father were that new and vigorous life streamed towards the Gallic part of the kingdom from Germany, while the Germans were brought into closer contact than before with the higher and more refined civilization of the Gauls. Pippin the Short, the first king of the Carolingian line, although his chief fame was won in his wars with Aquitania and with Lombardy, did not neglect Germany, in which he strove to assert an authority more thorough and extensive than had been exercised even by the early Merovingian sovereigns.

Saxons.

After all, however, even these powerful Frankish conquerors had but imperfect success in Germany. When they were present with their formidable armies, they could command obedience; when engaged, as they often were, in distant parts of the vast Frankish territory, they could not trust to the fulfilment of the fair promises they had exacted. One of the chief causes of their ill-success was the continued independence of the Saxons. Ever since they had acquired the northern half of Thuringia, this warlike race had been extending its power. They were still heathens, and maintained all the old customs and institutions of primitive Germany. As in ancient times, they appointed a herzog only when an officer of this class was needed, in time of war; at ordinary times the chiefs elected by the freemen ruled in association with the popular assemblies. They cherished bitter hatred towards the Franks, whom they justly regarded as the enemies both of their liberties and of their religion; and their hatred found expression, not only in expeditions into Frankish territory, but in help willingly rendered to every German confederation which wished to throw off the Frankish yoke. No rebellion against the dukes of the Franks, or against King Pippin, took place in Germany without the Saxons coming forward to aid the rebels. This was perfectly understood by the Frankish rulers, who tried again and again to put an end to the evil by subduing the Saxons. They could not, however, attain their object. An occasional victory was gained, and some border tribes were from time to time compelled to pay tribute; but the mass of the Saxons remained unconquered. This was partly due to the fact that the Saxons had not, like the other German confederations, a duke who, when beaten, could be held responsible for the engagements forced upon him as the representative of his subjects. A Saxon chief who made peace with the Franks could undertake nothing for the whole people. As a conquering race, they were firmly compact; conquered, they were in the hands of the victor a rope of sand.

Introduction of Christianity.

715-755.

St. Boniface.

Although, at the time of King Pippin's death in 768 the Germans were still imperfectly subdued, they had received the germs of new life; for, with the exception of the Saxons, they were then nominally Christians. The first missionaries to Germany were Irish monks. In the 7th century a number of these labored with considerable success in different parts of the country, especially among the Alemanni and the Bavarians; and when the influence of the Franks became dominant, Frankish missionaries also began to do for the church what the warriors did for the state. The honor of converting Germany as a whole, however, belongs mainly to St. Boniface, an Englishman, who in 717 began the task of his life as an assistant to another English missionary, Willibrord, in Friesland. Soon afterwards, during a visit to Rome, he received from Pope Gregory II. a commission as apostle of the Germans, and worked incessantly among the Thuringians and the Frisians. He proved himself one of the most skilful of missionaries, adapting the conceptions of Christianity to the ideas of those whom he taught. The peculiar powers of Wodan, for instance, were transferred to the archangel Michael, those of Donar to St. Peter; and the chief Christian festival, Easter, received its name from the goddess Ostara. His zeal and talent, although largely rewarded, effected less than he had hoped, so that in 723 he went once more to Rome to obtain, if possible, increased powers. Hitherto the mission in Germany had possessed an essentially independent character; Boniface now undertook to work in all things under the direction and for the benefit of the papacy. In return for this engagement he was not only made bishop of all Germans who had been or should be converted, but received from the pope a letter commending him to Charles, the mighty duke of the Franks. The Frankish bishops, who had no wish to become subordinate to the papacy, received Boniface coldly, and threw every kind of obstacle in his way. Charles, however, believing that the conversion of Germany would be the most effectual means of establishing Frankish authority, took Boniface under his protection, and sent him forth with orders that he should be everywhere respected. Thus strengthened, he entered upon a wholly new stage of his career. He was looked upon as to some extent armed with the authority of the great warrior and ruler, and he and his fellow-workers rapidly brought vast districts within the pale of the church. Possessing a high talent for organization, he would willingly have established an orderly ecclesiastical system as he proceeded; but the Alemanni and the Bavarians, among whom Christianity had made some progress before his time, would not allow him free scope for his activity; and Charles, who, by "resuming" church lands and granting them to faithful followers, had done much to weaken ecclesiastical authority in Gaul, did not wish to see it assume threatening proportions in Germany. In 738 Boniface again visited Rome, from which he returned in the following year as papal legate to the Frankish state. Armed with this new authority, he was able to some extent to give effect to his ideas. The duke of Bavaria permitted him to divide the whole of Bavaria into the episcopal sees of Salzburg, Freisingen, Ratisbon, and Passau, and to appoint the bishops; and a little later, with the sanction of Charles, he formed also the sees of Würzburg, Erfurt, Buraburg, and Eichstädt.

Before Pippin the Short was made king, he ruled for some years in association with his brother Carlman, to whom the Eastern part of the kingdom was confided. Carlman was a man of strongly religious temperament, and warmly supported Boniface. He set up by his advice bishoprics and monasteries, among the latter being the great abbey of Fulda, which, throughout the Middle Ages, was one of the chief centres of intellectual light in Germany. In 742 was held the first German council, summoned by Carlman, and presided over by Boniface. It did much for the organization of the church, and was the beginning of an important movement for the reform of ecclesiastical abuses among the Franks. Boniface wished to become archbishop of Cologne, that he might the more readily influence the Frisians; but the suggestion met with opposition, and he ultimately accepted the see of Mainz. As archbishop of Mainz and primate of Germany, he was able to foster and control the institutions he had established. The last years of his life he spent in missionary labors among the Frisians, and in 755 he died a martyr's death. By that time all German tribes, with the exception of the Saxons, professed Christianity; and the church was not only highly organized, but possessed great wealth. The old pagan faith had struck its roots too deeply into the German nature to be at once or soon completely destroyed. Traces of its influence may even yet be detected in popular beliefs and customs; and for many centuries some of its conceptions, in altered forms, had hardly less vitality than those of the Catholic creed. Christianity was, however, the dominant power, and soon became a great civilizing agency. It was a fact of high importance that its

771-800.

triumph was due mainly to the influence of the papacy. The German church thus stood from the beginning in close relation to the pope,—a circumstance which added largely to his power, and which was followed by results of the utmost consequence in the later history of the nation.

Charlemagne.

Conquest of Saxony.

Under Charles the Great (Charlemagne) a momentous era dawned in the history of the Germans. From the outset of his reign he had vast plans, which, however, were not so great as those ultimately realized. He saw at once that he could not hope to execute his schemes if on the north-eastern boundary of his kingdom there was a powerful and hostile people, ready at all times to plot against him, and to take advantage of any misfortune which might temporarily befall him. Accordingly, when the death of his brother Carlman made him, in 771, sole king, one of his first resolutions was to advance against the Saxons, and thoroughly to subdue them. It is not necessary to suppose that he went to war without an adequate special reason; for, as the Frankish and the Saxon frontiers touched each other along the whole western and southern boundary of Saxony, and as the Saxons were continually robbing their neighbors, pretexts for war were always over-abundant. In his first campaign in 772 he overran the country, took the fortress of Eresburg, previously supposed to be impregnable, and cast down the Irminsul, a mysterious column to which the Saxons attached profound religious significance. Awed by the lordly bearing of the great Frank, by the numbers and discipline of his army, and by these proofs of his power, the Saxons appeared to submit at once, and Charles was under the impression that he had conquered them. Never was there a more profound mistake; in reality, he was at the beginning of a struggle which lasted upwards of thirty years. Time after time, when apparently they were utterly beaten, they rose against the invaders, and tried with desperate energy to drive them from the country. The execution of 4500 prisoners by Charles—an act which even then was looked upon as barbarous—only deepened their resolve never to yield to his authority. At last, however, their strength was exhausted, and they had no alternative but to submit. Charles introduced among them the political institutions which were established throughout the kingdom; and they were compelled to exchange their heathenism for the Christian faith. Thus one of the greatest dangers which threatened the stability of the Frankish kingdom was overcome, and all Germany was for the first time brought under a single ruler.

Bavaria.

The part of Germany which, next to Saxony, had retained most independence was Bavaria. Its duke, Thassilo, had been on ill terms with Pippin, and, had he allied himself with the Saxons during their great conflict, he might have baffled even Charles. But he did not become troublesome until they were too weak to be of service to him. Repeated acts of treachery gave Charles a pretext for depriving him of his office, and after him no duke was placed over the country. As the dukes of the Alemanni and the Thuringians had also been displaced, Germany became, more directly than it had ever before been, subject to the Frankish sovereign. Not content with completing the conquest of the German people, he made war on the tribes which harassed their eastern frontier. The Avars, who held the greater part of what is now Hungary, were thoroughly beaten; and the Slavs, including the Czechs of Bohemia and Moravia, and the Slavonic tribes to the north of them, as far as the Baltic, were also more or less effectually forced into submission.

The imperial title.

The great step taken by Charles on Christmas Day, 800, when at St. Peter's in Rome he was crowned Roman emperor, intensified the allegiance of his German as of his other subjects; but it could not produce so powerful an impression in Germany as in Gaul. Ultimately, however, it was in Germany that the significance of the step was fully revealed; for, in becoming emperor, Charles created so splendid a prize, that later German kings could not resist the temptation to grasp at it, and its possession proved their ruin.

All the advantages which attended the rule of Charles throughout his vast empire were shared by the Germans. The border countries he formed into "marches," over which he appointed margraves, whose duty was to administer justice in his name, to collect tribute, and to extend his conquests. Germany itself was placed under counts, who did not merely, like the counts of an earlier time, execute the sentences of the royal tribunals, but themselves decided questions of justice in accordance with local laws and the capitularies of Charles. Four times a year the whole country was visited by his Missi Dominici, who reported as to the state of their districts, investigated grievances, and proclaimed the imperial decrees. Although he could not write, Charles was a man of true culture, and encouraged education by causing schools to be established in connection with cathedrals and monasteries. These schools were modelled on the famous school of the palace over which Alcuin presided, and in which the emperor himself passed some of his happiest hours. By his magnificent basilica in Aachen (Aix-la-Chapelle), his favorite capital, and by the palaces he built there and in Ingelheim and Nimeguen, he fostered a love of art among the more advanced of his German subjects.

The clergy.

In Germany, as in Gaul, Charles treated the clergy in the spirit in which he treated the papacy; he set up and put down archbishops, bishops, and abbots, as if he were the supreme lord of the church,—which indeed, in theory as well as in practice, he claimed to be. But the church never had a truer friend. As emperor, he believed that his chief duty was to protect and to encourage it, and he was stimulated to the performance of his supposed duty by the conviction that a strong spiritual power would be one of the soundest pillars of his secular authority. Hence he not only founded bishoprics and monasteries in Germany, and enriched them with magnificent gifts of land, but invested the prelates with some of the functions which properly belonged to the counts. Criminal cases they did not yet decide; but they were allowed to settle all civil disputes between the inhabitants of their territories. This policy may have been beneficial at the time, but it caused much disaster to his German successors; for the church became one of the most vigorous and obstinate powers with which they had to contend in maintaining their lawful functions.

The people.

Although in many respects one of the greatest of statesmen, Charles was of thoroughly despotic temper; more than any previous Frankish king he set himself against popular liberties. Hitherto all Germans had had the right of attending national assemblies or diets; the common freemen were now excluded, and only the great nobles, spiritual and secular, were summoned. Even they had but slight influence. They had the right of advising, but Charles himself originated and decided; and he would not brook opposition, although, indeed, so commanding was his presence, and so high the moral authority conferred by his great deeds, very little opposition was ever offered. Popular assemblies of all kinds he discouraged, transferring their functions to the counts. Not only were the rights of freemen limited, but severe hardships were imposed upon them by Charles's incessant warlike expeditions. At any moment they were liable to be dragged from their homes to some distant corner of the empire; and while they were away, their fields lay neglected, and their families suffered grinding poverty. What made this evil most galling was the fact that its pressure was very unequally felt. Well-off freemen knew how to purchase exemption from the counts, part of whose business was to see that the ranks of the army should be properly filled. It is true that Charles treated severely offences of this kind; but in such an empire as his, it was impossible even for his Missi Dominici to find out every case of injustice. Thus the burden of his many wars fell to the largest extent on the poorer class of freemen, who had but a sorry recompense in the glory their sacrifices reflected on their lord.

Feudalism.

Not content with the general allegiance due to him as king and emperor, Charles compelled many great land-owners to take the oath of vassals; he imposed a like condition on his prelates and counts. A man might be his vassal without possessing land; but no land was granted by Charles except to those who were willing to assume this intimate personal relation. As his conquests put vast quantities of land at his disposal, especially in Saxony and on the frontiers, many freemen gladly swore to be his "men" in the hope that he would reward them for their services with extensive benefices. On the other hand, large numbers of poor freemen became the vassals of their stronger neighbors, as there was a chance that the military demands made upon them would thus be made rather less exorbitant. By these changes, due either directly or indirectly to him, Charles helped to build up that system of feudal tenures, the foundations of which had been laid by the first Merovingian kings. As in giving great temporal power to the church, so in establishing feudalism, he imagined that he was providing for the monarchy a steady support; but in the latter case, even more than in the former, he prepared weakness and humiliation for those who came after him.

Louis the Pious.

After the death of Charles Germany remained for some time, in common with the other countries which composed the Frankish empire, under the direct rule of his son, Louis (Hludwig or Ludwig) the Pious. On the division of the monarchy, effected by the emperor in 817, in order to secure the succession, Bavaria was given to his second son Louis; the other parts of Germany fell to his eldest son Lothair (Hlothar), who received also the rest of the empire, except Aquitania, which was the portion of Pippin, the youngest. This arrangement lasted until the emperor fell completely under the power of his second wife, Judith, a Bavarian princess, who intrigued incessantly to obtain for her son Charles—afterwards "Charles the Bald"—a position similar to that of his half brothers. The emperor at last, at the expense of his son Lothair, marked off an important territory for this inconvenient child. In the wars which followed, Louis the Bavarian firmly maintained his rights; but he disapproved the cruel harshness with which his father was treated by Lothair. In Germany the emperor was highly esteemed,—especially in Saxony, where he softened the rigorous system introduced by Charles, by sanctioning as far as possible a return to ancient popular institutions. The result was that when he was virtually deposed by Lothair, and afterwards not only deposed but humiliated almost beyond endurance, the Germans warmly supported Louis the Bavarian in insisting that the emperor should be restored to imperial rights. For his services on these occasions Louis received extensive additions of territory, and had he continued to be fairly treated, he would have been the most effectual support of his father's power. But the spirit of the gentle-hearted emperor was broken by misfortune, and when Pippin of Aquitania died, he was easily persuaded by Judith, who had come to an understanding with Lothair, to sanction a division of the empire by which his son in Germany would have been confined strictly to his original possession of Bavaria. Louis instantly revolted; and it was in marching against him that the emperor fell sick and died, in 840, on a small island on the Rhine opposite Ingelheim. The last words of the dying sovereign were a message of forgiveness to his rebellious son.

Lothair at once assumed the imperial dignity, and showed that he intended to demand the complete submission of his brothers, Louis and Charles. They combined against him, and in the battle of Fontenay, in 841, after fearful slaughter, defeated him. The armies of the allied brothers soon afterwards met in Strasburg, where they swore to be true to each other, Louis taking the oath, so as to be understood by the army of Charles, in a language in which we find the beginnings of modern French, Charles in a German dialect. In 843 the treaty of Verdun was signed. By this treaty Lothair retained the title of emperor, and received, in addition to the Italian territory of the Franks, a long narrow kingdom, stretching from the Mediterranean up through the valleys of the Rhone and the Rhine to the North Sea. This kingdom was called Lotharingia, a name afterwards confined to the northern part of it along the left bank of the Rhine. To the west of Lotharingia was the kingdom of Charles, which included the greater part of what is now France. Louis received most of the German lands to the east of the Rhine, with the towns and sees of Mainz, Worms, and Spires, on the western bank.

Treaty of Verdun.

Beginning of German kingdom.

Nothing was further from the intention of the brothers than finally to break up the Frankish state by this division. In relation to the outer world the empire was still considered a single power, as the kingdom had been after the death of Chlodwig, more than three centuries before. And, after a time, it was for a brief period reunited under one head. Still it is not an arbitrary impulse that has led historians to fix upon 843 as the date of the real beginning of the German as well as of the French kingdom. Although it can hardly be said that a true national life had yet revealed itself in Germany, at least the foundations of national life had been laid. For the first time Germany was ruled by a king who reigned nowhere else, and it could not but be that the people should slowly acquire a sense of common interests.

817-875.

Middle Mediæval Period.

Louis the German.

Keen animosity soon revealed itself between Louis and Charles the Bald, and on one occasion when the former, accepting the invitation of certain West-Frankish nobles, rashly invaded his brother's territory, he was made prisoner. He escaped without dishonor only by the intercession of Lothair II., the emperor Lothair's second son, who, after his father's death, had received the greater part, and ultimately the whole, of Lothair's kingdom to the north of Italy. When Lothair II. died in 869, Charles the Bald pounced upon his territory; but Louis the German had naturally something to say to this seizure of the whole prize, and in 870 the rival brothers signed the treaty of Mersen, by which Louis became possessed of most of Lotharingia or Lorraine. Germany at this time assumed very nearly the proportions which it maintained during the Middle Ages. On the east its boundaries were the Elbe and the Saale; to the west it reached to and included the valleys of the Meuse and the Moselle, taking in, among others, the important towns and dioceses of Utrecht, Aix-la-Chapelle, Metz, Strasburg, and Basel. Franconia, which reached eastward from the Rhine through the valleys of the Neckar and the Main to the Saale, and extended also a little to the west of the Rhine, occupied the central position, and, as the home of the Franks, was the most important division of the kingdom. To the north and north-east of it were Saxony and Thuringia; to the south, Alemannia, or, as it now began to be called, Swabia; and to the east of Swabia, in the valley of the Inn, Bavaria. There were five archbishoprics, those of Mainz, Treves, Cologne, Salzburg, and Bremen.

New boundaries.

Louis, who was on the whole the worthiest of the grandsons of Charles the Great, ruled his kingdom vigorously and efficiently. During his reign the Frankish empire was vexed throughout nearly its whole extent by the Northmen, whom the fame of Charles the Great had held in awe, but who now swept the coasts of northern, southern, and western Europe with persistent fury. The East-Frankish kingdom was, however, much less troubled at this time than the kingdom of the West Franks; the main evil with which Louis had to contend was the arrogance of his Slavonic neighbers. Exactly to the east of Franconia, from the Saale to the Oder, were the Sorabi, and to the north of them, between the Elbe and the Oder, the Wiltzi and Abotrites; while along the Baltic coast, as far as the Vistula, in what is now Pomerania, were the Wends. To the south of the Sorabi, behind the Bohemian Forest, were the Czechs of Bohemia and Moravia. All these Slavonic tribes Charles the Great had either thoroughly subdued or made tributary; and of course Louis the German claimed supremacy over them. But it was hard to make his claims good. While he was a very young ruler, a vigorous duke—Moimir—acquired a position of great power among the Moravians. Soon after the signing of the treaty of Verdun, Louis, becoming alarmed at the growing influence of this chief, advanced against him, and put in his place a chief named Rastislaus, on whose allegiance he thought he could rely. But on his way back he was defeated by the Bohemians, who were on good terms with the Moravians. From this time the Moravians were a source of incessant anxiety to him. Rastislaus extended his kingdom far to the east, and formed alliances with the Bulgarians and even with the Byzantine emperor; at the same time he stirred up the Bohemians and the Sorabi against Louis, and built strong fortresses on his western frontier. This gallant chief, after much fighting, at last fell into the hands of his enemies, who put out his eyes, and caused him to end his days in a monastery. But his successor, Suatopluk, was not less energetic, and Louis was never able to overmaster him.

Slavs.

The emperor Lothair's successor in the empire was his eldest son Louis II., who received as his kingdom the Frankish possessions in Italy. After his death Charles the Bald adroitly managed to secure the imperial crown. This happened in 875, almost immediately before the death of Louis the German. Having succeeded so easily in regard to the supreme title, Charles fancied he might be able to unite the whole empire under his rule. But Louis had divided Germany between his three sons, Carlman, Louis, and Charles; and the second of these met Charles the Bald on the field of Andernach, and by a decided victory convinced the West Franks that it was useless to hope for dominion east of the Rhine. The same son of Louis the German forced Charles the Bald to give up such portions of Lorraine as had been ceded to him by the treaty of Mersen, so that the right of possessing the whole of this important territory, which included the best part of what had been Austrasia, was vindicated for the Germans.

Charles the Fat.

The two eldest sons of Louis soon died, and the kingdom passed into the hands of the youngest, Charles the Fat, a prince of indolent habits and feeble mind. He crossed the Alps, however, and was crowned emperor; and, as the Northmen were at this time tormenting the West-Frankish kingdom, and no descendant of Charles the Bald was fit to cope with them, Charles the Fat was invited to become king of the West Franks. He thus ruled, with the exception of Burgundy, which at this time became an independent state, the whole empire of Charles the Great; but the mighty fabric could not exist without the genius which had built it up.

Northmen.

In Germany also the Northmen had made themselves more and more troublesome. Time after time their skiffs had penetrated far up the Rhine; they had plundered Cologne and Treves, and fed their horses over the grave of the great Charles himself, in his own beautiful basilica. His degenerate great-grandson adopted the policy of buying them off, and when he reached Paris, to the disgust of his subjects, he pursued the same course.

Arnulf.

It happened that his brother Carlman had left an illegitimate son, Arnulf, whom he had made ruler of Carinthia, a country lying to the east of Bavaria. This young noble, who inherited the undaunted spirit of his forefathers, was indignant at the cowardice of his uncle; and when the latter, in 887, summoned an assembly in Tribur, Arnulf, instead of obeying the summons, marched at the head of a powerful army against the emperor. Deserted even by his ministers, and unable to offer the smallest resistance, Charles was dethroned, and in a week or two afterwards died; and Arnulf, notwithstanding his illegitimacy, became king. For some time after this, Germany was still called East Francia, and the western kingdom West Francia, but they never again had a common ruler; they were now in all respects separate, independent states. The empire of Charles the Great had fallen to pieces.

Arnulf, following the example of Charles the Fat, went to Rome and was made emperor. He could exercise but little authority in Italy, however, and soon returned. In 890 the Northmen desolated the valleys of the Meuse and the Moselle, and Arnulf, instead of buying them off, sent against them a powerful army. As it was defeated, he himself took the command in the following year. The Northmen occupied a strongly entrenched camp near Louvain; and Arnulf's force, consisting mainly of cavalry, seemed to be quite powerless. Leaping from his horse, he induced his men to fight beside him on foot; and they were so stimulated by his valor that for the first time the dreaded enemy fled, leaving thousands of bodies on the field. They never returned in such numbers as to be again a national peril: The emperor had also to wage war with the Moravians, but his efforts here were not crowned with like success. By this time the fierce and warlike Magyars had become a terror to eastern Europe, and it occurred to Arnulf to ask for their alliance. They gladly assented; and with their help he overcame one of the three reigning sons of Suatopluk, and contrived to detach from Moravia the Bohemians, the Sorabi, and other Slavs whom Suatopluk had joined to his kingdom. But at the time of his death, in 899, he had not succeeded in breaking up the state established by this powerful warrior and his predecessor.

Louis the Child.

During the nominal reign of Louis the Child—the last of the Carolingian dynasty in Germany (899–911)—the German people passed through one of the darkest periods of their history;

Magyars.

for when the Magyars heard that Arnulf had been succeeded by a child, they swept into Germany in vast numbers, and fearful was the havoc they caused in every part of the kingdom. At such a time as this it happened that there was no leader around whom the nation could rally; it was virtually defenceless, and year after year savage hordes returned, bearing away with them as much plunder as they could carry, and driving before them as many prisoners as they could control. Where the Northmen had whipped with cords, these barbarians lashed with scorpions.

Growth of feudalism.

During the wars with the Magyars, the Northmen, and the Slavs, feudalism made rapid advances in Germany. Even in the days of Louis the German and Arnulf it was impossible for the sovereign to protect at all times every part of the kingdom. The people themselves were obliged to rise against their enemies, and, as in old times, they appointed herzogs or dukes for special warlike expeditions. These leaders, being chosen from the ancient ducal families, naturally began to think of restoring the power of which their fathers had been deprived; and, as there never was more urgent need of strong local rulers, they found no great difficulty in gratifying their ambition. The first reigning duke of whom we hear is Otto of Saxony, a country not only liable, like the rest of Germany, to the attacks of the Magyars, but specially exposed to the Scandinavian sea-robbers and the northern Slavs. This duke ruled over both Saxony and Thuringia. Soon afterwards we hear also of dukes in Bavaria, in Swabia, in Lorraine, and last of all, in Franconia. Having unusual opportunities of acquiring new lands, the dukes increased their power by granting them as fiefs to vassals on whom they could depend; and many independent landowners were glad to obtain their protection by offering them homage. Multitudes of the humbler class of freemen either were forced to change the tenure of their possessions into a feudal tenure, or did so in order to escape from still greater evils. Thus, when Louis the Child died, the feudal tenure of land was the prevailing system in nearly all parts of the country. Even those who held their offices and lands immediately of the monarch, like the dukes themselves, might still, in theory, be deprived of both; but in reality they asserted almost complete independence, rendering only such service to their lord as he could force from them, or as suited their convenience. The royal authority, nominally great, had become but a shadow of the authority exercised by the early Carolingian kings.

Had Germany had no powerful external enemy, it is probable that it would now have lost the slight measure of unity to which it had attained. While Louis lived, the dukes were virtually kings in their duchies; and their natural tendency would have been to make themselves absolute rulers. But, threatened as they were by the Magyars, with the Slavs and Northmen always ready to take advantage of their weakness, they could not afford to do without a central government. Accordingly the nobles assembled at Forchheim, and by the advice of Otto, the aged duke of Saxony, Conrad of Franconia was raised to the throne (911–918).

Conrad I.

He had some excellent qualities, and in quieter times would have done good service to Germany; but he was rash and impulsive, and far too ready to submit to priestly influence. The dukes of Bavaria, Swabia, and Lorraine were not present at his election; and the choice displeased them, probably because he was likely to prove considerably more powerful than they wished. Rather than acknowledge him, the duke of Lotharingia or Lorraine transferred his allegiance to Charles the Simple of France; and it was in vain that Conrad protested and despatched armies into Lorraine. With the help of the French king the duke maintained his ground, and, for the time, his country was lost to Germany. Bavaria and Swabia yielded, but, mainly through the fault of the king himself, their submission was of brief duration. The rise of the dukes had been watched with extreme jealousy by the leading prelates. They saw that the independence they had hitherto enjoyed would be much more imperilled by powerful local governors than by a sovereign who necessarily regarded it as part of his duty to protect the church. Hence they had done everything they could to prevent the dukes from extending their authority, and as the government was carried on during the reign of Louis the Child mainly by Hatto, archbishop of Mainz, they had been able to throw considerable obstacles in the way of their rivals. They now induced Conrad to force a quarrel both upon Swabia and upon Bavaria, and the result was a series of wars in which he had only partial success. What was incomparably worse, his clerical advisers involved him in a struggle with Henry, duke of Saxony, son of the duke to whom he chiefly owed his crown. Henry was a man of great personal charm, a just ruler, strong, and brave. The Saxon people were devoted to him; and his influence over them was intensified by the virtues of his beautiful wife, to whom he was known to be passionately attached. Conrad committed a profound mistake in making an enemy of a man like this; and he lived to repent his error. On his death-bed he recommended the Franconian nobles to offer the crown to Henry, whom, with fine generosity, he recognized as the only man in the kingdom who could cope with the anarchy by which he had himself been baffled.

Saxon dynasty.

Henry I.

The nobles of Franconia acted upon the advice of their chief and king, and the Saxons were very willing that the duke they loved so well should rise to still higher honors. Henry I. (918-936) was one of the best kings Germany ever had, a born statesman and warrior. His ambition was of the noblest order, for he sank his personal interests in the cause of his country; and he knew exactly when to attain his objects by force, and when by calmness and moderation. By wise concessions he almost immediately overcame the opposition of the dukes of Swabia and Bavaria; and some time later, taking advantage of the troubled state of France, he accepted the homage of the duke of Lorraine, which for many centuries afterwards remained a part of the German kingdom.

Fortification of towns.

Having established internal order, Henry was able to turn to matters of even more pressing moment. In the very first year of his reign the terrible Magyars, who had continued to scourge Germany during the reign of Conrad, broke into Saxony and plundered the land almost without hindrance. In 924 they returned, and this time, by good fortune, one of their greatest princes fell into the hands of the Germans. Henry restored him to his countrymen on condition that they should agree to a truce of nine years; and he had the courage to undertake to pay, during this period, yearly tribute. The heedless barbarians accepted his terms, and faithfully kept their word in regard to the immediate lands of Henry, although Bavaria, Swabia, and Franconia they occasionally invaded as before. He made admirable use of the opportunity he had secured, confining his efforts to Saxony and Thuringia, the only parts of Germany over which he had strong control. In the southern and western German lands, towns and fortified places had long existed; but in the north, where Roman influence had but feebly extended, and where even the Franks had not exercised much authority until the time of Charles the Great, the people still lived as in ancient times either on solitary farms or in exposed villages. Such fortresses as Charles had built had been for the most part destroyed in the wars after his time, and almost the only attempts at fortification were to be found around the towers or castles of the great nobles, and the dwellings of the leading churchmen. Henry saw that, while this state of things lasted, the population could never be safe, and began in earnest the construction of fortresses and walled towns. Of every group of nine men one was compelled to devote himself to this work, while the remaining eight cultivated his fields, and allowed a third of their produce to be stored against times of trouble. The necessities of military discipline were next attended to. Hitherto the Germans had fought mainly on foot, and, as the Magyars came on horseback, the nation was placed at an immense disadvantage. A powerful force of cavalry was now raised, while at the same time the infantry were drilled in new and more effective modes of fighting. Although these preparations were carried on directly under Henry's supervision only in Saxony and Thuringia, the neighboring dukes knew what he was doing, and were stimulated to follow his example. When he concluded that he was almost ready, he made use of his new troops, before turning them against their chief enemy, the Magyars, to punish refractory Slavonic tribes; and at this time he brought under temporary subjection nearly all the Slavs between the Elbe and the Oder. He proceeded also against the Bohemians, whose duke was compelled to do homage.

Defeat of Magyars.

918-936.

At the expiry of the truce the Magyar messengers came as usual for their tribute. They were sent away empty handed, whereupon a vast body of invaders crossed as in former years the frontier of Thuringia. Henry prudently waited until dearth of provisions forced the enemy to divide into two bands. He then swept down upon the weaker force, annihilated it, and rapidly advanced against the remaining portion of the army. The second battle was more severe than the first, but not less decisive. The Magyars, unable to cope with a disciplined army, were cut down in great numbers, and those who survived rode in wild terror from the field. The exact scenes of these conflicts are not known, but few more important battles have ever been fought. The power of the Magyars was not indeed destroyed, but it was broken, and the way was prepared for the effective liberation of Germany from an intolerable plague. While the Magyars had been troubling Germany on the east and south, the Danes had been irritating her on the north. Charles the Great had established a march between the Eider and the Schlei; but in course of time the Danes had not only seized this territory, but had driven the German population beyond the Elbe. The Saxons had been slowly reconquering the lost ground, and now Henry, advancing with his victorious army into Jutland, forced Gorm, the Danish king, to become his vassal. The German lands were given back, and it is probable that the march of Schleswig was at this time instituted.

Importance of Henry's reign.

When this great king died, every land inhabited by a German population formed part of the kingdom, and none of the duchies were at war either with him or among themselves. Along the northern and eastern frontier were tributary races, and the country was for the time rid of an enemy which, for nearly a generation, had kept it in perpetual fear. Vast as were these results, perhaps Henry did even greater service in beginning the growth of towns throughout north Germany. He was not content with merely making them places of defence, he decreed that they should be centres for the administration of justice, and that in them should be held all public festivities and ceremonies; he also instituted town markets, and encouraged traders to take advantage of the opportunities provided for them. A strong check was thus imposed upon the tendency of freemen to become the vassals of great lords. This movement was made so powerful by the troubles of the epoch that, had no other current of influence set in, the entire class of freemen must soon have disappeared. As they now knew that they could in the last resort find protection without looking to a superior, they had less temptation to give up their independence, and many of them settled in the towns, where they could be safe and free. Besides maintaining a manly spirit in the population, the towns rapidly added to their importance by the stimulus they gave to all kinds of industry and trade.

Otto I.

Before his death, Henry obtained the promise of the nobles at a national assembly or diet in Erfurt to recognize his son Otto as his successor, and the promise was kept. Otto I. (936-973) began his reign under the most favorable circumstances. He was twenty-four years of age, and to so high a pitch of honor had Henry raised the crown that, at the coronation festival, which was of unprecedented splendor, the dukes performed for the first time the nominally menial offices known as the arch offices of the German kingdom. These peaceful relations soon came to an end. It was Henry's aim to establish the dukes in their rights, maintaining the royal authority rather by moral influence than by force. Otto, who was of haughty temper, despotic, and ambitious, seems early to have resolved that the dukes should act in the strictest sense as his vassals, or lose their dignities. At the time of his coronation Germany was virtually a federal state; he wished to transform it into a firm and compact monarchy. This policy speedily led to a formidable rebellion, headed by Thankmar, the king's half-brother, a fierce warrior, who fancied that he had a prior claim to the crown, and who had managed to secure a number of followers in Saxony. He was joined by the dukes of Franconia and Bavaria; and it was only by the aid of the duke of Swabia, whom the duke of Franconia had offended, that the rising was put down. A second rebellion, led by Otto's brother Henry, was supported, among other nobles, by the dukes of Franconia and Lorraine. Otto again triumphed, and derived immense advantages from his success. The duchy of Franconia he kept in his own hands, and he granted Lorraine to Conrad, an energetic and honorable count, whom he still further attached by promising him his daughter to wife. Bavaria, on the death of its duke, was placed under Henry, who,

936-966.

having been pardoned, had become a loyal subject and friend of his brother. The duchy of Swabia was also brought into Otto's family by the marriage of his son Ludolf with the duke's daughter. By these means he made himself master of the kingdom, as none of his immediate predecessors had been. For the time, feudalism in truth meant that lands and offices were held on condition of service; the king was the genuine ruler, not only of freemen but of the highest vassals in the nation.

Trouble with France.

Slavs.

Danes.

In the midst of his troubles at home Otto had brought fresh perplexities upon himself by intriguing in the West-Frankish kingdom against "Louis d'Outremer." Louis responded with unexpected vigor, giving the signal for the second rising against Otto by invading Alsace. He also asserted a claim to Lorraine. When peace had been restored in Germany, Otto penetrated far into France and received the homage of "Hugh the Great," his son-in-law; but he soon returned, and afterwards used his great influence in favor of Louis against his rebellious nobles. Much more important than Otto's doings in France were his wars with his northern and eastern neighbors. The duke of Bohemia, after a long struggle, was brought to submission. Among the Slavs between the Elbe and the Oder the king was represented by Margrave Gero, one of his most important vassals, a warrior well fitted for the rough work he had to do, loyal to his sovereign, but capable of any treachery towards his enemies, and sometimes guilty of outrageous harshness. This remarkable man conquered most of the country north of Bohemia between the Oder and the Upper and Middle Elbe. Margrave Billung, who looked after the Abotrites at the Lower Elbe, was less fortunate, mainly because of the neighborhood of the Danes, who, after the death of King Henry, often attacked the hated Germans. At last they made Billung prisoner, and Otto himself had to proceed against them. Their king did him homage, and he re-established the march of Schleswig, after which the margrave made rapid way among the Abotrites and Wends. Otto, having profound faith in the power of the church to reconcile conquered peoples to his rule, provided for the benefit of the Danes the bishoprics of Schleswig, Ripen, and Aarhuus; and among those which he established for the Slavs was the important bishopric of Brandenburg. In his later years he set up the archbishopric of Magdeburg, which took in the sees of Meissen, Zeitz, and Merseburg.

Expedition into Italy.

Civil war.

Defeat of Magyars.

Having secured peace in Germany, and begun the real conquest of the border races, Otto was by far the greatest sovereign in Europe; and, had he and his successors refused to go beyond the limits within which he had hitherto acted, it is almost certain they would have established a united monarchy. But a decision to which Otto soon came deprived posterity of the results which might have sprung from the policy of his earlier years. About this time Adelaide, the young and beautiful widow of Lothair, son of King Hugh of Provence, having refused to marry the son of Berengar, king of Lombardy, was cast into prison and cruelly treated. She appealed to the mighty German sovereign, and the appeal not only touched his sympathies, but awoke an overmastering ambition, since the way was thus opened for a partial restoration of the Carolingian empire. At the head of a great force, accompanied by his son Ludolf and many of his chief nobles, he crossed the Alps in 951, and descended into Lombardy. He displaced Berengar, and was so fascinated by Queen Adelaide that within a few weeks he married her. Ludolf, who had received a promise of the German crown, saw his rights threatened by this marriage, and returned sullenly to Germany. He went to an old enemy of his father, the archbishop of Mainz, and the two plotted together against the king, who, hearing of their proceedings, hastily departed, leaving Duke Conrad of Lorraine to attend to Italy. Otto had already taken the title of king of Italy, and Duke Henry, who hoped to obtain a large addition to his duchy, joined Queen Adelaide in urging him to assert the claims of the old Frankish sovereigns. Conrad, however, soon appeared with the intelligence that he had restored the Italian kingdom to Berengar, although as a fief of the German crown. This news being roughly received, Conrad took offence, and entered into the conspiracy of Ludolf and the archbishop. Otto, who did not suspect how deep were their designs, paid a visit to Mainz, and there was compelled to take certain solemn pledges which, after his escape, he repudiated. War then broke out, and the struggle was the most serious in which he had been engaged. In Lorraine, of which Otto made his brother Bruno, archbishop of Cologne, administrator, his cause was triumphant; but everywhere else dark clouds gathered over his head. Henry of Bavaria was deserted by his vassals; in Swabia, in Franconia, and even in Saxony, the native land of the king, his own duchy, the majority sided with the rebels. It is extremely remarkable that the movement acquired so quickly this force and volume. The explanation, according to some historians, is that the people looked forward with alarm to the union of Germany with Italy and the empire. There were still traditions of the hardships inflicted upon the common folk by the vast expeditions of Charles the Great, and it is supposed that they anticipated like evils in the event of his empire being once more set up. Whether or not this be the true explanation, the power of Otto was shaken to its foundations. At last he was saved by the presence of an immense external peril. The Magyars were as usual stimulated to action by the disunion of their enemies; and Conrad and Ludolf were guilty of the fatal crime and blunder of inviting their co-operation. This baseness disgusted the Germans, many of whom fell away from the enterprise, and rallied to the head and protector of the nation. In a very short time Conrad and the archbishop of Mainz submitted; and although Ludolf held out a little longer, he too broke down and entreated to be pardoned. The archbishop was ordered to be closely confined in a monastery, and soon afterwards died. Lorraine was given to Bruno; but Conrad, its former duke, although thus punished, was not disgraced, for Otto had urgent need of his services in the war with the Magyars. The great battle against them was fought in 955 at the Lechfeld, near Augsburg. They had never before appeared in such numbers, and there was a strong feeling on both sides that it was to be finally settled whether the work of King Henry should be completed or wholly overthrown. After a fierce and obstinate fight, in which Conrad with many other nobles fell, the question was decided in favor of Germany and of Europe; the Magyars were even more thoroughly scourged than in the battles in which Otto's father had given them their first real check. The deliverance of Germany was complete, and from this time, notwithstanding certain wild raids towards the east, the Magyars began to settle in the land they still occupy, and to adapt themselves to the conditions of civilized life.

Otto crowned emperor.

Entreated by Pope John XII., who needed a helper against King Berengar, Otto went a second time to Italy, in 962; and on this occasion he received from the pope the imperial crown. He did not return to Germany for more than two years; and in 966 he was again in Italy, where he remained six years, exercising to the full his imperial rights in regard to the papacy, but occupied mainly in an attempt to make himself master of the southern as well as of the northern half of the peninsula.

Connection of Germany with the empire.

By far the most important act of Otto's eventful life was his assumption of the Lombard and the imperial crowns. His successors so steadily followed his example that the sovereign crowned at Aix-la-Chapelle claimed as his right to be afterwards crowned in Milan and in Rome. Thus grew up the Holy Roman empire, that strange state, which directly descending, through the empire of Charles the Great, from the empire of the Cæsars, contained so many elements foreign to ancient life. We are here concerned with it only in so far as it affected Germany. Germany itself never until our own day became an empire. It is true that at last the Holy Roman empire was as a matter of fact confined to Germany; but in theory it was something quite different. Like France, Germany was a kingdom, but it differed from France in this, that its king was also king in Italy and Roman emperor. As the latter title made him nominally the secular lord of the world, it might have been expected to excite the pride of his German subjects; and doubtless, after a time, they did learn to think highly of themselves as the imperial race. But the evidence tends to show that at first they had no wish for this honor, and would have much preferred had their ruler limited himself strictly to his own people. There are signs that during Otto's reign they began to have a distinct consciousness of national life, their use of the word "deutsch" to indicate the whole people being one of these symptoms. Their common sufferings, struggles, and triumphs, however, account far more readily for this feeling than the supposition that they were elated by their king undertaking obligations which took him for years together from his native land. So solemn were the associations with the imperial title that, after acquiring it, Otto probably looked for more intimate obedience from his subjects. They were willing enough to admit its abstract claims; but in the world of feudalism there was a multitude of established customs and rights which rudely conflicted with them, and in action, remote and abstract considerations gave way before concrete and present realities. Instead of strengthening the allegiance of the Germans towards their sovereign, the imperial title was the means of steadily undermining it. To the connection of their kingdom with the empire they owe the fact that for centuries they were the most divided of European nations, and that they have only now begun to create a genuinely united state. France was made up of a number of loosely connected lands, each with its own lord, when Germany, under Otto, was to a large extent moved by a single will, well organized and strong. But the attention of the French kings was concentrated on their immediate interests, and in course of time they brought their unruly vassals to order. The German kings, as emperors, had duties which often took them away for long periods from Germany. This alone would have shaken their authority, for, during their absence, the great vassals seized rights which it was afterwards difficult to recover. But the emperors were not merely absent, they had to engage in struggles in which they exhausted the energies necessary to enforce obedience at home; and, in order to obtain help, they were sometimes glad to concede advantages to which, under other conditions, they would have tenaciously clung. Moreover, the greatest of all their struggles was with the papacy; so that a power outside their kingdom, but exercising immense influence within it, was in the end always prepared to weaken them by exciting dissension among their people. Thus the imperial crown was the most fatal gift that could have been offered to the German kings; apparently giving them all things, it deprived them of nearly everything. And in doing this, it inflicted on many generations incalculable and needless suffering.

Increase of nobles.

By the policy of his later years Otto did much to prepare the way for the process of disintegration which he rendered inevitable by restoring the empire. With the kingdom divided into five great duchies, the sovereign could always have maintained at least so much unity as King Henry secured; and, as the experience of Otto himself showed, there would have been chances of much greater centralization. Yet he threw away this advantage. Lorraine was divided into two duchies, Upper Lorraine and Lower Lorraine. In each duchy of the kingdom he appointed a palsgrave, whose duty was to maintain royal rights; and after Margrave Gero died, his territory was divided into several marches, and placed under six margraves, each with the same powers as Gero, and having extensive lands. Otto gave up the practice of retaining the duchies either in his own hands or in those of relatives. Even Saxony, his native duchy, and the chief source of his strength, was given to Margrave Billung, whose family long afterwards kept it.

The church.

As a set-off to the power of the princes—for the reigning immediate vassals of the crown ranked as princes—Otto, especially after he became emperor and looked upon himself as the protector of the church, immensely increased the importance of the prelates. They received great gifts of land, were endowed with jurisdiction in criminal as well as civil cases, and obtained several other valuable sovereign rights. The emperor's idea was that, as church lands and offices could not be hereditary, their holders would necessarily favor the crown. But he forgot that the church had a head beyond Germany, and that the passion for the rights of an order may be not less intense than that for the rights of a family. While the empire was at peace with the popes, the prelates did strongly uphold it, and their influence was unquestionably, on the whole, higher than that of rude secular nobles. But with the empire and the papacy in conflict, they could not but abide, as a rule, by the authority which had the most sacred claims to their loyalty. From all these circumstances it curiously happened that the sovereign who did more than almost any other to raise the royal power, was also the sovereign who, more than any other, wrought its decay.

966–982.

Otto II.

Otto II. (973–983) had been crowned king and co-imperator in his father's lifetime. His troubles began within a year in Bavaria, which was now a very great duchy, not only including the valley of the Inn, but reaching up along the western frontier of Bohemia and the eastern frontiers of Swabia and Franconia as far as the Bohemian Forest. Henry, the brother of Otto I., had died soon after the battle of the Lechfeld, and had been succeeded by a young son, who, as he grew up, showed himself of so contentious a disposition that he was known as Henry the Wrangler. This young duke's sister had married the aged duke of Swabia, over whom she had absolute control, so that the younger branch of the house of Saxony had acquired an importance which the emperor could not affect to ignore. Taking offence at some action of Otto's, Henry the Wrangler conspired against him and rebelled. This first rebellion was easily put down, but Henry soon escaped from the imprisonment to which he was condemned, and then Bavaria was the scene of a war which gave occasion to great bloodshed. When at last Henry was overcome, his duchy was taken from him and granted to one of the emperor's cousins, a son of Ludolf, who had caused so much anxiety to Otto I. As this prince had already received Swabia, Otto was able, without seeming to be harsh, to deprive Bavaria of some of its importance. The southern part, Carinthia, which had hitherto been a march, was separated from it and made a duchy; and the eastern march, Austria, was also taken away, and formally made over to Liutpold, of the Babenberg family, who had already ruled it for some time, and had proved himself a faithful vassal. Another member of the same house was invested with the Nordgau, a part of Bavaria to the north of the Danube, which formed a sort of wedge between Bohemia on the one hand and Franconia and Swabia on the other. Having arrived at this settlement, Otto went to chastise the unruly Bohemians; but while he was away war was begun behind him by the new duke of Carinthia, who, forgetful of the benefits he had just received, rose to avenge the wrongs of his friend Duke Henry. The emperor hastily concluded peace with Bohemia, the duke of which did him homage; and the rising was quickly put down. Henry was made over to the keeping of the bishop of Utrecht, and Carinthia received another duke.

Civil wars.

In his anxiety to obtain southern Italy, Otto I. had secured, as wife for his successor, Theophano, daughter of the Byzantine emperor, to whom southern Italy belonged. Otto II., having all his father's ambition with much of his strength and haughtiness, and being in the full flush of youth, longed to get away from Germany and to claim these remote possessions. But he was detained for some time by a sudden and unscrupulous invasion of Lower Lorraine in 978 by Lothair, king of France. So stealthily did the invader advance that the emperor and empress, who happened at the time to be at Aix-la-Chapelle, had just time to escape before the town was seized. As quickly as possible Otto placed himself at the head of a great army, and marched to Paris. The approach of winter compelled him to return without taking the city, which was well fortified; but soon afterwards Lothair gave up all claim to Lorraine, and peace was restored. At this time Lower Lorraine, which Otto I. had added to the crown lands, was held as a fief of the German sovereign by King Lothair's brother Charles, the last of the Carolings, whose claims to the French throne were afterwards put aside in favor of Hugh the Great.

Invasion of France.

At last Otto was able to fulfil the wish of his heart, and he did not again see Germany. His claims to southern Italy were vehemently opposed; and in 982 he suffered a disastrous defeat at the hands of the Greek emperor's subjects and their allies, the Saracens of Sicily,—saving his life by a romantic adventure. The tidings of this crushing blow cast gloom over Germany, and in the north and east the Danes and Slavs, as if the spell by which the first Otto had held them was broken, attacked the Germans with an audacity and a determination they had never before displayed. With the Danes the Saxons were able to cope; but the Slavs, who vehemently detested the German yoke, fought with such desperate courage that much of the work effected by Margraves Billung and Gero was altogether undone. They had

Defeat of Otto in Italy.

seemed to be decisively conquered, but two centuries passed before they were beaten back to the position to which they had been reduced in the previous reign. Such were the first fruits of the assumption of the imperial title.

Otto III.

About a year before his sudden death in Rome, Otto held a diet in Verona which was attended by the German princes. They would not help him in his Italian enterprise, which was extremely unpopular; but they consented to recognize his infant son Otto as his successor. This child they took back with them to Germany, and after the emperor's death he was crowned in Aix-la-Chapelle. Henry the Wrangler, as his near relative, was released from confinement and made his guardian; but as this restless prince soon showed an inclination to secure the crown for himself, the infant king was taken from him and placed under the charge of his mother Theophano. Afterwards, when she died, he lived with his grandmother, the empress Adelaide. While these two ladies acted, one after the other, as regent, the chief functions of government were discharged by Willigis, archbishop of Mainz, a vigorous prelate who had risen from a humble rank to the highest position in the German Church. He was aided by the princes of the state, each of whom claimed to have a voice in the supreme administration. Under these conditions vigorous rule was impossible; so that during the minority of Otto the royal authority was greatly weakened. In Bavaria, after the death of Henry the Wrangler, the higher vassals, without waiting for the appointment of a duke, returned to the ancient German custom, and elected Henry's son. A similar election took place in Thuringia, the head of which, although not a duke, ranked with the chief aristocracy. And along the coasts of Friesland was formed a virtually free state, which was at a later time the scene of a long-continued contest between the Frieslanders and the powerful counts of Holland. At the age of fifteen Otto III. (983–1002) was declared to have reached his majority. He had been so carefully trained in all the learning of the age that he was called "the wonder of the world," and a certain fascination still attaches to his imaginative, although somewhat fantastic, nature. His mother having imbued him with the extravagant conceptions of the Byzantine emperors, he introduced into his court an amount of splendor and ceremonial that had hitherto been unknown in western Europe.

Scheme of Otto III.

Most of his time he spent in Rome, and here he cherished a vast scheme by which he was to do much more than recall the empire of Charles the Great in its whole extent. As the heir of the Western emperors, and the grandson of an Eastern emperor, he fancied that he might unite the entire known world under his rule. Rome was to be its centre, and Germany but a province. In this vague design he was warmly encouraged by Gerbert, the greatest scholar of the day, whom, as Silvester II., he raised to the papal see. Silvester saw that in such an empire, with such an emperor, it would not be difficult for the papacy to become the real source of influence. Meanwhile Germany suffered severely from internal disorder and from the inroads of her rude neighbors; and when, in the year 1000—a year which Otto, with many others, feared might see the end of the world—he visited his northern kingdom, there were eager hopes that he would smite the national enemies with something of the vigor of his predecessors. But the imperial dreamer found it more interesting to go to Aix-la-Chapelle, and to descend into the tomb of the mighty Charles, beside whose gorgeously arrayed body, as it sat on its marble throne, he gave free scope to his fancy—apparently under the strange impression that his was a spirit akin to that of the worldly and resolute conqueror. One practical step he did take, but it was in a direction contrary to that desired by his subjects. The Poles, of whom we hear first during the reign of Otto I., and who inhabited the country immediately to the east of the Oder, had since his time owed a vague allegiance to the Germans. They were now ruled by Boleslaus, a chief of an aggressive and determined spirit, who by ostentatious loyalty gained the good-will of Otto III. The latter commissioned him to conquer the Pomeranians, a duty which he gladly and effectually discharged, adding to the Pomeranians the Prussians and some of the Bohemians. The large state thus formed the emperor made independent of Germany, probably in the hope that it might form the centre for a province of his future empire. Its Christian missions were severed from the church of Germany and formed into a new Polish church; and the emperor himself founded the head see at Gnesen, where his friend Adalbert had met a martyr's death. This was done with the sanction of Pope Silvester, who at the same time established an independent national church in Hungary, and encouraged Stephen to become the first Magyar king, by sending him from Rome a golden crown.

The Poles.

Otto's magnificent plans received a fatal shock from the insubordination of the Romans, for whose city he designed so much honor. When he died, perhaps by poison, there was no representative of the elder branch of the Saxon family, and several candidates came forward for the throne. Henry II. (1002–1024), son and successor of Henry the Wrangler, and therefore the great-grandson of King Henry I. by a younger line, managed to reach Aix-la-Chapelle before his chief rival, the duke of Swabia, and was there crowned. As he had not been elected, he was obliged to humble himself by going about among the princes and entreating their allegiance. His shattered health, querulous temper, and abject submission to priestly influence unfitted him for the great position to which he had raised himself, and his reign was an unfortunate one for Germany. For ten years civil war raged in Lorraine; in Saxony, too, torrents of blood were shed in petty quarrels. Hitherto it had been the right of the crown, when a duke or other prince died, to appoint his successor; and obviously no royal right was of greater importance. In Henry's time the principle of inheritance was virtually established in favor of the immediate vassals of the sovereign. He the more willingly made this concession because of his extravagant generosity to the church, in which, like Otto I., he looked for his main support. He had his reward in the attachment of the papacy, by which he was ultimately canonized; but he succeeded no better than his predecessors in counterbalancing the secular by the spiritual princes. In his foreign wars he was as little prosperous as in his government at home. Boleslaus, who was now a powerful sovereign, had conquered Bohemia and Lusatia; and so anxious was Henry to win back these lands that, notwithstanding his Christian zeal, he obtained the alliance of certain Slavonic tribes by undertaking that their religion should not be interfered with. Bohemia and Lusatia were for a time detached from the Polish kingdom, but they were reconquered, and after a war of fourteen years the Pole was a greater ruler than ever. Henry went three times to Italy, and was crowned Lombard king and emperor. Before he became emperor, in order to assert his right of sovereignty over Rome, he called himself king of the Romans; and this was the designation borne by his successors until they received the higher title from the pope. Up to this time a sovereign crowned in Aix-la-Chapelle was simply "king of the East Franks" or "king of the Franks and Saxons."

Henry II.

Franconian dynasty.

Conrad II.

The great nobles now met at Oppenheim, and elected to the throne Conrad, a count of Franconia. The dukes of Upper and Lower Lorraine, with a number of prelates, opposed this choice; but their objections were overborne, and Conrad II. (1024–39) seemed to have no reason to dread internal enemies. Very soon, however, he had to battle with a formidable conspiracy, and during nearly his whole reign he was exposed to dangers of this kind; for he was a masterful king, looked with extreme jealousy on the rights the princes had acquired, and wished his crown to be the symbol of a genuine central authority. He was remarkably successful in contending with rebellion; and the chief cause of his success was that he allied himself with a powerful force, the significance of which had not been detected by previous sovereigns. Hitherto the vassals of great lords—the mediate nobles—had been very much at the mercy of their superiors. Conrad, seeing that he and they had a common danger, made them more independent. It was not until nearly the end of his reign that he issued his famous edict in Italy, decreeing that no fief-holder should be deprived of his fief without judgment of his peers; but he carried out this policy from the beginning in Germany, and even from the judgment of a fief-holder's peers there was a right of appeal to the royal tribunals. The result of this policy was that the inferior fief-holders were unwilling to follow their lords against the king. Thus when Duke Ernest of

Mediate nobles.

Swabia, his stepson, rose against him, and appealed to his men, as in old times, to make his cause their own, they refused, urging that the sovereign was the supreme protector of their liberties. Conrad soon revealed that his object was the same as that which Otto I. long pursued—not to do away with the duchies, but to get them, if possible, under his immediate control. The principle of inheritance he extended to the throne; and in his case it was recognized, his son Henry being crowned as his successor soon after he himself became king. To young King Henry he granted Bavaria in fief, when the reigning duke, by rising against him, forfeited his title; and afterwards, despite the bitter opposition of the nobles, he invested the same prince with Swabia, the ducal family of which died out. Carinthia, being vacant, was given to Conrad's nephew. As Franconia ever since the time of Otto had remained in the hands of the sovereign, Saxony, Thuringia, and the two Lorraines were the only duchies of which Conrad was not more or less master.

Neighboring powers.

When Conrad mounted the throne, the safety of Germany was endangered from three different points. On the north Denmark was ruled by Canute, the great English sovereign; on the east was the wide Polish state, whose sovereign Boleslaus crowned himself king, and still had possession of Bohemia and Lusatia; to the south-east was Hungary, which, under Stephen I., was rapidly becoming an organized and formidable power. Conrad was prudent enough to ask in marriage for his son Henry Canute's daughter; and in return he ceded to Denmark the march of Schleswig. The Danes thus became the friends of the Germans, and were of service to them in keeping down the Wends. With Hungary, Conrad waged war, but not successfully, for although a statesman, he appears to have been no great general. He was more fortunate in Poland; Boleslaus having died, the Poles plunged into a furious civil war, and he was able to turn their disunion to his own advantage. Moreover, a youthful hero, Breteslaus, an illegitimate son of the duke of Bohemia, having carried away from a convent a young German lady, a powerful noble's daughter, whom he passionately loved, and who had unbounded influence over him, was induced to place his sword at the disposal of Conrad, and by a single raid he drove the Poles from Lusatia. Lusatia and Bohemia were thus restored to Germany, and the Polish ruler, who now claimed no higher title than duke, did homage to Conrad for his lands.

In Italy Conrad was ill received, for although as emperor and Lombard king he was its lawful sovereign, the Germans were still looked upon as intruders, and by force alone they could maintain their rights. The event which at the time threw most lustre on his reign was his aquisition of the kingdom of Burgundy or Arles. It was bequeathed to him by Rudolf III. whose niece Gisela was Conrad's wife. In 1032 he was crowned, and was at once recognized by the German-speaking population. The others resisted, but in two years all opposition had been overcome, and he received in Geneva the homage of the leading southern nobles. This beautiful kingdom was full of prosperous cities, and its possession seemed to add incalculably to the power of the German kings; but in the end it proved an occasion of humiliation rather than of strength.

Burgundy.

Henry III.

Henry III. (1039–56), who had been crowned, while his father was alive, king of Burgundy as well as of Germany, had none of the rudeness and reckless impulsiveness which marred Conrad's great qualities; but he had the same decisive judgment, far-reaching ambition, and irresistible will. In the later years of Conrad, Breteslaus, the young Bohemian prince who had served him so well in Lusatia, having succeeded his father as duke of Bohemia, waged war in his own interest against the disunited Poles, and easily brought their whole state into subjection. As he showed signs of wishing to become an independent sovereign, Henry invaded his territory, and so completely overcame him that he appeared before the king in Ratisbon, barefooted and in a penitent's garb. Henry treated him generously, and was rewarded by receiving to the end of his reign the service of a loyal vassal; and the young king also gained the good-will of the Poles by placing over them their lawful prince, Casimir, who willingly did homage for his land. The king of Denmark, too, acknowledged Henry as his feudal lord. Moreover, by several campaigns in Hungary, forced upon him by the violence of its king, Samuel, son-in-law of Stephen I., Henry brought that country for the first time, but only temporarily, into the position of a fief of the German crown. In Germany itself he acquired during the first ten years of his reign an authority which had been unknown since the days of Otto I. His bitter enemy, Duke Gottfried of Upper Lorraine, who conspired against him time after time, and found powerful allies in certain Burgundian nobles and in the counts of Flanders and of Holland, was beaten down; and he was able to dispense against the most powerful princes the laws of the kingdom, and to force them to maintain the public peace. Under this severe and beneficent rule Germany enjoyed a period of internal quiet such as she had probably never before experienced. But even Henry could not permanently divert from its course the central political tendency of the age. The princes, convinced that his aim was to bring the duchies under his direct authority, and thus to create a monarchy which should have but one head, sullenly awaited their opportunity; and it came when, in 1052, after a ten months' siege of Presburg, he was obliged to retreat precipitately from Hungary. The influence of his great fame was shaken, and from this time he had to contend against warlike nobles. On one occasion he found out, only through the death-bed repentance of a rebel, that he was the object of a widespread conspiracy, which, had he remained in ignorance, would inevitably have succeeded. Even the mediate nobles, who had stood loyally by Conrad, were not his friends; for his wars made serious demands upon them, and his administration of justice was often stricter in regard to their class than they quite approved. Although at the time of his death he was still one of the most powerful sovereigns who ever reigned in Germany, he was obliged to adopt a conciliatory policy,—even Duke Gottfried, after all his offences, being established in his duchy.

The Papacy.

At the beginning of Henry's reign the church all over Europe was in a deplorable condition. Simony in its basest forms was almost universally practised, and morality among the clergy was at its lowest ebb. The papacy, too, had sunk into a degraded state, its authority being annihilated, not only by the character of successive popes, but by the fact that there were at the same time three claimants of the Roman see. These evils were regarded with sorrow by Henry, who was a man of sincere and rigorous piety. Associating himself with the reforming movement which proceeded from Cluny, he not only commanded and pleaded with his prelates to put an end to abuses, but resolved to strike the evil at its root by stern exercise of his imperial rights. In 1046 he entered Rome at the head of an army which had secured for him in northern Italy such respect as had been given to no German ruler since Charles the Great, and summarily deposed the three popes whose contentions had caused scandal throughout Christendom. He then raised to the papal see the bishop of Bamberg as Clement II., who crowned him emperor; and after Clement, when death made fresh appointments necessary, three other German popes, Damasus II., Leo IX., and Victor II. Under these popes a new era began for the church and for the papacy. Behind the two latter was the stern, unfaltering, highminded Hildebrand, who, as their adviser, silently prepared the way for his own memorable term of rule. In thus reforming the papacy, Henry III. fulfilled what was regarded as the noblest duty of his imperial office; but he also sharpened a weapon whose keen edge was first tried against his son.

The last years of Henry III. form a turning-point in German history. Great kings and emperors came after him; but none of them possessed the direct, absolute authority which he freely wielded; even in the case of the strongest, the forms of feudalism more and more interposed themselves between the monarch and the nation, and at last royal authority virtually altogether disappeared. The process was hastened by the unfortunate fact that Henry III. was succeeded by a child. The infant king, Henry IV. (1056–1106), was at first in charge of his mother, the empress Agnes, a lady of excellent qualities, but too gentle for a position which demanded the exercise of stern virtues. Her rule was jealously watched by Anno, archbishop of Cologne, a rigid churchman of imposing personality, cold to the ordinary interests of the world, but passionately devoted to his order. Discontented by the predominant influence of the bishop of Augsburg at court, he managed by a clever trick, to get

Henry IV.

1056-1089.

Saxony.

possession of the king and the insignia of royalty. Agnes, knowing his power, and deserted by her friends, retired from the regency; and Anno began forthwith to rule the state. By and by he was compelled by the diet to share his duties with Adalbert, archbishop of Bremen, who was not less ambitious than Anno, but was as gay, sociable, and worldly as his rival was proud and morose. In the end Adalbert made himself complete master of Henry, who thus grew up under the most diverse influences. The young king was generous, and endowed with considerable intellectual gifts; but, passing as he did from the gloomy palace in Cologne, where he lived a monk's life under terrible censors, to the palace in Bremen, where he was petted and flattered, he became wayward and self-willed. He assumed the duties of government at the age of fifteen, and soon made enemies of nearly all the chief princes. In Saxony, where, like his father, he held his court, he excited by a series of injudicious proceedings intense hostility. While the Ottos were in pursuit of the imperial phantom, a number of the crown lands in this duchy had been seized by nobles whose descendants now held them. Henry insisted on restoring these; and, as Henry I. had taken possession of the domains of his Carolingian predecessors, so Henry IV. claimed the domains of his Saxon predecessors. As if this were not enough, he built a number of fortresses which the free peasantry imagined were intended for prisons; he kept in confinement the heir to the duchy, and he persistently spoke of the Saxons in a tone of supreme contempt. All classes were thus combined against him; and in 1073 the universal discontent found expression in a vast popular assembly, attended alike by freemen and by nobles, and in which—such was the gratitude of the church for royal favors—a leading place was taken by the archbishop of Magdeburg and by the bishop of Halbertstadt, the former the brother, the latter the nephew, of Archbishop Anno. Henry was surprised by a band of rebels in his fortress of Harzburg, near Goslar. Attended by few followers he escaped, and appealed to the princes for support; but he could not compel their aid, and of free will they would grant him nothing. After tedious and degrading negotiations, in which he was accused of every kind of crime, he was at last obliged to yield the demands of his enemies. As these demands did not include the destruction of the fortresses, the peasants, fancying they were betrayed, refused to lay down their arms, and stormed through the duchy, not only battering down the detested buildings, but even destroying the chapel of the Harzburg fortress and committing acts of desecration with ruthless fury. This so alarmed the princes, both spiritual and secular, that Henry was able to advance with a large army into Saxony, where in 1075 he gained a decisive victory, and re-established the authority of the crown.

Gregory VII.

While Germany was in this confused state, Hildebrand had become pope, as Gregory VII., and in 1075 he issued his famous decree against the marriage of the clergy and against their investiture by laymen—for boldness and vastness the most magnificent policy ever devised, since, had it been effected, the pope must have become the secular as well as the spiritual lord of Christendom. So quickly had the reforming zeal of Henry III. made the papacy a power which threatened to overshadow the world. To the decree as to investiture it was impossible for any sovereign to submit, and in Germany there were stronger reasons than elsewhere for resistance. Half the land of the country was held by the clergy, and most of it had been granted to them because, in virtue of their feudal relation to the sovereign, it was supposed that they would be his most efficient helpers. Had the feudal tie been broken, the crown would soon have vanished, and the constitution of mediæval society must have undergone a radical change. Henry, who had hitherto treated the new pope with excessive respect, and was believed at the Vatican to have no strength of character, now announced his intention of going to Rome and assuming the imperial title. The pope, to whom the Saxons had been encouraged to make complaint, responded by sending back certain messengers of Henry's, with the command that he should do penance for the crimes of which his subjects accused him. Enraged by this unlooked-for arrogance, Henry summoned a synod of German bishops, who declared Hildebrand deposed. The answer was a bull excommunicating the German king, dethroning him, and liberating his subjects from their oath of allegiance.

Effect of Henry's excommunication.

Never had a pope ventured to take so bold a step. It was within the memory of even young men that a German king had dismissed three popes, and raised, one after another, four of his own prelates to the Roman see. And now a pope attempted to drag from his throne the successor of this very sovereign. The effect of the bull was tremendous; no other was ever followed by equally important results. The princes had long been chafing under royal power; they had shaken even so stern an autocrat as Henry III., and the authority of Henry IV. was already visibly lowered. At this important stage in their contest with the crown a mighty ally suddenly offered himself, and, with indecent eagerness, they hastened to associate themselves with him. Their vassals and subjects, appalled by the invisible powers wielded by the head of the church, supported them in their rebelliousness. Henry had looked for no such result as this; he had not comprehended the influences which lay beneath the surface, and was horrified by his unexpected isolation. At a diet in Oppenheim he in vain humbled himself before the princes. They turned from him coldly and decided that the pope should be asked to come to Germany to investigate, along with themselves, the accusations brought against him; that if, within a year, the sentence of excommunication were not removed, the king should lose his crown; and that in the meantime he should live in retirement.

Scene at Canossa.

Now came the strange scene at Canossa which burned itself into the memory of Europe. For three days, in the depth of winter, the representative of the Cæsars, clad in a penitent's shirt, shivered in the outer court of the Countess Mathilda's castle, entreating to be admitted into the pope's presence. No other mode of escape than complete subjection to Gregory had suggested itself, or was perhaps possible; but it did not save him. Although the pope in a manner forgave him, the German princes, being resolved not to miss the chance which fortune had given them, met in his absence and deposed him, electing Rudolf, duke of Swabia, as his successor. But Henry's bitter humiliations transformed his character; they brought out all his latent capacities of manliness. From being a wilful, thoughtless lad, he became a resolute man, with many evil traces indeed of his irregular training, but with a deep consciousness of his rights, and a fixed determination to maintain them.

War of investitures.

The war that followed—the war of investitures—was the opening of that tremendous struggle between the empire and the papacy, which is the central fact of mediæval history, and which, after two centuries of conflict, ended in the exhaustion of both powers. Its details belong more to the history of Italy than to that of Germany, but in Germany its effects were most deeply felt. It was now that the nation plucked the bitter fruits of the seed planted by Otto I. in assuming the imperial crown, and both by Otto and his predecessors and successors in lavishing worldly power upon the church. In the ambition of the spiritual and the secular princes the popes had an immense engine of offence against the emperors; and they unscrupulously turned it to the utmost advantage. The most loyal friends of the emperors were the cities. They had been steadily growing up, especially in the Rhine country and in southern Germany, and could not but see that they had far more to fear from the princes than from the crown. Hence, when Henry returned to Germany, Worms, Spires, and many other towns opened their gates to him, and freely contributed of their wealth; and towards his successors they pursued a like policy.

After several indecisive battles the rival king, Rudolf, was, in 1080, defeated and slain. Henry then carried the war into Italy, where he was crowned emperor by his own anti-pope, and in 1085 Hildebrand died an exile from Rome, although with unbroken spirit. In Germany two other rival kings were set up, Hermann count of Luxembourg, and Ekbert, margrave of Meissen; but they were only partially successful, and after the death of the latter in 1089, had Germany followed her own impulses, there would have been peace. In the papacy, however, Henry had an implacable foe; and again and again, when he seemed to be on the point of complete triumph, it kindled anew the smouldering embers. His son Conrad was stirred up against him in Italy; and in Germany when he was near the end of his days, his second son Henry was induced to head a dangerous rebellion. During his reign the first

First crusade.

crusade took place, and he suffered severely from the pious zeal which it expressed and intensified. The movement was not in the end favorable to papal supremacy, but the early crusaders, and those who sympathized with them, regarded the enemies of the pope as the enemies of religion.

Henry V.

Pope Paschal II. did not doubt, after the death of Henry IV., that he would immediately triumph, but he was mistaken. Henry V. (1106–25), who had promised, with unconscious irony, to treat him as a father, went on like his predecessors, investing prelates with ring and staff, and, when expostulated with, replied that he could not be expected to give up a right which had belonged to all previous kings. War broke out anew, and, as in the time of Henry IV., the pope found enthusiastic supporters among the princes. One of the most ardent of these was Lothair, whom Henry V. himself had made duke of Saxony, after the extinction of the Billung line, by which for a century and a half the duchy had been ruled. Henry's chief friends were the two Hohenstaufen princes, Frederick and Conrad, to the former of whom Henry IV. gave the duchy of Swabia when Rudolf became his rival king, while the latter was created by Henry V. duke of Franconia, a country which had been attached to the crown lands since the time of Otto I. These two brothers were enthusiastic imperialists, and upheld with persistent courage the cause of their sovereign on the repeated occasions on which he went to Italy to chastise the pope. At last, in 1122, peace was restored by the concordat of Worms.

Concordat of Worms.

By this compromise, which was forced by exhaustion upon both parties, the right of electing the prelates was granted to the clergy, and the emperor resigned the right of investing them with ring and staff. On the other hand, it was arranged that the elections should take place in the presence either of the emperor or of his representative, and that he should invest the prelates with the sceptre. The papacy was thus very far from realizing the great schemes of Hildebrand; still, even in regard to the particular question in dispute, it gained solid advantages, and its general authority was incomparably more important than it had been half a century before. For it had waged war on the emperor himself; instead of acknowledging its inferiority as in old times, it had claimed to be the highest power; it had even attempted to dispose of the imperial crown as if the empire were a fief which it granted of its good will; and it had found out that it could at any time hamper, perhaps paralyze, imperial authority, by exciting strife in Germany.

Lothair the Saxon.

The Franconian dynasty died out with Henry V., and Lothair, duke of Saxony, was elected to succeed him. Lothair (1125–37) excited the enmity of the Hohenstaufen princes by demanding that they should give up certain crown lands which had been incorporated with their duchies. Unable to defend himself against them without help, he secured a powerful ally by granting his daughter in marriage to Henry the Proud, grandson of Welf, a prince whom Henry IV. had made duke of Bavaria.

Henry the Proud.

As this vehement noble soon succeeded to Bavaria, and was also invested with Saxony, he became by far the greatest subject in Germany. Nevertheless, the duke of Franconia and the duke of Swabia withstood him, and not until within three years of the emperor's death were they forced to crave for peace. A considerable portion of Lothair's reign was spent in Italy; and Innocent II. claimed that when he received the imperial crown he did so as a vassal of the pope.

Decay of royal power.

Nothing could indicate more clearly than this fact how much of their old power the German kings had lost. It was not past hope that even yet some of their former splendor might be restored; and for a brief period monarchy did again stand high. Still, its foundations were sapped. Incessant war, both at home and in Italy, had deprived it of its force; it had lost moral influence by humiliations of which the scene at Canossa was an extreme type. Steadily, with unwearied energy, letting no opportunity escape, the princes had advanced towards independence, and they might well look forward to such a bearing in regard to the kings as the kings had formerly adopted in regard to them.

Later Mediæval Period.

1106–1156.

Hohenstaufen dynasty.

Conrad III.

Henry the Proud was confident that he would succeed Lothair; but, by a hasty and irregular election, Conrad, duke of Franconia, was chosen king. Conrad III. (1137–52) an impulsive and not very wise ruler, found himself at once in serious perplexities. Henry the Proud, knowing that evil was designed against him, rebelled, whereupon he was declared to have forfeited his duchies; and Saxony was granted to Albert the Bear, a strong and truly great Saxon noble, while Bavaria fell to Leopold, margrave of Austria. Thus again the country was ravaged by war, for Henry the Proud, although he was unpopular in Bavaria—the duchy he had inherited—was powerfully upheld in Saxony, which, ever since Henry IV. had alienated it, had always been ready to join in an attack on the monarchy. Henry suddenly died, but the struggle was continued by his brother Duke Welf; and, but for the opportune death of some of the chief combatants, among them Leopold of Bavaria, it seemed probable that it would go hard with the king. Welf, hoping to be made Leopold's successor, agreed to a compromise, by which Saxony, with the assent of Albert the Bear, was granted to Henry—afterwards Henry the Lion—the young son of Henry the Proud. Bavaria, however, was in the end given to Henry Jasomirgott (so called from his habit of saying "Ja so mir Gott helfe!"), margrave of Austria, a rough noble, who was afterwards found to have a decidedly inconvenient temper. Welf again took to arms, and for years contended with his rival. Notwithstanding this and many other sources of confusion, Conrad was persuaded by the passionate eloquence of St. Bernard to take part in the second crusade.

Second crusade.

He came back broken, dispirited, and near his end, to find Henry the Lion at the head of a great army, claiming Bavaria in addition to Saxony,—a claim which Conrad in vain attempted to dispute.

Frederick Barbarossa.

Germany now passed under one of the greatest of her sovereigns, Frederick Barbarossa (1152–90), nephew of King Conrad, and son of the Frederick, duke of Swabia, who had fought along with Conrad against Henry the Proud. He was a man of large and noble nature, capable, indeed, if resisted, of great harshness, but a passionate lover of justice, with far-reaching ideals, ready to battle with gigantic difficulties, yet knowing how to recognize and submit to the inevitable. Allied to the Welfs through his mother, and having a personal regard for Henry the Lion, he was anxious to bring to an end the strife of the Welfic and the Hohenstaufen families, and began his reign by promising to secure for Henry the duchy of Bavaria. For his adventurous and imaginative spirit the splendor of the imperial name had an irresistible charm; and two years after he ascended the throne, in 1154, he went to Rome to be crowned emperor. After this the best years of his life were spent in Italy, where, in his obstinate struggle with the Lombard cities and with Pope Alexander III., he chiefly acquired his fame. Although it was conducted on his side mainly with German troops, it properly comes under Italian history, in which the record of his reign forms a bloody page, while his name is associated with one of the most peaceful and prosperous periods in the internal history of Germany.

Henry the Lion.

The promise that Bavaria should be granted to Henry the Lion was not easily fulfilled, for Henry Jasomirgott doggedly refused to give it up. At last, however, Frederick, after his return from his first expedition to Italy, in 1156, reconciled the surly prince by detaching Austria, his native march, from Bavaria, and making it a duchy with certain special privileges,—an important step in the process by which Austria gradually became the centre of a powerful state. Henry the Lion then became duke both of Bavaria and of Saxony. This prince often gave offence by a haughty and aggressive disposition, but few German dukes won so true a title to the good-will of posterity. Since the time of Otto II. and Otto III. the Slavonic countries to the east of Saxony had been very imperfectly held in subjection. Henry devoted himself to the conquest of the territory along the shores of the Baltic, and he succeeded as no one before him had ever done. But he was not a mere conqueror; he built towns and encouraged those which already existed, founded bishoprics in the newly-won lands, and planted in them bodies of industrious colonists. While he was thus at work, a similar task was fulfilled a little to the south of him by Albert the Bear, the first margrave of Brandenburg, who, by just and energetic rule, worthily prepared the land for its great, although far-off, destinies.

1156-1220.

Frederick's relations to other countries.

Early in his reign, by settling the dispute between two brothers who claimed the crown of Denmark, Frederick brought the king of that country once more into the position of a vassal of Germany. He broke into Poland also, and compelled its ruler to do homage, and in return for great services rendered in his Polish campaign, raised the duke of Bohemia to royal rank,—a change which in no way affected his duties to the German crown, but which gave him a certain precedence over all other subject princes. The king of Hungary, although no attempt was made to subdue him, became a useful ally of Frederick. Thus the ancient fame of Germany, which was lost during the confusion that came after Henry III., was to a large extent restored in the neighboring countries. Frederick reasserted the royal authority in Burgundy, and added to the kingdom, by right of marriage, Upper Burgundy, or, as it was afterwards called, Franche Comté.

Internal prosperity.

Internal quiet he established by strictly applying such laws as existed against those who should break the peace; and the robber nobles never found a more implacable enemy. The cities flourished during his reign, and he attached them to himself by granting to many of them the very liberties which, by a too literal interpretation of his imperial rights, he withheld from the cities of Lombardy. Yet, with all this, the nobles appear to have been enthusiastically devoted to him. They followed him time after time into Italy, going through incredible sufferings that he might assert claims which were of no advantage to them, and which had been a curse to their nation. On one occasion, when a too confident legate read before the diet a papal letter, which seemed to imply that the empire was a fief of the papacy, indignant murmurs broke from the assembly, and the life of the offender was saved only by the intervention of Frederick himself. The secret of this great popularity was partly the national pride excited by his foreign achievements, partly the ascendency which his genius gave him over other minds, partly the conviction that, while he would abate nothing of his rights, he would ask no more than the laws of the empire sanctioned.

Fall of Henry the Lion.

In the later years of Frederick's reign, Henry the Lion had the misfortune to incur his deep displeasure. The duke, rendered arrogant by success, positively refused, because his conditions were not admitted, to attend the emperor in the Italian campaign which resulted in the fatal battle of Legnano. Ascribing this defeat wholly to Henry, Frederick returned to Germany resolved to work his ruin. Summoned on three different occasions to attend the diet, Henry held aloof; whereupon, by judgment of his peers, he was condemned to the loss of both his duchies. After some resistance he submitted; but the utmost favor he could secure was permission to retain Brunswick and Lüneburg, while his term of banishment to England was reduced from seven years to three. Bavaria was granted to Otto of Wittelsbach, but it lost much of its importance, for, among other changes, Styria was taken from it and made a separate duchy. Saxony was finally broken up. The duchy was confined to a comparatively small territory to the east of Brunswick and Lüneburg, and conferred upon Bernard, son of Albert the Bear, while most of the western half of the country was attached, as the duchy of Westphalia, to the archbishopric of Cologne. The chief prelates of Saxony, and many of the most important vassals of the duke, such as the counts of Oldenburg, of Holstein, and of Schwerin, were made virtually independent of all control save that of the crown. Frederick's object in thus disintegrating the two greatest duchies in the kingdom was, by playing off the nobles against each other, to secure imperial authority. But, in reality, he made it doubly certain that the princes would one day shake off imperial power altogether; for it was incomparably more difficult for the sovereign to contend with scores of petty nobles than with two or three great lords.

Last years of Frederick.

Towards the close of Frederick's career fortune appeared to smile upon him. Germany was at peace; even in Italy, since the force of events had persuaded him that the time was past for too severe a straining of his lawful claims, he had been well received by the cities which had wrought him so much disaster; pope and emperor were temporarily reconciled; and, by the marriage of his son Henry with the princess Constantia, he had reason to hope that the empire would soon include Naples and Sicily. Resolving that the sunset of his life should be even more splendid than its dawn, he undertook the third crusade, and started with a great army for the Holy Land. When the news reached Germany that he had been drowned, men felt that evil days must come, since the elements of strife could no longer be controlled by his strong hand.

Henry VI.

Evil days did not, however, come in the time of Henry VI. (1190–97), who, although without his father's greatness of soul, had his determination and energy. Partly by means of the immense ransom obtained from his prisoner Richard of England, he was able to beat down resistance in the south Italian kingdom to which his marriage entitled him; and the papacy was more completely subject to him than it had ever been to Frederick. In Germany he was so powerful that he not only secured the election of his infant son Frederick as king of the Romans (as a king elected during the lifetime of an emperor was now and henceforth called), but he made proposals that the crown should be declared hereditary. To secure this important end, he offered so many concessions that, but for his sudden death, it would probably have been achieved.

Philip and Otto IV.

Great as was Henry's authority, there had been a dangerous conspiracy against even him, and after his death the princes who had taken part in it refused to recognize his son. There was now a double election, those who were favorable to the Hohenstaufen dynasty choosing Philip, Henry's brother, their enemies appointing Otto, son of Henry the Lion. Had Germany had no relation to the papacy, or had the papacy continued as weak as in the days of Henry VI., there could have been no doubt how the strife would end. A large majority of the princes were on Philip's side, and his personal character commanded universal respect, while Otto was a man without principle, harsh, and violent. But, to Germany's misfortune, the papal see was at this time held by Innocent III., a pope in whom were revived the ambition, statesmanship, and force of Hildebrand. After a little delay he decided for Otto, and thenceforward for some years the country was desolated by civil war. Even with the help of the pope, Otto by and by lost ground; and Philip, had he not been murdered, in 1208, would soon have been universally acknowledged. After his death, however, there was no longer any excuse for war, and Otto IV. was crowned emperor. While his position was undecided he remained a humble suppliant of the pope, but after his coronation he cast aside his pledges, and began to act as an independent sovereign. Up to this time Frederick, the son of Henry VI., had lived in his southern kingdom, nominally under the guardianship of Innocent, but in reality left to be trained by the severe discipline of practical life. Although the pope did not altogether like him, he now resolved to punish Otto by bringing forward this young prince as a candidate for the German throne. A party among the princes was easily induced to elect him, and in 1214 he started, full of youthful hope, on his journey across the Alps. In the period which followed, he displayed an unsurpassed power of managing men; while Otto, thinking to injure him by indirectly striking a heavy blow at his patron the pope, was short-sighted enough to leave Germany and to support John of England against the French king, Philip Augustus. In the battle of Bouvines, memorable alike in the history of England, France, and Germany, his fate was sealed. After so crushing a defeat nothing remained for him but to make way for his rival by withdrawing from public life.

Frederick II.

Frederick II. (1212–50), if not the strongest, was personally the most brilliant, of the German kings. With the mediæval passion for adventure he combined the intellectual freedom and culture of a modern gentleman. A lover of poetry, of science, and of art, he was also a great statesman; with a power of will which the most adverse circumstances could not break, he knew how to adapt his policy to changing circumstances, and how to move men by appealing at one time to their selfishness and weakness, at another to the most ideal qualities of human nature. And for outward splendor his position never was surpassed, since, when he died, he possessed no fewer than six crowns,—the imperial crown, and the crowns of Germany, Burgundy, Lombardy, Sicily, and Jerusalem. But Germany, his proper kingdom, profited not at all by his magnificent gifts. In 1220 he left it for a space of 15 years, to accomplish his famous crusade, to carry on his bitter contest with the Lombard cities and Pope

Gregory IX., and to rule Sicily, with an insight into its needs that made it the most prosperous land in Christendom. In his absence he was represented in Germany by his young son Henry, who was crowned king of the Romans, and in whose name the country was governed by two successive regents. Throughout the kingdom the princes did very much what seemed good in their own eyes; and in the north a confused warfare was carried on between the Germans and the Danes. As there was now no powerful Saxon duke to uphold the northern interests of the kingdom, and as the central government did not choose, or was unable, to act with energy, the Danes had decidedly the best of this struggle, and extended their power along the Baltic coast. At the same time Prussia was conquered for Christianity and for civilization by the knights of the Teutonic Order, who here slowly built up the state which ultimately, in association with Brandenburg, was to influence so profoundly the course of history. Crusading knights from all lands came to their help against the Prussian heathen, and their strength was permanently increased by their union with the Knights of the Sword, who, before their appearance in Prussia, had been subduing Livonia and Courland. In all these countries Christian institutions were introduced, and German settlers brought with them the peaceful arts.

Conquest of Prussia.

As young King Henry grew up he displayed none of the good characteristics of his house, and in 1235 he openly rebelled. So confident was Frederick of his own position that he entered Germany with only a few personal attendants, and his presence had the effect he anticipated. At Mainz, amid circumstances of unprecedented pomp, he held a diet which was attended by nearly all the princes, and Henry was solemnly deposed. Yet Frederick was in reality watched with sullen suspicion. The princes did not know what might be implied in his extraordinary display of imperial power; they resented his evident dislike of their country; as loyal sons of the church, they could not but hold somewhat aloof from one who was believed to be at heart a Mahometan. It was significant of the limits of his influence that, in declaring private war to be unlawful, he had to except cases in which justice could not be obtained; and that, although desirous of setting up courts of justice which should make private war unnecessary, he could only establish a tribunal from whose jurisdiction princes of the empire were excluded.

The Mongols.

Some years after this, the gulf between Frederick and the nation was further widened by his indifference to a fearful danger by which Germany was threatened. Hordes of Mongols appeared on the eastern frontiers, yet Frederick had neither counsel nor help for his subjects; the peril was warded off independently of him by the brave margrave, Henry of Liegnitz. At that time he was once more absorbed by his Italian wars. In Innocent IV. he found an enemy quite as persistent as Gregory IX. Innocent grasped at the old and well-tried weapon—the ambition of the princes; and he succeeded so far as to induce a number of them, mostly prelates, to accept his sentence of deposition, and to appoint a rival king.

Henry Raspe.

William of Holland.

Conrad IV.

The king of their choice was Henry Raspe, landgrave of Thuringia, a rude noble, who had extended his territories at the expense of those of his dead brother, husband of the famous St. Elizabeth of Hungary. Frederick's younger son, Conrad, who had some time before been elected king of the Romans, resisted the parsons' king, as Henry Raspe was popularly called; and the rebellion did not at any time assume dangerous proportions. After Henry Raspe's death, the papal party elected William, count of Holland, a prince who had no quality to recommend him, except that he was young and weak, and therefore likely to be a willing tool in the hands of his friends. Had Frederick chosen to leave the Lombard cities, he might still have found sources of strength in Germany; but he preferred to remain at what he considered the centre of his empire, and King Conrad had not influence enough to restore harmony. At the time of the emperor's death, when he was almost ready to make a new spring at his enemies, but when to the world he seemed to have lost everything, the prospects of his supporters were dark indeed. They acknowledged Conrad IV. as their lawful sovereign, but he, too, fought in Italy rather than at home, and the country continued till his death, in 1254, to be torn by the two contending factions.

1220-1254

With King Conrad IV. the Hohenstaufen line came to an end in Germany, and William of Holland received a nominal allegiance. In two years he followed his predecessors, and then there was a double election, that of Alphonso, king of Castile, and Richard, earl of Cornwall, brother of Henry III. of England. Richard was crowned, but he went to Germany only three times, and the majority of his subjects probably hardly knew his name. Alphonso never even visited the country of which he also claimed to be the sovereign.

Period of Hohenstaufen dynasty.

The age of the Hohenstaufen emperors is, in many respects, the most interesting in the mediæval history of Germany. Everywhere there were dramatic contrasts of character; in the innumerable struggles of the time we are struck, now by heroic devotion, again by almost incredible selfishness; a gay enjoyment of the world as it is existed side by side with almost superhuman spirituality. Chivalry was in full bloom, with much in its nature that was fantastic and insincere, but keeping alive a beautiful ideal of manliness, courtesy, and generosity. Women never held a higher place, nor, on the whole, did they ever respond more nobly to the honors freely lavished upon them. The excitement of the crusades, contact with the life of Italy (in that age presenting so many elements fitted to awaken even dull minds), and study of the Provençal poets revealed worlds that had been hitherto unknown; while the national genius for the first time flowered in the romances and lyrics of the Minnesänger. In the cities, magnificent churches in the Gothic style gave expression to high aspiration, and gratified a cultivated feeling for art. And the problems of government were seen in new lights, partly from the study of Roman law which passed from Italy to Germany, partly from the summaries of native custom in the "Sachsenspiegel" and "Schwabenspiegel." Altogether, Germany has seen no more fascinating epoch, none more full of life, movement, and color.

Political character of Germany settled.

Yet it was in this age that the German nation utterly lost its political strength. Even after Lothair the Saxon, a line of sovereigns rigidly confining themselves to their own kingdom might have mastered the many influences which were making for disunion. But the Hohenstaufen family, like their Saxon and Franconian predecessors, would be content with nothing short of world-dominion; and thus the crown which had once been significant of power and splendor gradually sank into contempt. Under the strong rule of Frederick Barbarossa and his son the process was temporarily stopped, but only to advance the more rapidly when they were gone. During the confusion of the civil war carried on by Otto IV. and Philip, the princes, being subject to hardly any check, seized crown lands and crown rights; and the mischief was too extensive to be undone by Frederick II. In 1220, in order to secure the adhesion of the church to his son Henry, he formally confirmed the spiritual princes in their usurpations, agreeing not to introduce into their territories, without their consent, new coinage, or customs, or tolls. Fifteen years later the rebel king, Henry, was isolated by similar advantages being granted to the secular princes. The two pragmatic sanctions in which Frederick made these concessions formed the lawful basis of the independence of the princely class. Such authority as he reserved he could ill exercise from a distant land in which his energies were otherwise occupied. His immediate successors can hardly be said to have exercised any authority whatever; and they lost hold of the border countries which had hitherto been dependent upon or connected with Germany. Denmark and Poland rendered no homage thenceforth to the German crown, and Burgundy was gradually absorbed by France.

Classes of the population.

The country was not now divided into a few duchies which, with skilful management, might still on difficult emergencies have been made to act together. The age of the great duchies was past. As we have seen, Bavaria was shorn of extensive lands, over which new dukes were placed, and the duchy of Saxony was altogether broken up. Swabia and Franconia also ceased to have dukes, and Lorraine gave place to the duchy of Brabant and other small immediate states. Thus there were prelates, dukes, palsgraves, margraves, landgraves, counts—forming together a large body—each of whom claimed to have no superior save the emperor, whose authority they and their predecessors had slowly destroyed. All imme-

1254-1298.

diate nobles were not princes; but even petty knights or barons, who possessed little more than the rude towers from which they descended upon passing travellers, if their only lord was the emperor, recognized no law save their own will. Another independent element of the state was composed of the imperial cities. So long as the emperor really reigned, they enjoyed only such liberties as they could wring from him, or as he voluntarily conferred. But when the sovereign's power decayed, the imperial cities were really free republics, governing themselves according to their own ideas of law and justice. Besides the imperial cities, and the princes and other immediate nobles, there were the mediate nobles, the men who held land in fief of the highest classes of the aristocracy, and who, in virtue of this feudal relation, thought themselves entitled to look down upon allodial proprietors or freemen, and upon simple burghers. There were also mediate towns, acknowledging the supremacy of some lord other than the sovereign. Beneath all these, forming the mass of the agricultural population, were the peasantry and the serfs, the latter attached to the land, the former ground down by heavy taxes.

Great interregnum.

The electors.

The period which followed the death of Conrad IV., called the Great Interregnum, was made good use of by the princes for the extension of their territories and the confirmation of their authority. On several occasions the crown had seemed to be on the verge of becoming hereditary; but the jealousy of the papacy, and the growing influence of the aristocracy, had succeeded in keeping it elective. Although each election needed the sanction of the whole class of immediate nobles, the right of appointing the king had long been virtually in the hands of the leading princes. During the interregnum, mainly through the influence of Pope Urban IV., it was definitely transferred to the archbishops of Mainz, Cologne, and Treves, the houses of Wittelsbach and Saxony, the margrave of Brandenburg, and the king of Bohemia. After this the electors became a distinct element in the state. Their importance consisted in this, that they could maintain the existing disunion by imposing rigid conditions on candidates for the crown, and by taking care that it should be conferred on no prince likely to be dangerous to the aristocracy.

Division of principalities.

Up to the time of the interregnum the territories of a prince were never divided among his descendants, the reason being that, although the private fiefs of the princes were hereditary, their offices as rulers were in theory at the disposal of the crown. This principle was now set aside. Otto, duke of Bavaria, of the house of Wittelsbach, had become by marriage lord also of the Rhenish palatinate. After his death these extensive lands were ruled in common by his two sons; but a formal division soon took place, by which the powerful family of Wittelsbach was separated into two branches, the Palatine and the Bavarian. The small duchy of Saxony was also divided into two duchies, that of Wittenberg and that of Lauenburg, the former to the south, the latter to the north, of the great march of Brandenburg. About the same time there were like divisions in Nassau, Brunswick, Meissen, and Holstein. It was thus practically settled that the offices and territories, as well as the private fiefs, of the princes were hereditary, to be disposed of by them at their pleasure. This being thoroughly established, it would have been hard, perhaps impossible, even for a sovereign of the highest genius, to reassert in anything like its full extent the royal authority. The process of division and subdivision which steadily went on broke up Germany into a bewildering multitude of principalities; but as a rule the members of each princely house held together against common enemies. Ultimately they learned to arrange by private treaties that no territory should pass from the family while a single representative of it survived.

Importance of the cities.

This consolidation of the power of the princes was contemporary with the rise of the cities into new importance. The destruction of imperial authority compelled them to organize their resources, so as to be at all times prepared against ambitious neighbors. They began to form leagues which the greatest princes, and combinations of princes, could not afford to despise. Of these leagues the chief at this time was the Rhenish Confederation, which was founded by Mainz and Worms, and which, within a year of its formation—so pressing was the need of union—included about 70 cities,—among them Cologne, Strasburg, Basel, and towns far to the east and north, such as Nuremberg, Erfurt, and Bremen. Great importance was also acquired by the Hanseatic League, which had originated some time before the interregnum in a treaty of alliance between Lübeck and Hamburg. It ultimately included more than 80 cities, and became one of the greatest commercial powers in Europe.

Rudolf I.

A political system which allowed the princes to do as they pleased was exactly to their liking; and had they been able to follow their own impulses, it is improbable that they would have placed over the country even a nominal king. But the papacy intervened. It found from its troubles at home and from its diminished northern revenues that it would still be convenient to have in Germany a sovereign who would, like his predecessors, be the protector of the church. Pope Gregory X. therefore, after the death of Richard, let the electors know that if they did not choose a king he himself would appoint one. This threat was effective. The electors met, and raised to the throne Rudolf, count of Hapsburg, a petty Swabian noble who was supposed to be too unimportant to do much harm. Rudolf (1273–91), however, proved himself to have much more energy than the electors supposed. For a long time the most powerful prince in Germany had been Ottocar, king of Bohemia. He had by marriage and conquest obtained a great territory beyond his native state, including the Austrian possessions of the house of Babenberg, of which the male line had died out. As he had himself expected to receive the German crown, he refused to do homage to the new sovereign, who could not for a time compel his allegiance. At last, in a great battle at the Marchfeld, Ottocar was defeated and slain. Rudolf has often been called the restorer of the German kingdom, but he has no real claim to this honorable title. In the later years of his life he made some attempts to maintain the public peace, and he distinguished himself by the vigor with which he punished robber barons; he also won back some of the crown lands and dues which had been stolen during the interregnum. But he made no essential change in the condition of Germany. There was but one way in which a king could hope still to overcome the arrogance of the princes, and that was to encourage the cities and to form with them a close and enduring alliance. This was the policy pursued by the French kings, and it was pursued with splendid effect. But Rudolf invariably favored the princes rather than the cities. The latter had a peculiar class of citizens called "pfahlbürger," who dwelt in the open country beyond the city palisades, and could claim the protection of the city authorities. As freemen were able, by becoming pfahlbürger, to escape from the tyranny of local despots, the princes vehemently opposed the right of the towns to receive them. Rudolf not only took the side of despotism in this important struggle, but harassed and weakened the cities by subjecting them to severe imposts. He had all the sympathies and prejudices of a noble; and the supreme object of his life was not to increase the authority of the state, but to add to the greatness of his own family. In this he was brilliantly successful. Some years after the fall of Ottocar he obtained the assent of the princes, notwithstanding their dislike of the scheme, to the granting of Austria, Styria, and Carniola in fief to his son Albert. Carinthia was given to Meinhard, count of Tyrol, on condition that on the dying out of his male line it should fall to Rudolf's descendants. Thus Rudolf made himself memorable as the founder of the house of Hapsburg, which from his time formed one of the most influential forces in the national life of Germany.

Adolf of Nassau.

In vain Rudolf sought to obtain the crown for his son; the electors would not take a step that might endanger their special rights. Guided mainly by the archbishop of Cologne, they chose Adolf, count of Nassau (1291–98), a noble of even less importance than Rudolf had been. He had, however, a considerable reputation for valor and ability. Edward I. of England persuaded him to form an alliance against France. Instead of applying the large sum sent from England to promote the objects of the alliance, Adolf was unprincipled enough to expend it in the purchase of Thuringia from the worthless landgrave, Albert the Degenerate. As the transfer was resisted by Albert's sons, it led to a war in which Adolf was opposed by several princes. In his general policy he was much more enlightened than in these wretched proceedings, for he detected what had escaped his predecessor, the value of the cities as the true support of the monarchy. He relieved them of some of their burdens, and upheld them in the controversy respecting the pfahlbürger. Taking alarm, the electors met, and by an irregular vote proclaimed him dethroned. Adolf resisted, but lost his life in a battle near Worms.

Albert I.

Now that there could be no pretext for asserting that the crown had been obtained by inheritance, Duke Albert of Austria, Rudolf's son, was chosen to be Adolf's successor. Albert I. (1298–1308), like his father, made it his principal object to extend the power of his house, and he came very near to securing Bohemia and Thuringia; but his schemes were cut short by a violent death. Although a hard, stern man, he had a keen sense of justice when his selfish interests were not involved, and few of the German kings possessed so strongly practical an intelligence. He encouraged the cities even more effectually than his predecessor, and was not content with issuing proclamations against private war, but formed alliances with the princes in order to enforce his decrees. The serfs, whose wrongs seldom attracted notice in an age indifferent to human dignity, found a friend in this severe monarch, and he protected even the despised and persecuted Jews.

Henry VII.

Albert's successor was Henry, count of Luxembourg. Henry VII. (1308–13) was fortunate enough to obtain for his son John the crown of Bohemia, but the aggrandizement of his family was not the main object of this remarkable sovereign, the last of the German kings of the old, grandly ambitious type. It was the memory of the empire which stirred his blood; and from the beginning of his reign he looked forward to the assumption of the Lombard and imperial crowns. His purpose of crossing the Alps at the head of a mighty force was hailed with delight in Italy by the Ghibelline faction, whose aspirations found noble utterance in Dante's prose; but the emperor lived too short a time to fulfil the hopes of his friends. The effect of the connection of Germany with the empire was in his time, as in former ages, altogether mischievous; for before starting for Rome he tried to conciliate the princes by adding to their already enormous privileges and by repressing the energies of the cities.

Frederick III. and Louis IV.

The electors, with their usual dread of the crown becoming hereditary, would not appoint Henry's son, John, the young king of Bohemia. But they were unable to agree on any one else, and the result of their disputes was a double election—one party choosing Frederick the Fair, duke of Austria, son of Albert I.; another, Louis, duke of Bavaria. War at once broke out and lasted for about nine years. In 1322 the rival claims were set at rest by the battle of Mühlberg, in which Frederick's army was decisively routed. Louis had no personal ill-will to his opponent, who was the friend of his youth; and in 1325 he agreed that they should rule in common. Frederick III., however, being without strength of character, sank into insignificance, and in 1330 he died.

Swiss League.

The success of Louis IV. (1314–47) in the war with Frederick was to a large extent due to the imperial cities, which clung to him from the first. They not only willingly paid high taxes, but made splendid voluntary contributions; and they often stimulated anew the king of their choice, when he himself would have preferred to give up a struggle in which the sympathies of most of the princes and nobles were with his enemy. He was even more indebted to the memorable conflict between the house of Hapsburg and the League composed of Schwyz, Uri, and Unterwalden. The inhabitants of these districts claimed to have never owed allegiance to any sovereign save the emperor. Although this claim had been confirmed by King Adolf and Henry VII., the dukes of Austria would not recognize it; and when Frederick was chosen king by his party among the electors, he sent bailiffs into the country to bring it under the rule of his family. Probably the tyranny of these officers, although it occurred at a later time than that to which the Tell legend refers, afterwards gave rise to the romantic tales which gathered around the name of the mythical champion of Swiss independence. At any rate it brought on a conflict between Austria and the confederates, which strained the resources of Frederick at the very time when he needed them in defence of his royal claims. It was not only Louis who profited by this struggle, for the splendid battle of Morgarten Pass laid the foundation of the structure which we now see in free Switzerland.

Relations of Louis to the papacy.

Had Louis been a wise prince it would have been easy for him to rise to a great position after the battle of Mühlberg; but he was wayward, treacherous, and selfish. He mortally offended King John of Bohemia, who had been of great service to him, but who now became his bitter and unrelenting enemy. Pope John XXII., stirred up by Charles IV. of France, who had some hope of obtaining the empire for himself, took advantage of the strife of the two princes, and arrogantly claimed that the German crown could not be worn but with papal sanction. When Louis gave the answer that was to be expected, the pope responded by excommunicating him and by placing under the interdict all places by which he should be supported. Thus it seemed that the ancient struggle between the papacy and the empire was to be revived; but the pope and his French master had altogether misread the signs of the times. The princes had no longer, as in former ages, reason to dread an ambitious ruler; the kingdom was their own, and therefore they could not tolerate that its destinies should be decided by a foreign power. Even the spiritual princes for the most part took this view. The electors had of course the strongest of all motives for resisting the papal claim, since, had it been conceded, they would have been deprived of their importance. As for the cities, they had stood beside the empire in the most difficult crises of its contest with Rome, and they were not likely to desert it now. Encouraged, or rather driven forward, by the national sentiment, Louis continued to maintain the independence of his crown, and even made a descent upon Italy, where he was crowned emperor by his own anti-pope. This enterprise ended disastrously, but it made no difference in the conditions of the controversy. Louis was personally very much frightened by the possible consequences of excommunication, and intrigued incessantly with Pope John and his successor Benedict XII. to be taken back into the church. In order to win papal favor he basely betrayed Edward III. of England, with whom he had formed an alliance against the French king, Philip VI. The nation, however, stood fast, and in 1338 the electors, with the exception of King John of Bohemia, met at Rense, near Coblentz, and formally declared that the German king and emperor, if appointed by a majority of the electors, received his authority from God alone, and needed not papal sanction in the exercise of his rights. This declaration was accepted as the fundamental law of the empire by a diet which Louis summoned in Frankfort, and which was largely attended by princes, nobles, and citizens.

Unpopularity of Louis IV.

Louis did not maintain the popularity forced upon him by this conflict. His greed of territory for his family made him so unscrupulous, and excited so many jealousies, that the Bohemian king succeeded in forming a party against him; and in 1346 a number of the electors voted his deposition, and appointed in his place Charles, margrave of Moravia, King John's son. The cities persisted in their loyalty, and few of the princes were willing to involve themselves in another great war; so that for a time the sentence of deposition had no effect. But after King John had met his death, fighting heroically despite his blindness as the French king's ally, on the field of Crécy, Charles, who succeeded him on the Bohemian throne, began to make vigorous preparations; and probably the sudden death of Louis prevented Germany from being once more rent by civil strife.

Louis IV. and the cities.

Notwithstanding the defects of Louis's personal character his reign was one of the most important in German history. The claim of the papacy to political supremacy received in his time its deathblow, and the popes themselves sowed the seeds of the spiritual alienation from Rome which was effected at the Reformation. In regard to the public peace, Louis persistently followed the lines laid down by Albert I. He encouraged the princes to form alliances for its maintenance, and at the time of his death such alliances existed in all parts of the country. To the cities he usually showed himself a faithful friend. In many of them there had been for more than a century a struggle between the old patrician families and the guilds composed of workmen and trades-people. Louis could not always follow his own impulses; but whenever he could, he associated himself with the latter party. Thus in his day the government of the imperial cities became more democratic, and industry and trade flourished as they had never before done.

1347-1437.

The steady dislike of the princes was the best proof of the importance of the cities. They contained elements capable of enormous development; and had a great king arisen he might even yet, by their means, have secured for Germany a truly national life.

Luxembourg dynasty.

Charles IV.

The friends of Louis elected Günther, count of Schwarzburg, but Charles IV. (1347–78) by a liberal use of bribes, bought over his enemies; and Günther himself resigned his claim, and soon afterwards died. Charles was an accomplished diplomatist, of a keen and penetrating intellect, but capable of almost any trickery in order to gain his ends. Apparently the most pliant of men, he had in reality great persistence of character, and if foiled in one set of plans readily turned round and reached his goal by a wholly different path. The result of his endless intrigues was that, when he died, he wore the crowns of Bohemia, of Germany, of Burgundy, of Lombardy, and of the empire; and he succeeded in adding to his native kingdom Lusatia, Silesia, and Brandenburg. As a Bohemian king he ranked high among the rulers of his day. He so carefully organized the administration, and practised such strict economy in government, that no German country was so lightly taxed as Bohemia; and it became, under his rule, a home of learning and of the arts. Towards Germany he was cynically indifferent, caring for it only in so far as it could add to his personal welfare. It never stood in more urgent need of a strong and beneficent ruler than in the early years of his reign, for the Black Death swept over the land, and the half-mad population rose in fury against the Jews, who were supposed to have in some way caused the evil. In dealing with this monstrous outburst of fanaticism, many of the princes, both spiritual and secular, displayed vigor and humanity; but Charles saw in the suffering of the down-trodden race, which was peculiarly under his protection, only an excuse for robbing it of its wealth.

Golden Bull.

His most famous achievement is the Golden Bull. Although the principle of election to the crown had long been settled, it was surrounded by many practical difficulties. It had never, for instance, been decided whether all the princes of each electoral house were entitled to vote; nor was it certain, when a choice was made among several branches of a family, by what law the choice ought to be regulated. The Golden Bull, which was granted as the result of many tedious negotiations in 1356, was primarily intended to set at rest such doubts as these; but it did very much more. It decided that the number of electors should be strictly limited to seven, that the spiritual electorates should belong as before to the archbishops of Mainz, of Cologne, and of Treves, and the secular electorates to the king of Bohemia, the Rhenish palsgrave, the duke of Saxony (Sachsen-Wittenberg), and the margrave of Brandenburg. That there might be no possibility of dispute between the princes of a single house, these countries were declared to be indivisible, and to be heritable only on the principle of primogeniture. The electors were invested with full sovereign rights within their territories, and their subjects were allowed to appeal to the royal or imperial tribunals only if the administration of justice should be refused. The king of Bohemia received precedence among the secular electors, but it is difficult to believe that this alone was his aim in making these vast concessions. Whatever may have been his motives, the effect of the Golden Bull was to perpetuate the disunion of the state. With such powers the electors collectively were of more importance than the sovereign; and their greatness stimulated the other princes to seize every chance of acquiring like privileges.

Fehmgerichte.

The cities.

If we except the Golden Bull, the true interest of Charles's reign is not in his unimportant labors for Germany, but in the movements beyond the range of his influence. It is significant that at this time the Fehmgerichte, for whose origin we must go back to the 12th century, vastly extended the sphere of their activity, and that in the utter absence of central authority they were respected as a rough check upon the lawlessness even of high princes. The cities, notwithstanding every kind of discouragement, formed new associations for mutual defence, or strengthened those which already existed. The Hanseatic League carried on war with the Danish king and forced him to come to terms, and its commerce was extended to nearly every part of the known world. A powerful league was formed by the Swabian towns, but it was defeated in the battle of Altheim by a confederation of princes who regarded its growth with fear and jealousy.

Wenceslaus.

Wenceslaus (1378-1400), son of Charles IV., and also king of Bohemia, had some good natural qualities; but he had been badly trained, and when he became his own master was indolent and capricious. His bloodhounds had stronger attractions for him than the duties of government, and even more than his father he left Germany to look after itself. The tendency to association became the deepest of the time; princes allied themselves against cities, cities against princes, and nobles against both. For a brief period the prospects of the cities seemed to be splendid, for the Swabian League recovered from the effects of its reverse, extended its relations far and wide, and formed an alliance with the Swiss confederates. The latter won the brilliant victories of Sempach and Näfels, and had the Swabian League taken advantage of the opportunity, it might have definitely gained predominance. But it gave the princes time to reorganize their scattered forces, and in 1388, in the battle of Döffingen, it suffered complete defeat. So crushing was this blow that the Swabian cities were never again so strong, and all over Germany it encouraged the princes to fresh aggression.

Rupert.

Sigismund.

The confusion caused by the king's neglect of his most elementary duties gave rise to a conspiracy against him, in which Rupert, the elector of the palatinate, took a leading part. Wenceslaus was deposed, and after much intrigue the crown was granted to Rupert (1400–10). He was an excellent elector, and under favorable circumstances would have been a good king; but such were the jealousies and divisions of the state that he found no scope for his energy beyond his native dominions. He made an attempt to reach Rome, but the result covered him with ridicule. After his death Jobst, margrave of Moravia, and Sigismund, king of Hungary, brother of Wenceslaus, were elected by opposing parties. Jobst soon died, and then Sigismund was generally recognized. Sigismund (1410–37) was an intelligent and cultivated prince, but vain, restless, and shifty. He could form great plans, but had not determination to execute them, and was easily moved by flattering counsellors. The commanding questions of his reign were ecclesiastical. It was the age of the great schism, and through all ranks of the church there was an urgent cry for thorough reform. Unfortunately, the council of Constance, summoned mainly through the efforts of Sigismund, marred its labors by the judicial murder of Huss and Jerome of Prague. This atrocious act, for which the king was to a large extent responsible, stirred vehement rage among the Bohemians; and when, after the death of Wenceslaus, Sigismund, as his heir, claimed the crown, they broke into revolt. Led for a time by the blind general Ziska, and afterwards by commanders who, although his inferiors in genius, were of equally resolute temper, they defeated army after army, and spread havoc through the neighboring German lands. So divided was Germany, and so poor was Sigismund himself, that for fifteen years he could not collect a force sufficient to put down the rebellion; and he at last succeeded only because the Hussites gradually split into two factions, the Calixtines and Taborites, and he was able to conciliate the less extreme party.

Hussite war.

Brandenburg.

Sigismund, who was of lavish habits, never had enough money for his wants; sometimes he had even to force himself upon princes and cities as an unwelcome guest. This undignified poverty had one good result. In return for 400,000 gulden he granted to his friend Frederick, count of Hohenzollern, first as a pledge, afterwards as a permanent fief, the march of Brandenburg. Thus Brandenburg passed into the hands of the family under whom it was destined to become the centre of a mighty kingdom.

Hapsburg dynasty.

Albert II.

Sigismund was succeeded by Albert, duke of Austria, who, as his son-in-law, became king of Bohemia and Hungary. Although the German crown remained elective, it was henceforth always conferred on a member of the house of Hapsburg until the extinction of the male line; and the same family never willingly lost its grip of the two countries which now

Frederick IV.

fell to it, and of which it ultimately gained complete possession. Albert II. (1438–39) evidently meant well by Germany; but his reign was too short to enable him to do more than indicate his good intentions. He was succeeded by Frederick, duke of Styria. Frederick IV. (1440–93), unfortunately for his subjects, occupied the throne longer than any other sovereign. He was a solemn trifler, obstinate without being firm, and bent on promoting only the interests of his family. The council of Basel having met after the council of Constance, King Albert accepted its reforming decrees; and it appeared probable that the abuses which scandalized Christendom were about to be brought to an end. But Frederick, whose dull mind did not see that in the changed circumstances of the world the papacy could be strong only in proportion to its purity, fancied that in its existing condition it might be made a powerful ally of the empire. He accordingly carried his submissiveness so far as to sign in 1448 the concordat of Aschaffenburg, perpetuating the very evils from which the church had aimed at delivering itself. After his assent had been obtained it was comparatively easy to overcome the scruples of the princes, so that the chances of a voluntary reformation were lost; the upheaval of the 16th century was rendered inevitable.

Private wars.

Frederick's career is one of great importance in Austrian history; he was involved in wars with the Turks, with the Hungarians, with his brothers, and with his own subjects. In 1452 he was crowned emperor, being the last who passed through the ceremony in Rome. He had no influence in Italy; and in Burgundy he could neither check the towering ambition of Charles the Bold, nor after Charles's death prevent the seizure of the duchy of Burgundy by the French king. In Germany he hardly made a pretence of exercising supreme authority, and many private wars were waged, especially between the cities and the princes. The most famous of these was the margraves' war, carried on by Albert of Brandenburg with a number of princely allies against Nuremberg, which had the support of the Swiss League and upwards of 70 cities. The war was in every respect a critical one. Had the cities gained they might still have aimed at balancing the power of the princes; but owing partly to their imperfect union, partly to the necessity of fighting with hired troops, they were not successful. They won, indeed, great advantages in the course of the war; but after the conclusion of peace it was felt that on the whole they had decidedly lost ground. After this struggle, which lasted seven years, there could be no doubt as to the element in which the centre of gravity of the state was to be found.

Local diets.

The princes, however, did not have everything their own way. About this time their power was seriously limited by the formation of diets in nearly all the principalities. These bodies were composed of the mediate prelates, the mediate nobles, and representatives of the mediate cities. They were not summoned because the princes wished their aid, but because arms could be had only with the consent of the nobles, and money only with that of the cities and the clergy. When once formed, the local diets soon extended their functions. They claimed the right of sanctioning taxation; they had something to say as to the expenditure of the public revenues; they insisted on justice being administered. Such institutions as these were clearly of the highest importance, and for two centuries they did much to make up for the lack of a genuine monarchy.

Agitation for national reform.

During this reign the conditions of warfare began to be radically changed. The discovery of gunpowder made small bodies of men, properly armed, more than a match for great forces equipped in the mediæval style. Hence the custom of hiring mercenary troops came into use; and a prince could never feel sure, however numerous his vassals, that the advantage would not rest with his opponent. This fact, added to the influence of the local diets, made even the princes sick of war; and everywhere a demand arose for the reform of the national institutions. In 1488 a great Swabian confederation, consisting of princes, nobles, and towns, was created for the establishment of peace; and its effects were excellent. But obviously no partial remedy of this kind could suffice; it was essential that there should be some central reform by which every part of the kingdom could be effectually reached. Had the proposal been that the imperial authority should be directly strengthened, Frederick would not have objected; but the scheme repeatedly forced upon him was that he should in some form delegate to others the power which theoretically belonged to him, so that it might really be put in force. The emperor doggedly withheld his assent, and the nation impatiently waited in the hope that his successor would be more pliant.

Maximilian I.

Maximilian I. (1493–1519) mounted the throne with unusual advantages. He was not only lord of the great Austrian lands, but, as husband of the princess Mary, daughter of Charles the Bold, administered the Low Countries and the free county of Burgundy. These territories he soon gave up to their lawful ruler, his son Philip; but the fact that they were in the possession of his family added to his influence, which was still further increased when Philip, by marrying the infanta Joanna, had the prospect of becoming king of Spain. From this time the empire exercised in the affairs of Europe an authority which had not belonged to it for several centuries. The reason was not that the empire itself was stronger, but that the crown was held by princes who were in their own right mighty sovereigns.

This emperor is often called the last of the knights, and in some respects the name is strikingly appropriate. He had not, indeed, sufficient dignity to rank among the greatest representatives of chivalry. A knight who was also emperor ought not, for instance, as Maximilian did at the siege of Terouenne, to have served a foreign prince for pay. But he possessed many of the more prominent qualities suggested by the word chivalry; he was a man of fascinating manner, a lover of poetry and art, and endowed with a bold and adventurous spirit. Above all, he was a knight in his political opinions. Maximilian never could learn that the world had changed since the time of the Hohenstaufen dynasty; that the old order of society was passing away, and a new order arising, was altogether hidden from him. An irresistible fascination attracted him to the glitter of the mediæval empire, and the best part of his life he spent in vague schemes for its revival. The agitation for reform in the direction indicated by the princes and the cities met his unqualified disapproval. During the whole course of his reign the diet, which was now composed of three colleges, the electors, the princes, and representatives of the imperial cities, urged him with even greater importunity than it had displayed toward his father, to adapt himself to the circumstances of the time. The only occasions on which it could bend him to its will were when he needed money for his military enterprises; and by taking advantage of these opportunities it obtained his sanction to the division of the kingdom into ten circles, each with its own administrators appointed for the purpose of preventing private war. These institutions were of genuine service, but no other real concession could be wrung from Maximilian. In his first diet, held at Worms in 1495, a permanent public peace was proclaimed, and he unwillingly consented to the formation of an imperial chamber, consisting of a president and assessors, the former to be appointed by the emperor, the latter by the states. This chamber was to judge between princes of the empire, and to act as a court of appeal for parties of lower grade; and partly for the payment of its expenses a tax called the common penny was granted. Maximilian, who was always in straits for money, took much interest in the common penny; but to the imperial chamber, which limited the rights of the crown, he was so persistently hostile that it did no good in his day. An administrative council to which, after his defeat by the Swiss League in 1499, he was forced to agree, also failed in consequence of his opposition.

Foreign wars.

The famous invasion of Italy by Charles VIII. of France in 1494 brought Maximilian into the field, and ever afterwards he mixed himself up in the confused struggles to the south of the Alps, hoping to assert the ancient claims of the German kings, at least in northern Italy. In 1508 he joined the infamous League of Cambray against the Venetian republic, and at a later time he took part in the conflict of the Holy League against Louis XII. of France. He was everywhere baffled, for his own territories, great as they were, did not suffice for his vast undertakings, and Germany refused to let herself be dragged into conflicts in which she was not directly concerned.

Period of the Reformation.

1517-1521.

Decay of feudal relations.

The reign of Maximilian must be regarded as in many respects the end of the Middle Ages. The feudal relation between the king and the princes, and between the princes and their vassals, had become purely nominal. No real control was exerted by the crown over the heads of the various states, and now that war was carried on mainly by mercenary troops, the mediate nobles did not hold their lands on condition of military service. The princes were sovereigns, not merely feudal lords; and by the institution of local diets in their territories an approach was made to modern conceptions of government. The age of war was far indeed from being over, but men had at least begun to see that unnecessary bloodshed is an evil, and that the true outlet for the mass of human energies is not conflict but peaceful industry. By the growth of the cities in social if not in political importance the products of labor were being more and more widely diffused; and it was now incomparably easier than at any previous time for the nation to be moved by common ideas and impulses. The discovery of the New World, the invention of printing, the revival of learning, and many other causes had contributed to effect a radical change in the point of view from which the world was regarded; and the strongest of all mediæval relations, that of the nation to the church, was about to pass through the fiery trial of the Reformation. This vast movement, which began in the later years of Maximilian, definitely severed the mediæval from the modern world.

The Reformation.

The seeds of the Reformation were laid at so remote a time as that of the conflict between the papacy and the empire. The arrogance and the ambition of the popes then stamped upon the minds of the people an impression that was never effaced. During the temporary struggle of Louis IV. with the popes of his day the old feeling revived with fresh intensity; all classes, clerical as well as lay, looked upon resistance to papal pretensions as a necessity imposed by the national honor. At the same time the spiritual teaching of the mystics awakened in many minds an aspiration which the church, in its corrupt state, could ill satisfy, and which was in any case unfavorable to a merely external authority. The Hussite movement, shaking as it did many ancient beliefs and shattering many ancient institutions, further weakened the spell of the church. Still more powerful, because touching deeper elements of human nature and affecting a more important class, was the influence of the Renaissance, which, towards the end of the 15th century, passed from Italy to the universities of Germany. The men of the new learning did not sever themselves from Christianity, but they became indifferent to it; its conceptions seemed to them dim and faded, while there was a constantly increasing charm in literature, in philosophy, and in art. No kind of effort was made by the church to prepare for the storm which might have been foreseen. The spiritual princes, besides displaying all the faults of the secular princes, had special defects of their own; and as simony was universally practised, the lives of multitudes of the inferior clergy were a public scandal, while their services were cold and unimpressive. The moral sense was outraged by such a pope as Alexander VI.; and neither the military ambition of Julius II. nor the refined paganism of Leo X. could tend to revive the decaying faith in the spirituality of their office. Pope Leo by his incessant demands for money, and his unscrupulous methods of obtaining it, awakened bitter hostility in every class of the community.

Luther.

The popular feeling for the first time found expression when Luther, in 1517, nailed to a church door in Wittenberg the theses in which he contested the doctrine at the root of the detestable traffic carried on for the pope by Tetzel and his accomplices. In appearance a slight circumstance, this was in reality an event of vast significance for it brought to the front, as the exponent of the national sentiment, one of the mightiest spirits whom Germany has produced,—a man who had certainly many faults, but who amply made up for them by the force of his intellect, the loftiness of his aims, and the rare combination of caution and audacity with which he devoted himself to noble causes. Under the influence of Luther's great personality the most active and progressive elements of the nation were soon in more or less open antagonism to the papacy.

Charles V.

When Maximilian died, the throne was competed for by his grandson Charles, by Henry VIII. of England, and by Francis I. of France. The first and the last were the only real candidates, and ultimately Charles was chosen. By the time he reached Germany in 1521, Luther had passed through his famous controversy with Eck; he had confronted the papal legate, Cajetan; he had burned the pope's bull. After this retreat was impossible; and his innumerable adherents waited with keen excitement to see on which side the new king would declare himself. Charles V. (1520–55), although a boy in years, was not really young. He soon made up his mind as to the general lines of his policy, and no one who knew his grave and obstinate spirit supposed that any influence would cause him to diverge from his path.

His policy.

He had no adequate conception of the strength of the feeling which had been aroused. He fancied, as had at first been imagined in Rome, that he had to deal with a monkish quarrel; at one time he even supposed that a little money would easily set the difficulty at rest. Nor did he ever comprehend the real nature of the questions which stirred the hearts of his subjects. For Charles, although a diplomatist of astonishing skill, was a man of cold and narrow nature; it was incredible to him that men should be genuinely moved by aspirations to which he was himself a stranger. Even if his knowledge had been far more exact, he would not have turned against the church. Since the interregnum none of the emperors, with the exception of Maximilian, had been powerful princes apart from the empire, and some of them had been wretchedly poor and insignificant. Maximilian himself could not compete on equal terms with the leading European monarchs. Charles, however, was by far the most important sovereign of his time. He was king of Spain and the Two Sicilies, with the resources of the New World at his command, lord of the Low Countries and of the county of Burgundy, co regent with his brother Ferdinand of the great Austrian inheritance; and now he had been made king of Germany with a right to the imperial crown. To such a potentate it naturally seemed possible to restore the splendor of Charles the Great, and he early set before himself this ideal. But the protection of the church had always been looked upon as the chief function of the empire; he could not, therefore, desert it at the very time when it seemed to be in need of his services. He reserved to himself the same right as his predecessors to resist it in the realm of politics; in the realm of faith he considered that he owed it his entire allegiance. Moreover, he intended to complete the task at which his grandfather had worked in vain, the subjection of northern Italy; and in order to realize this scheme it was of high importance that he should in no way needlessly offend the pope. Hence, in 1521, in the diet of Worms, without really examining the positions of Luther, Charles issued an edict denouncing him and his followers, and placing him under the ban of the empire.

National Reform.

Alarmed lest the emperor's great power should be too freely applied in Germany, the electors had before his appointment exacted a promise that he would respect German liberties and institute the reforms which had been vainly demanded of Maximilian. At the diet of Worms steps were taken to give effect to these conditions. An administrative council was nominated for the government of Germany while Charles should be away; and the imperial chamber was so effectually re-established that, with the aulic council (which was at first subordinate to it, but ultimately became independent), it lasted till the destruction of the empire. A matricula was drawn up settling the number of troops to be raised for common purposes by each state; and this also was in force while the empire existed. Having made these arrangements, Charles invested his brother Ferdinand with the sole authority in the Austrian territories, and then left Germany, to begin soon after his long struggle with Francis I. of France.

Nobles' war.

While Charles was absent carrying on his wars with Francis, great disturbances took place in Germany. One of the most remarkable of Luther's friends was Ulrich von Hutten, a young noble, who, although penetrated by the enthusiasm of the Renaissance, was emphatically a man of action. His class, the nobles, had ever chafed against the supremacy of the princes; and it occurred to him that the Reformation might be made the means of effecting a total change in the constitution of the empire. As no general reform either in church or state could be effected while the nation was cut up into a large number of principalities, his plan was to combine against the princes all who were discontented with the existing order, and to place the emperor at the head of a united country. Then the nobles would obtain their due, peace would be secured throughout the land, and papal authority might be easily put down. The scheme was a great one, and Hutten inspired with his enthusiasm Francis von Sickingen, an energetic and popular Rhenish baron who could at any time attract a large army to his standard. A force of 12,000 men was soon collected, and the enterprise was begun in 1522 by an attack on the elector of Treves, who, being a spiritual prince, would not, it was supposed, receive the sympathy of the reforming party. For a moment it seemed as if this dream of a new empire might be realized; but it was too late to make so vast a change. Several princes united, and in 1523 Sickingen was defeated and slain, while Hutten, who had devoted pen and sword to his cause, died in loneliness and misery on an island in the Lake of Zürich.

Peasants' war.

This war was followed by another of a still more serious nature. The peasantry of Germany had grievances compared with which those of the nobles were imaginary, for they were treated as if they had no right to expect any ray of brightness in their dreary lot. Extravagant hopes were kindled among them by the Reformation, and in a few years, notwithstanding all Luther's efforts to dissuade them, widespread conspiracies were formed. In 1524 war broke out in the greater part of southern and central Germany, and the peasants, aided by a few valiant knights like Götz von Berlichingen, were at first triumphant. But they soon became so violent that Luther himself urged that they should be sternly punished; and in 1525, after a vast amount of confusion and bloodshed, the rising was completely suppressed. By these two wars the authority of the princes was made greater than ever; the peasantry suffered if possible more severe oppression, and many even of the immediate nobles were compelled to submit to a yoke which they detested.

Progress of the Reformation.

Notwithstanding the injurious impression caused by the struggles of the peasantry and of the barons, the Reformation made rapid progress, and those who remained loyal to the church became so alarmed that at the diet of Spires in 1526 they clamored for repressive measures. The administrative council at the head of Germany in Charles's absence was, however, not unfriendly to the Reformers, and the diet ended by decreeing that, until the questions in dispute should be authoritatively settled, each state should have religious freedom. This proved to be a most important edict. As yet no religious body had been organized to compete with the Catholic Church; now the leading states in which the ideas of the Reformation prevailed began, under the guidance of Luther and Melanchthon, to carry out measures which they had in vain hoped the church itself, by means of a general council, would undertake. The Catholics saw clearly the significance of what was done; and at another diet held in Spires in 1529 they obtained, in opposition to the previous edict, a new decree, forbidding further changes in religion. The supporters of Luther formally protested; but the Catholics maintained their ground. In the following year the emperor, who was no longer an untried youth, but a sovereign famous for skill in council and success in war, came to Germany for the express purpose of making an end of heresy. At the diet he held in Augsburg the Lutherans submitted a summary of their doctrines in the Augsburg Confession, which had been drawn up, with the sanction of Luther, by Melanchthon, and which was afterwards regarded as their chief standard of faith. Charles made no real effort to comprehend the controversy; he was resolved, whether the heretics had right on their side or not, that they should submit, and he had at first no doubt that he would awe them into submission by an unwonted display of power and splendor. To his surprise the Lutheran princes, while perfectly respectful, continued firm, and not only declined to attend mass, but held Lutheran services in their own quarters. Paying no attention to the edict of Spires of 1526, he renewed that which he had issued at Worms in 1521; and it seemed more than probable that if it were not obeyed he would soon have recourse to arms.

Diet of Augsburg.

But fresh difficulties with France, and a threatened invasion of the Turks, who had besieged Vienna in 1529, forced him to mask his designs. In 1532 he granted the religious peace of Nuremberg, which conceded temporary toleration to the adherents of the Augsburg Confession, and this peace was repeatedly confirmed in the following years. Meanwhile, the Lutherans, both princes and cities, had increased their power by forming the League of Smalkald, and this confederation ultimately took in, besides many cities of South Germany, most of the North-German cities and principalities. The Reformation in Germany was above all things a popular movement. It sprang directly from the heart of the nation, and, the conditions favorable to it being widely spread, it passed with extraordinary speed from one part of the country to another. Thus many princes, who would not of their own accord have deserted the church, were compelled to do so from political motives. They had been strong enough to undermine imperial authority; they were not strong enough to resist the pressure of the majority of their subjects.

War made on the Protestants.

His hands being full elsewhere, Charles was obliged to temporize during his second absence from Germany, and to send counsels of moderation to his brother Ferdinand, who had been elected king of the Romans. He never, however, gave up his original purpose. His plan was, when he should have leisure to devote himself to the task, to secure the meeting of a general council which should make all necessary reforms, and to insist, at whatever cost, on the Lutherans abiding by its decisions. The peace of Crespy, signed in 1544, gave him free scope; and he began by inducing Pope Paul III. to summon the council which ultimately met at Trent. At the same time he made vigorous preparations for war. He affected that he had no intention of fighting for religious objects, but merely wished to bring to subjection certain states which had set him at defiance. By these means he was able to detach from the League of Smalkald the reforming states which were without real enthusiasm, or which were too timid to enter upon a great struggle. Those which took up arms were so disunited that the troops sent to Charles from Italy and the Low Countries had no difficulty in joining him; and in 1546 he not only made himself master of the South-German Lutheran cities, but in the battle of Mühlberg completely routed the Saxons and took their elector, John Frederick, prisoner. Shortly afterwards the landgrave Philip of Hesse, who with the Saxon elector had been the main political support of Lutheranism, fell into his hands, and both were treated with great harshness. Charles took advantage of his triumph to issue what was called the "Interim," a confession which was to be obligatory on the Lutheran states until the council then sitting should conclude its labors. It was everywhere resisted, but most of the states had at least outwardly to submit. All Germany thus seemed to be at the emperor's feet. The Reformation had enabled him to deal both with the princes and the imperial cities as no sovereign had dealt with them for five centuries.

Defeat of Charles.

But his triumph was too great to be enduring. The Catholic princes themselves were alarmed at his predominance; King Ferdinand was alienated by his attempts to secure the crown for his son Philip; and the Lutheran princes chafed angrily under his severe rule. The general discontent found a representative in Maurice, a subtle and ambitious Saxon prince, who, caring little about doctrinal disputes but a great deal about the increase of his own importance, had sided with Charles against the Lutherans, and had been rewarded by being made John Frederick's successor. He now turned, under the influence of what motives it is hard to determine, and plotted against the emperor, forming an alliance with the chief Lutheran princes and with Henry II. of France, who eagerly caught the opportunity to profit by the dissensions in the empire. Charles heard vague rumors of what was going on; but he had been thrown off his guard by the ease with which he had hitherto attained his will, and carelessly trusted to chance. Suddenly, in 1552, Henry II. invaded Germany as protector of her liberties, and Charles learned that Maurice was marching rapidly to Innsbruck with the intention of making him prisoner. He fled, and all the advantages he had gained by the battle of Mühlberg were at once lost. Within six months he had to sign the treaty of Passau, agreeing that a diet should be summoned for the purpose of arriving at a new settlement, and that in the meantime Lutherans and Catholics should have like privileges. In 1555 the religious peace of Augsburg was concluded by the diet thus promised.

Henry II. had seized the bishoprics of Metz, Verdun, and Toul; and Charles endeavored at the earliest possible opportunity to win them back. But his efforts failed; and thus in his last years the power he fancied he had thoroughly humbled began a series of depredations which were thenceforth to be continued at frequent intervals. Disgusted with his ill fortune, he handed over the government of Germany to his brother Ferdinand in 1555, having in the previous year entrusted Spain, the Two Sicilies, and the Low Countries to his son Philip.

Peace of Augsburg.

The peace of Augsburg, instead of bringing tranquillity, was the cause of fresh discord. The toleration it conceded did not include the Calvinist or Reformed faith; only the Lutherans received liberty of worship. And even a Lutheran was not tolerated unless his prince chose to let him alone; for each secular state had the right to eject from its territory all who did not accept the doctrine it established. Thus Catholic, Lutheran, and Calvinist were exposed to irritating despotism; and each came to regard the other with hearty detestation. Another source of trouble was a clause in the treaty called the ecclesiastical reservation. It required that if a spiritual prince accepted the Augsburg Confession he should forthwith resign his lands. The Lutherans denied the validity of this clause; and notwithstanding the protests of the Catholics several prelates became Lutherans and kept their territories as secular possessions.

Ferdinand I.

Ferdinand I. (1556-64), who, like all German sovereigns after him, was recognized as emperor without being crowned by the pope, had at one time been distinguished for his zeal for the church. But the experience of his brother had taught him the necessity of prudence; and he was also kept quiet by troubles in Bohemia and Hungary, both of which countries he had acquired by marriage, and to both of which the house of Hapsburg soon began to lay hereditary claim. He tried to moderate the excesses of each party, and was anxious that the council of Trent should follow a conciliatory policy.

Maximilian II.

Rudolf II.

Matthias.

Maximilian II. (1564-76), one of the most enlightened princes of his time, adopted the same line. He would have had the state withdraw altogether from religious disputes, and so sincerely did he carry out his principles that, although he was himself a Catholic, Protestant doctrines spread during his reign throughout the Austrian hereditary lands, from which they had hitherto been excluded. Rudolf II. (1576–1612) reversed the policy of his immediate predecessors. The Jesuits, who had been hard at work, although without much success, during his father's reign, gained complete ascendency over him; and acting on their advice he continually warred against the Protestants. But he was too weak to do much good to his friends or injury to his enemies. Trained in the gloomy court of Spain, he had come to be of a moody, variable temperament; and he was given to outbursts of violent passion, followed by abject submission to his advisers. So much confusion sprang from his incompetence that the archdukes of Austria, with the sanction of the Spanish branch of the house of Hapsburg, met in 1606, and placed the government of the hereditary lands in the hands of his brother Matthias. He took refuge among his Bohemian subjects, who, in 1609, wrung from him a royal charter, granting religious freedom to the nobles, knights and cities, with the right to build churches on their own and the royal lands. Matthias, who succeeded him as emperor (1612–19), was almost as unfit for the duties he assumed. He put forth his whole energy against Protestantism; but he could not in the least discourage it, and in his time it prevailed over by far the larger part of the Austrian territory.

Catholic reaction.

Protestant Union and Catholic League.

By this time, however, there were signs of a great Catholic reaction which was to work fearful havoc in Germany. It was due mainly to the persistent zeal of the Jesuits. For a long time the Protestants absorbed the intellectual strength of the country; but many able scholars and divines among the Jesuits could hold their own with their antagonists, who afforded them excellent vantage ground by foolish and bitter controversies. These devoted missionaries of the church gave their attention mainly to the young; and during the reign of Rudolf they were fortunate enough to make a profound impression upon two princes, each of whom was destined to play a great part in the events of the time. These princes were Maximilian, duke of Bavaria, and Ferdinand, duke of Styria. The former early showed the fruit of his training by executing, in 1606, an unjust imperial mandate against the Protestant city of Donauwörth, and afterwards treating it as his own. The Protestant princes, rendered suspicious by this arbitrary act, formed in 1608 a confederation called the Union, which was to last for ten years; and in response the Catholics, under the guidance of Maximilian, to whom they gave the command, united in a similar confederation called the League. As the Union was headed by the elector palatine, who was a Calvinist, many Lutherans, among them the Saxon elector, regarded it coldly. It acquired, however, immense importance by an alliance with Henry IV. of France, who, like Henry II., wished to profit by German quarrels. War was on the point of breaking out between the two confederations in regard to the Juliers-Cleves territory; but the Union did not venture to fight after the sudden death of the French king.

Ferdinand II.

Ferdinand was even more vigorous than his friend in the defence of his religion. His faith was that of a genuine fanatic, narrow, intense, austere; and with the feelings of a monk rather than of a secular ruler, he began at once, on assuming the government of Styria, to extirpate Protestantism. Individuals and families were driven without mercy from their homes until at last a country which had been mainly Protestant became in appearance altogether Catholic. He was the heir of Matthias; and on coming to Vienna after the death of that sovereign, he found himself in the midst of what seemed hopeless confusion. The Bohemians, embittered by the violation of the royal charter granted by Rudolf, refused to acknowledge him as king, and elected Frederick V. of the palatinate, son-in-law of James I. of England; and the people of Hungary and of the Austrian lands, terrified by the prospect of a stern rule in opposition to their religious beliefs, were almost in open revolt. He succeeded in obtaining the imperial crown; and from that time Ferdinand II. (1619–37) was dominated by a fixed resolve to secure the triumph of his church throughout the empire,—a resolve which cost Germany the Thirty Years' War.

Thirty Years' War.

Bohemia.

Palatinate.

He began with Bohemia. Although supported by Spain, he could not obtain from her sufficient troops for his purpose; and as he was for some time nearly powerless in Vienna he was obliged to come to terms with Duke Maximilian, who, after securing his own interests, put the army of the League commanded by Tilly at his disposal. The Union helped Frederick V.; but being a man of feeble character he wasted precious months, needlessly irritated his subjects, and vaguely hoped that his wife's father would see him out of his embarrassments. In 1620 his army was utterly routed at the battle of Weissenburg; and he and his family had just time to escape from the kingdom he had rashly undertaken to govern. Ferdinand drove to the uttermost the advantages of his victory. The Union was broken up; and Bohemia was placed under such a system of government that in becoming Catholic it lost more than two-thirds of its population, sank from high prosperity to a state of indigence, and ceased to be a seat of art and learning. The Spanish troops and the army of the League next invaded the Palatinate, which after severe struggles, was finally subdued; and there also the process of conversion was carried on with a thoroughness which ended in the death or exile of multitudes of the inhabitants. Frederick was banished from his inheritance; and the electorate he was declared to have forfeited was conferred on Duke Maximilian.

Danish war.

Wallenstein.

Thus ended the first stage of the Thirty Years' War. The second began (1625) by the formation, after much fruitless negotiation, of the Protestant League, which comprised England, Holland, and Denmark. The burden of the struggle fell on the last-named power, whose king, Christian IV., was also duke of Holstein, and therefore a prince of the empire. It was in the war with him that Europe first became familiar with the great name of Wallenstein, a Bohemian noble who, by marriage and by loyal service to the emperor, had risen to immense wealth and power. Ferdinand became restive at his dependence on the League, and gladly accepted Wallenstein's offer to raise an army over which it should have no control. This scheming, mysterious general, co-operating with Tilly and soon casting him into the shade, chased Christian, after the battle of Lutter, into Denmark, and overran Mecklenburg, of which he was created duke. He apparently intended to make himself master of the Hanse towns with the view of securing predominance at sea as well as on land; but this purpose was thwarted by the bravery of the city of Stralsund, which he in vain tried to conquer. Denmark, however, was compelled to conclude peace in 1629.

Edict of restitution.

Gustavus Adolphus.

Intoxicated by success, Ferdinand now issued the edict of restitution, demanding the restoration of all ecclesiastical lands of which the Protestants had become possessed since the treaty of Passau. As two archbishoprics and twelve bishoprics had become Protestant, this was to strike a tremendous blow at his enemies; and it stirred among them intense and universal opposition. At the same time, yielding to Duke Maximilian and other members of the League, he recalled Wallenstein, whose movements had given rise to suspicion. A more inauspicious moment could not have been chosen for these two important steps, for in 1630 Gustavus Adolphus left Sweden at the head of a well-disciplined army for the purpose of raising up the Protestant cause which had fallen so low. At first this great king was received coldly, even by his co-religionists. They were ignorant of his designs, and did not want a stranger to profit by the internal disputes of their country. A mistake at the outset would probably have proved fatal to him; but he saw the dangers of his position, and moved so warily that in less than a year he had obtained, partly by intimidation, partly by argument, the alliance of the duke of Pomerania and the elector of Saxony. Tilly, at the head of nearly the whole force of the League, met him at Breitenfeld, and was completely defeated. This victory put Germany at his feet; and had he realized how utterly he had broken the imperial strength, he might have advanced on Vienna itself. He preferred, however, to make the country around and behind him absolutely secure; and everywhere the cities opened their gates to him as the deliverer of the Protestants. After again defeating Tilly, who was wounded and died, he took possession of the palace at Munich, while Duke Maximilian fled. Whatever may have been the motives of Gustavus in undertaking this memorable expedition,—and they were probably not altogether unselfish,—he had the power of kindling confidence and enthusiasm among those who depended upon him; and the result of his presence in South Germany was that the faith of the Protestants in their cause and in themselves revived, and that they no longer doubted of ultimate victory. The emperor felt how great had been his mistake in dismissing Wallenstein, and after many fruitless entreaties, at last persuaded him to come forth from his retirement and form a second army. He did so on condition that he should have absolute command; and so urgent was the need of his services that Ferdinand allowed him to make himself in this way a great and dangerous power within the state. In 1632 he was defeated at the battle of Lützen; but the defeat was better than an ordinary victory, for the Swedish hero was among the slain. Wallenstein now aimed at becoming a great sovereign; perhaps he even aspired to the imperial crown itself. In any case his dilatory movements, his endless intrigues, and his haughty tone caused such profound uneasiness at Vienna that in 1634 he was got rid of by murder.

Richelieu.

For fourteen years longer, although the original objects of the war were almost forgotten, the tempest continued to sweep over Germany. It received a fresh impetus from the intervention of Cardinal Richelieu, who, although the enemy of Protestants in France, thought fit to weaken Austria by aiding them in Germany. While Gustavus Adolphus lived, Richelieu was kept comparatively in the background; after the king's death he was one of the mainsprings of the war. At last, in 1648, after five years of negotiation at Osnabrück and Münster, the peace of Westphalia was concluded.

Effects of the Thirty Years' War.

Religious freedom.

The Thirty Years' War settled once for all the principle that men should not be persecuted for their religious faith. It is true that the peace of Westphalia formally recognized only the three creeds, Catholicism, Lutheranism, and Calvinism, but so much suffering had been caused by the interference of the state with individual conviction, that toleration in the largest sense, so far as law was concerned, was virtually conceded. This was the sole advantage gained from the war by the Protestants. The Catholics insisted at first on keeping all the ecclesiastical lands which had been taken from them before the edict of restitution in 1630. The Protestants responded by demanding that they should lose nothing which they had held before 1618, when the war began. A compromise was at last effected by both parties agreeing to the date 1624—an arrangement which secured to the Catholics their immense gains in Bohemia and the other territories of the house of Hapsburg. The restoration of the elector palatine to part of his lands, and his reinstatement in the electoral office, were important concessions; but on the other hand, the duke of Bavaria kept the Rhenish palatinate, and as he remained an elector, the votes of the Protestants in the electoral college were fewer by one than they had been in 1618.

1629-1648.

Loss of territory.

The country suffered enormous territorial losses by the war. Up to this time the possession of Metz, Toul, and Verdun by France had never been officially recognized; now these bishoprics were formally conceded to her. She also received as much of Alsace as belonged to Austria. To the Swedes were granted Western Pomerania, with Stettin, and the bishoprics of Bremen and Verden. These acquisitions, which surpassed the advantages Gustavus Adolphus had hoped to win, gave Sweden the command both of the Baltic and of the North Sea. In virtue of her German possessions Sweden became a member of the empire; but France obtained absolute control of her new territories. There was a further diminution of Germany by the recognition of the independence of Switzerland and the United Provinces. Both had long been virtually free; they now for the first time took the position of distinct nations.

The Reformation and the political constitution.

In the political constitution of Germany the peace of Westphalia did not so much make changes as sanction those already effected. The whole tendency of the Reformation had been to relax the bonds which united the various elements of the state to each other and to their head. It divided the nation into two bitterly hostile parties, and the emperor was not able to assume towards them a perfectly impartial position. His imperial crown imposed upon him the necessity of associating himself with the Catholics; so that the Protestants had a new and powerful reason for looking upon him with jealousy, and trying to diminish his authority. The Catholics, while maintaining their religion, were willing enough to co-operate with them for this object; and Germany often saw the strange spectacle of princes rallying round the emperor for the defence of the church, and at the same time striking deadly blows at his political influence. The diet was a scene of perpetual quarrelling between the two factions, and their differences made it impossible for the imperial chamber to move beyond the region of official routine. Thus before the Thirty Years' War the empire had virtually ceased to exist, Germany having become a loose confederation of principalities and free cities. For a moment the emperor Ferdinand appeared to have touched the ideal of Charles V., in so far, at least, as it related to Germany, but only for a moment. The stars in their courses fought against him, and at the time of his death he saw how far beyond his power were the forces with which even Charles had been unable to contend. The state of things which actually existed the peace of Westphalia made legal. So nearly complete was the independence of the states that each received the right to form alliances with any of the others or with foreign powers, nominally on condition that their alliances should not be injurious to the emperor or to the empire. Any authority which still lawfully belonged to the emperor was transferred to the diet. It alone had now the power of making laws, of concluding treaties in the name of Germany, and of declaring war and re-establishing peace. No one, however, expected that it would be of any real service. After 1654 it became a permanent body, and was attended only by the representatives of the princes and the cities; and from that time it occupied itself mainly with trifles, leaving the affairs of each state to be looked after by its own authorities, and those of the country generally to such fortunes as chance should determine.

It would not have been strange if so shadowy an empire

Continuance of the empire.

had been brought altogether to an end. Some slight bond of connection was, however, necessary for defence against common dangers; and the empire had existed so long, and so many great associations were connected with it, that it seemed to all parties preferable to any other form of union. Moreover, Sweden, and other states which were now members of the empire, warmly supported it; and the house of Hapsburg, on which it reflected a certain splendor, would not willingly have let it die. An Austrian ruler, even when he spoke only in the name of Austria, derived authority from the fact that as emperor he represented many of the greatest memories of European history.

National life.

The effect of the Thirty Years' War on the national life was disastrous. It had not been carried on by disciplined armies, but by hordes of adventurers whose sole object was plunder. The cruelties they inflicted on their victims are almost beyond conception. Before the war the population was about twenty millions; after it the number was probably five or seven millions, and cannot have been more than ten. Whole towns and villages were laid in ashes, and vast districts turned into deserts. Churches and schools were closed by hundreds, and to such straits were the people often reduced that cannibalism is said to have been not uncommon. Industry and trade were so completely paralyzed that in 1635 the Hanseatic League was virtually broken up, because the members, once so wealthy, could not meet the expenditure it involved. The population was not only impoverished and reduced in numbers but broken in spirit. It lost confidence in itself, and for a time effected in politics, literature, art, and science little that is worthy of serious study.

The princes.

The princes knew well how to profit by the national prostration. The local diets, which, as we have seen, formed a real check on petty tyranny, and kept up an intimate relation between the princes and their subjects, were nearly all destroyed. Those which remained were injurious rather than beneficial, since they often gave an appearance of lawfulness to the caprices of arbitrary sovereigns. After the Thirty Years' War it became fashionable for the heirs of principalities to travel, and especially to spend some time at the court of France. Here they readily imbibed the ideas of Louis XIV., and in a short time every petty court in Germany was a feeble imitation of Versailles. Before the Reformation, and even for some time after it, the princes were thorough Germans in sympathies and habits; they now began to be separated by a wide gulf from their people. Instead of studying the general welfare, they cruelly wrung from exhausted states the largest possible revenue to support a lavish and ridiculous expenditure. The pettiest princeling had his army, his palaces, his multitudes of household officers; and most of them pampered every vulgar appetite without respect either to morality or decency. Many nobles whose lands had been wasted during the war, flocked to the little capitals to make their way by contemptible court services. Beneath an outward gloss of refinement these nobles were, as a class, coarse and selfish, and they made it their chief object to promote their own interests by fostering absolutist tendencies. Among the people there was no public opinion to discourage despotism; the majority accepted their lot as inevitable, and tried rather to reproduce than to restrain the vices of their rulers. Even the churches offered little opposition to the excesses of persons in authority, and in many instances the clergy, both Protestant and Catholic, acquired an unenviable notoriety for their readiness to overlook or condone actions which outraged the higher sentiments of humanity.

The cities.

In the free imperial cities there was more manliness of tone than elsewhere, but there was little of the generous rivalry among the different classes which had once raised them to a high level of prosperity. Most of them resigned their liberties into the hands of oligarchies, and others allowed themselves to be annexed by ambitious princes.

Modern Times.

Ferdinand III.

Ferdinand III. (1637–57) succeeded to the throne when the fortunes of his house were at a low ebb, and he continued the Thirty Years' War, not in the hope of re-establishing the Catholic religion or of restoring the imperial authority, but to undo as much as he could the havoc caused by his father's recklessness. After the conclusion of peace nothing happened to make his reign memorable.

Leopold I.

His son, Leopold I. (1658–1705), was a man of narrow intellect and feeble will; yet Germany seldom so keenly felt the need of a strong emperor, for she had during two generations to contend with a watchful and grasping rival. For more than a century it had been the policy of France to strengthen herself by fostering the internal dissensions of Germany.

Louis XIV. of France.

This was now easy, and Louis XIV. made unscrupulous use of the advantages his predecessors had helped to gain for him. Germany as a whole could not for a long time be induced to resist him. His schemes directly threatened the independence of the princes; but they were too indolent to unite against his ambition. They grudged even the contributions necessary for the maintenance of the frontier fortresses, and many of them stooped to accept the bribes he offered them on condition that they should remain quiet. In his war with the United Provinces and Spain, begun in 1672, he was opposed by the emperor as ruler of Austria, and by Frederick William, the elector of Brandenburg; and in 1675 the latter gained a splendid victory at Fehrbellin over his allies, the Swedes. At the end of the war, in 1678, by the peace of Nimeguen, Louis took care that Frederick William was deprived of the fruits of his victory, and Austria had to resign Freiburg in Breisgau to the French. Under the pretence that when France gained the Austrian lands in Alsace she also acquired a right to all places that had ever been united to them, Louis began a series of systematic robberies of German towns and territories. "Chambers of Reunion" were appointed to give an appearance of legality to these proceedings, which culminated, in 1681, in the seizure of Strasburg. Germans of all states and ranks were indignant at so gross a humiliation, but even the loss of Strasburg did not suffice to move the diet. The emperor himself might probably have interfered, but Louis had provided him with ample employment by stirring up against him the Hungarians and the Turks. So complete was his hold over the majority of the princes that when the Turks, in 1683, surrounded Vienna, and appeared not unlikely to advance into the heart of Germany, they looked on indifferently, and allowed the emperor to be saved by the promptitude and courage of Sobieski, king of Poland. At last, when, in 1689, on the most frivolous pretext, Louis poured into south Germany armies which were guilty of shameful outrages, a number of princes came forward and aided the emperor. This time France was sternly opposed by the league of which William III. of England was the moving spirit; and although at the end of the war he kept Strasburg, he had to give up Freiburg, Philipsburg, Breisach, and the places he had seized because of their former connection with Alsace.

War of Spanish succession.

In the war of the Spanish succession two powerful princes, the elector of Bavaria and the elector of Cologne, joined Louis; but as the states of the empire declared war against him in 1702, the other princes, more or less loyally, supported the emperor and his allies. Leopold died during the progress of this war, but it was vigorously continued by his son Joseph I. (1705–11).

Charles VI.

Charles VI. (1711–40) also went on with it; and such were the blows inflicted on France by the victories of Blenheim, Ramillies, and Malplaquet that the war was generally expected to end in her utter discomfiture. But the conclusion of the treaty of Utrecht by England, in 1713, so limited the military power of Charles VI. that he was obliged to resign the claims of Austria to the Spanish throne, and to content himself with the Spanish Netherlands, Milan, Naples, and Sardinia. He cared so little for Germany, as distinguished from Austria, that he allowed Louis to compel the diet to cede the imperial fortress of Landau. At a later stage in his reign he was guilty of an act of even grosser selfishness; for after the war of the Polish succession, in which he supported the claims of Augustus III., elector of Saxony, he yielded Lorraine to Leszczynski, whose claims had been defended by France, and through whom France ultimately secured this beautiful German province.

Pragmatic sanction.

Having no son, Charles drew up in 1713 the pragmatic sanction, which ordained that, in the event of an Austrian ruler being without male heirs, his hereditary lands and titles should pass to his nearest female relative. The aim of his whole policy was to secure for this measure, which was proclaimed as a fundamental law in 1724, the approval of

Europe; and by promises and threats he did at last obtain the guarantee of the states of the empire and the leading European powers.

Growth of Prussia.

Maria Theresa.

Germany was now about to be aroused from the torpor into which she had been cast by the Thirty Years' War; but her awakening was due, not to the action of the empire, which was more and more seen to be practically dead, but to the rivalry of two great German states, Austria and Prussia. The latter had long been laying the foundations of her power. Brandenburg, the centre of the Prussian kingdom, was, as we have seen, granted in the 15th century by the emperor Sigismund to Frederick, count of Hohenzollern. In his hands, and in those of his prudent successors, it became one of the most flourishing of the North-German principalities. At the time of the Reformation Albert, a member of a subordinate branch of the house of Hohenzollern, happened to be grand master of the Teutonic Order. He became a Protestant, dissolved the order, and received in fief of the king of Poland the duchy of Prussia. In 1611 this duchy fell by inheritance to the elector of Brandenburg, and by the treaty of Wehlau, in 1657, in the time of Frederick William, the Great Elector, it was declared independent of Poland. By skill, foresight, and courage Frederick William managed to add largely to his territories; and in an age of degenerate sovereigns he was looked upon as an almost model ruler. His son, Frederick, aspired to royal dignity, and in 1701, having obtained the emperor's assent, was crowned king of Prussia. The extravagance of Frederick drained the resources of his state, but this was amply atoned for by the rigid economy of Frederick William I., who not only paid off the debts accumulated by his father, but amassed an enormous treasure. He so organized all branches of the public service that they were brought to a point of high efficiency, and his army was one of the largest, best appointed, and best trained in Europe. He died in 1740, and within six months, when Frederick II. was on the Prussian throne, Maria Theresa claimed, in virtue of the pragmatic sanction, the lands and hereditary titles of her father, Charles VI.

Frederick the Great.

First Silesian war.

Charles VII.

Second Silesian war.

Frederick II., a young, ambitious, and energetic sovereign, longed not only to add to his dominions but to play a great part in European politics. His father had guaranteed the pragmatic sanction, but as the conditions on which the guarantee had been granted had not been fulfilled by Charles VI., Frederick did not feel bound by it, and revived some old claims of his family on certain Silesian duchies. Maria Theresa would not abate her rights, but before she could assert them Frederick had entered Silesia and made himself master of it. Meanwhile, the elector of Bavaria had come forward and disputed Maria Theresa's right to the succession, and the elector of Saxony had also put in a claim to the Austrian lands. Taking advantage of these disputes, France formed an alliance with the two electors and with the king of Prussia against Austria; and in the war which followed the allies were at first so successful that the elector of Bavaria, through the influence of France, was crowned emperor as Charles VII. (1742-45). Maria Theresa, a lady of a noble and undaunted spirit, appealed, with her infant son, afterwards Joseph II., in her arms, to the Hungarian diet, and the enthusiastic Magyars responded chivalrously to her call. To be more at freedom she concluded peace with Frederick, and ceded Silesia to him, although greatly against her will. Saxony also was pacified and retired from the struggle. After this Maria Theresa, supported by England, made way so rapidly and so triumphantly that Frederick became alarmed for his new possession; and in 1742 he once more proclaimed war against her, nominally in aid of the emperor, Charles VII. Ultimately, in 1748, she was able to conclude an honorable peace at Aix-la-Chapelle; but she had been forced, as before, to rid herself of Frederick by confirming him in the sovereignty of the territory he had seized.

Francis I.

After the death of Charles VII., Francis, grand duke of Tuscany, Maria Theresa's husband, was elected emperor. Francis I. (1745-65), an amiable nonentity, with the instincts of a shopkeeper, made no pretence of discharging important imperial duties, and the task of ruling the hereditary possessions of the house of Hapsburg fell wholly to the empress-queen. She executed it with discretion and vigor, so that Austria in her hands was known to be one of the most formidable powers in the world. Her rival, Frederick II., was, if possible, still more active. The bitter experiences of his youth, although they had soured his temper, had not quenched the generous aspirations which had been fed by study of the best writers of his time. It did not occur to him, any more than to the other German sovereigns of the 18th century, to associate his people with him in the government of the country; he was in every respect a thoroughly absolute sovereign. Even his ministers performed but the duties of superior clerks. But he shared the highest ideas of the age respecting the responsibilities of a king, and throughout his long reign acted in the main faithfully as "the first servant of the state." The army he always kept in readiness for war; but he also encouraged peaceful arts, and diffused throughout his kingdom so much of his own alert and aggressive spirit that the Prussians became more intelligent and more wealthy than they had ever before been. He excited the admiration of the youth of Germany, and it was soon the fashion among the petty princes to imitate his methods of government. As a rule, they succeeded only in raising far larger armies than the taxpayers could afford to maintain.

Preparations for war.

Maria Theresa never gave up the hope of winning back Silesia, and, in order to secure this object, she laid aside the jealousies of her house, and offered to conclude an alliance with France. Frederick had excited the envy of surrounding sovereigns, and had embittered them against him by stinging sarcasms. Not only France, therefore, but Russia, Saxony, and ultimately Sweden, willingly came to terms with Austria, and the aim of their union was nothing short of the partition of Prussia. Frederick, gaining knowledge of the plot, turned to England, which had in the previous war helped Austria. At the close of 1755 his offer of an alliance was acceded to; and in the following year, hoping by vigorously taking the initiative to prevent his enemies from united action, he invaded Saxony, and began the Seven Years' War (1756-63).

Results of the Seven Years' War.

The result of this war was to confirm Prussia for ever in the possession of Silesia, but it was followed by still greater indirect consequences. Prussia now took rank as one of the leading European powers, and by her rise a new element was introduced into the political life of Germany. Austria, although associated with the empire, could no longer feel sure of her predominance, and it was inevitable that the jealousies of the two states should lead to a final conflict for supremacy. Even before the Seven Years' War there were signs that the German people were tired of incessant imitation of France, for in literature they welcomed the early efforts of Klopstock, Wieland, and Lessing; but the movement received a powerful impulse from the great deeds of Frederick. The nation, as a whole, was proud of his heroic courage, his splendid military qualities, and his beneficent rule, and began, for the first time since the Thirty Years' War, to feel that it might once more assume a commanding place in the world. This stir of life ultimately revealed itself in the outburst of philosophic and literary activity represented by the names of Kant, Goethe, and Schiller. By that time Germany had not only asserted intellectual independence, but had become thoroughly tired of the national disunion and of the petty despotisms it imposed upon them.

Partition of Poland.

Joseph II.

In 1772 the necessities of Frederick's position compelled him to join Russia and Austria in the deplorable partition of Poland, whereby he gained West Prussia, exclusive of Dantzic and Thorn, and Austria acquired West Silesia. After this he had to watch closely the movements of the emperor Joseph II. (1765-90), who, although an ardent admirer of Frederick, was anxious to restore to Austria the greatness she had partially lost. The younger branch of the Wittelsbach line, which had hitherto possessed Bavaria, having died out in 1777, Joseph asserted claims to part of its territory. Frederick intervened, and although no battle was fought in the nominal war which followed, the emperor was obliged to content himself with a very unimportant concession. He made a second attempt in 1785, but Frederick again came forward. This time he formed a league for the defence of the imperial constitution, and it was joined by the majority of the small states. The memory of this league was almost blotted out by the tremendous events which soon absorbed the attention of Germany and the world, but it

1792–1813.

truly indicated the direction of the political forces which were then at work beneath the surface, and which long afterwards triumphed. The formation of the league was a distinct attempt on the part of Prussia to make herself the centre for the national aspirations both of northern and of southern Germany.

French Revolution.

The French Revolution was hailed by many of the best minds of Germany as the opening of a new era. Among the princes it excited horror and alarm, and in 1792 the emperor Leopold II. (1790–92), and Frederick William II., the unworthy successor of Frederick the Great, met at Pillnitz and agreed to support by arms the cause of the French king. A more important resolution was never taken. It plunged Europe into a conflict which cost millions of lives, and which overthrew the entire state system of the Continent. Germany herself was the principal sufferer. The structure which the princes had so laboriously built up crumbled into ruins, and the mistakes of centuries were expiated in an agony of disaster and humiliation.

The states of the empire joined Austria and Prussia, and, had there been hearty co-operation between the allies, they could scarcely have failed of success. While the war was in progress, in 1793, Prussia joined Russia in the second partition of Poland. Austria considered herself overreached, and began negotiations with Russia for the third and final partition, which was effected by the three powers in 1795. Prussia, irritated by the proceedings of her rival, did as little as possible in the war with France; and in 1795 she retired from the struggle, ceding to France her possessions on the left bank of the Rhine. The war was continued by Austria, but her power was so effectually shattered by blow after blow that in 1797 she was forced to conclude the peace of Campo Formio. Napoleon Bonaparte, to whose genius the triumph of France was mainly due, began separate negotiations with the states of the empire at Rastadt; but, before terms could be agreed upon, war again began in 1799, Austria acting on this occasion as the ally of England and Russia. She was beaten, and the peace of Lunéville added fresh humiliations to those imposed upon her by the previous war. France now obtained the whole of the left bank of the Rhine, the dispossessed princes being compensated by grants of secularized church lands and of mediatized imperial cities. The contempt of Napoleon for the empire was illustrated by his occupation of Hanover in 1803, and by his seizure of the duke of Enghien on imperial territory in 1804. In 1805 Austria once more appealed to arms in association with her former allies, but in vain. By the peace of Presburg she accepted more disastrous terms than ever, and for the moment it seemed as if she could not again hope to rise to her former splendor. In this war she was opposed not only by France, but by Bavaria, Würtemberg, and Baden, all of which were liberally rewarded for their services, the rulers of the two former countries being proclaimed kings. The degradation of Germany was completed by the formation, in 1806, of the confederation of the Rhine, which was composed of the chief central and southern states. The welfare of the empire was asserted to be its object, but a body of which Napoleon was the protector existed, of course, for no other purpose than to be a menace to Austria and Prussia. Francis II., who had succeeded Leopold II. in 1792, now resigned the imperial crown, and thus the empire and the German kingdom came to an end. The various states, which had for centuries been virtually independent, were during the next few years not connected even by a nominal bond.

Rhenish confederation.

End of the Holy Roman Empire.

Frederick William III. (1797–1840) of Prussia, the successor of Frederick William II., had held selfishly aloof from the struggle of Austria with France. Alarmed by the Confederation of the Rhine, he suddenly resolved on war. Napoleon gladly accepted the challenge, and Prussia was so ill-prepared for the contest she had invited that the first serious battle—the battle of Jena—prostrated her at his feet. Aided by Russia, the king held out some time longer; but when, after the battle of Friedland, in 1807, the czar was detached from the alliance, Frederick William had to sign the treaty of Tilsit, by which he was deprived of the best part of his kingdom and of more than half his subjects.

In 1809 Austria made one more attempt to retrieve her fortunes, and at first not without success. After the battle of Wagram, however, Napoleon dictated peace from Vienna.

Revival of Germany.

Germany was now thoroughly in the grip of France, and the French emperor proved how absolute was his power by annexing, in 1810, the whole northern coast as far as the Elbe. The completeness of the humiliation of Germany was the means of her deliverance. She had been taught self-respect by Frederick II., and by her great writers in literature and philosophy; it was felt to be intolerable that in politics she should do the bidding of a foreign master. Among a large section of the community patriotism became for the first time a consuming passion, and it was stimulated by the counsels of several manly teachers, among whom the first place belongs to Fichte. The Governments responded prudently to the national movement. Even in Austria timely concessions were made to her various populations. Prussia, under the guidance of her great minister Stein, reorganized her entire administration. She abolished serfdom, granted municipal rights to the cities, established an admirable system of elementary and secondary education, and invited all classes to compete for civil offices; and ample means were provided for the approaching struggle by drastic military reform. Napoleon had exacted an engagement that the Prussian army should be limited to 42,000 men. This was fulfilled in the letter, but in spirit set aside, for one body of men was trained after another until the larger part of the male population were in a position, when a fitting opportunity should occur, to take up arms for their country.

Deliverance of Germany.

The disastrous retreat of the French from Moscow in 1812 gave Germany the occasion she desired. In 1813 Prussia formed an alliance with Russia, which was ultimately joined by Austria, and in the great battle of Leipsic the issue was virtually settled. The first peace of Paris was soon followed by the escape of Napoleon from Elba; but in the battle of Waterloo he was decisively overcome, and Europe had no more to fear from his ambition. The Germans believed that by the second peace of Paris they ought to have received back all the lands which had ever been taken from them by France, but they had to content themselves with the recovery of their boundary as it had existed in 1792.

Congress of Vienna.

Between the conclusion of the first and the second peace of Paris the congress of Vienna had met and finished its labors. It was hard to reconcile the conflicting claims of so many states, and no party was fully satisfied with the compromise arrived at. The kingdom of Westphalia, and several other states set up by Napoleon, were brought to an end. Prussia was compensated for her losses by receiving a part of Saxony, the Rhineland, and Swedish Pomerania; and to Austria were restored Salzburg, Vorarlberg, and Tyrol. Most of the members of the Rhenish Confederation were either left alone or deprived of small portions of territory; Hanover was made a kingdom; Weimar, Mecklenburg, and Oldenburg became grand duchies; and Lübeck, Bremen, Hamburg, and Frankfort were declared free cities.

German confederation.

In regard to the political constitution of Germany, the people were prepared for great and far-reaching changes. The need of union had been impressed upon them by the bitter experiences of nearly a generation, and they would have welcomed the establishment of a vigorous empire. But the jealousies of Austria and Prussia, and the hostility of the petty princes, prevented the popular policy from being adopted. Instead of an empire the congress formed the German bund or confederation. It was composed of 39 states, each of which was to be independent in regard to its internal affairs, the confederation taking cognizance only of matters of common interest. A permanent diet, in which each state should have its representative, was formed; it was to sit in Frankfort, and to be presided over by the Austrian plenipotentiary. This body was to settle all disputed questions between the various states, each of which engaged never to make war on any of the others, nor to form alliances which should be injurious to a member of the bund.

Popular desire for freedom.

The events which arose from the French Revolution had awakened in the German mind not only a passionate desire for unity but an equally intense wish for freedom. Growing intelligence had revealed to the people that personal rule is ill-adapted to the wants of a civilized community, especially the personal rule of such men as the majority of their princes, who clung obstinately to every kind of abuse, and regarded their functions as a means rather of glorifying themselves than of promoting the general welfare. Humiliating as had been their submission to France, it had done something to deepen this conviction, for in the districts ruled by French officials a higher idea of human rights was introduced than had before prevailed, and what was great and attractive in the principles of the Revolution stirred general sympathy. So urgent were the demands for free government that, while the struggle with Napoleon remained undecided, the princes made lavish promises of concession after peace should be restored. The act of confederation contained a positive decree that in each state should be established a constitutional system.

Disloyalty of German sovereigns.

Carlsbad decrees.

Revolution of 1830.

The history of the next period is little more than a history of the elaborate and pitiful devices by which the German sovereigns evaded their engagements. Within a few years, indeed, the rulers of Nassau, Weimar, Bavaria, Baden, and Würtemberg granted constitutions, but even in these countries absolutism was only in a slight degree modified. In Austria, where Prince Metternich was the controlling spirit, the most diverse nationalities were governed as if they had been a single people, and the methods of rule were as despotic and harsh as could be tolerated in a modern community. Although Frederick William III. of Prussia could not act upon quite so antiquated a system as Francis I., he resisted popular aspirations. The utmost concession he made was to appoint a number of provincial diets, which tended rather to foster than to allay the general discontent. Every opportunity was seized by the various Governments to repress the free movement of ideas. A number of students were guilty of some follies at a festival in the Wartburg, and some time afterwards, a fanatical youth stabbed Kotzebue, the play-wright, who had sided with the reactionary party. These incidents were held to be symptoms of a grave peril; and in 1819 a conference of ministers at Carlsbad issued what were called the Carlsbad decrees, placing the universities under police supervision, reviving a rigid censorship, and opposing the cession of state constitutions. A central commission of inquiry was also appointed for the purpose of hunting out secret societies, the very existence of which was merely subject of conjecture. In the diet, whose authority was slighted by these decrees, there were several members favorable to a conciliatory policy; and in the small states liberal politicians continued to demand parliamentary representation. The reactionists, however, were united and determined, and succeeded in thwarting political progress until 1830. Even in that year the Prussian and Austrian Governments were able to hold on in their old path, but the French Revolution caused so loud an outcry in countries in which the police were less powerful, that Hanover, Brunswick, Saxony, and Hesse-Cassel received constitutions, and in the lands where parliaments already existed the Governments granted freedom of the press, and promised more liberal legislation for the future. The two leading powers looked upon these changes with extreme disapproval, and they soon made use of the diet as a means of virtually annulling every measure that conflicted with their own aims. When the diet was instituted, it had been hoped that it would ultimately lead to closer national unity, and to the establishment of modern political institutions. It was now seen to be a mere instrument in the hands of the enemies both of unity and of liberty. So soon did the princes pluck up courage that in 1837 Ernest Augustus, who succeeded William IV. of England as king of Hanover, abolished the constitution which his predecessor had sanctioned, and set up another of an earlier period and of a far less liberal character. This unlawful act met with resistance which had to be put down by force. An appeal on behalf of the constitution was made to the diet, but with the result that was to be expected from its previous action; it declined to consider the question.

Zollverein.

During this dismal period almost the sole political event on which Germans can look back with pleasure is the formation of the Zollverein or customs union. As in all other respects, the bund had failed to realize the expectations it had excited respecting the abolition of injurious restrictions on commerce. Several attempts had been made by groups of states to regulate their customs, but none of them had been attended with much success. At last Prussia arrived at an understanding with Bavaria, Würtemberg, and several other states, and between 1833 and 1835 the union thus formed was joined by all German countries with the exception of Austria. It happened that about this time railways began to be introduced. The customs union enabled the nation to derive from them the utmost possible benefit, so that the prevalent political confusion did not hinder the population from attaining to considerable material prosperity. The obvious advantages of commercial union deepened the desire for unity in every great department of the national life, and at the same time raised the position of Prussia, which had been wise enough to associate itself with a most important movement.

Frederick William IV. of Prussia.

It was not only by its relation to the customs union that Prussia attracted the attention and awakened the hopes of German liberals. In 1840 Frederick William IV. (1840–61) succeeded his father, and, as he was known to be a thoughtful and cultivated prince, there was a general expectation that he would abandon the arbitrary ideas of Frederick William III. He began his reign well. For some years the Government had been in conflict with the Catholic Church; the struggle was at once ended by graceful concessions. The king pardoned political prisoners, restored to their offices certain professors who had been degraded during the previous reign for supposed revolutionary tendencies, and welcomed to the Berlin University the brothers Grimm, who, with five other professors, had been driven from Göttingen for protesting against the violence of Ernest Augustus. But it soon became manifest that Frederick William's favorite conception of "the Christian state" did not include any genuine exercise of political power by the nation; he wished to rule in a more enlightened spirit than his father, but not less absolutely. It was arranged that the provincial diets established by Frederick William III. should meet periodically, but this was a poor substitute for the great positive measures which had been anticipated. And within a very few years "the Christian state" was found to be compatible with a strict censorship, with the arbitrary punishment of schoolmasters, clergymen, and judges who did not meet the approval of the Government, and generally with incessant and irritating interference with the private life of the individual. The king lost all the popularity he had acquired in the early days of his reign by vaguely enthusiastic promises, and impartial observers saw that he and his people must sooner or later enter upon a serious struggle. A like state of things existed all over Germany. The German, Hungarian, Slavonic, and Italian subjects of the emperor Ferdinand (1835–48), who succeeded Francis I., were all agitating for reform; and in Bavaria, Hesse-Cassel, and Baden reactionary ministers were confronted by opponents who daily acquired increased influence among the masses of the population.

Prussian united diet.

In so many threatening forms did the rising spirit of the Prussian people reveal itself that in 1847 the king summoned to Berlin a united diet composed of the representatives of the provincial diets. This assembly truly expressed the popular feeling, but with so much moderation, and accompanying its demands by so many sincere assurances of loyalty, that it could not alarm the most timid. Frederick William, however, was offended by its tone, and haughtily proclaimed that he would never abate the rights which, as a lawful prince, he held by a higher than human authority.

Revolution of 1848.

Such was the condition of Germany at the breaking out of the French revolution of 1848. Its effect upon the public mind was immediate and profound. It had been made clear that no dependence was to be placed upon the engagements of the sovereigns, and that if anything was to be done it must be done by the people themselves. At a convention in Mannheim four demands were formulated—freedom of the press, trial by jury, national armies, and national representation. These demands were universally adopted as the liberal programme; and within a few days there was a liberal ministry in every one of the small states. In Bavaria, King Louis, whose well-meant efforts to make Munich a centre of art had not induced the nation to forget its political rights, resigned the crown to his son Maximilian. The popular excitement in Austria became so intense that Prince Metternich was dismissed, constitutional government was promised, and the Hungarians received a new cabinet. Still more vehement was the revolutionary movement in Prussia. Scenes of great violence occurred

1848.

in the streets of Berlin, and on the 18th of March the king, who had previously tried to allay the storm by announcing that the united diet should meet periodically,—a concession he had refused to make at the proper moment,—declared that the national desire for a constitution should be satisfied. There was, however, a general feeling of distrust, and a conflict, which continued till the following morning, broke out between the troops and the population. Frederick William, who, although an ardent upholder of the divine right of kings, was too kind-hearted a man and too timid to approve of a struggle of this kind, laid aside his high pretensions, changed his ministers, and asserted that he would place himself at the head of the national movement. By these means a more pacific temper was restored, and, after the united diet had passed an electoral law, the country was called upon to choose a national assembly.

National union.

It was not only reform in the individual states that was demanded in 1848; the majority of the people felt that the time had come for sweeping away the effete bund which had done service only to the enemies of freedom, and for replacing it by a system of national representation which should maintain the dignity of Germany abroad and foster enlightened institutions at home. There was, indeed, a general conviction that only by means of a great central movement could the special agitations lead to enduring results. A number of deputies, belonging to different legislative assemblies, taking it upon themselves to give voice to the national demands, met at Heidelberg, and a committee appointed by them invited all Germans who then were, or who had formerly been, members of diets, as well as some other public men, to meet at Frankfort for the purpose of considering the question of national reform.

Preliminary parliament of Frankfort.

About 500 representatives accepted the invitation. They constituted themselves a preliminary parliament, and at once began to provide for the election of a national assembly. It was decided that there should be a representative for every group of 50,000 inhabitants, and that the election should be by universal suffrage. A considerable party wished that the preliminary parliament should continue to act until the assembly should be formed, but this was overruled, the majority contenting themselves with the appointment of a committee of 50, whose duty it should be in the interval to guard the national interests. Some of those who were discontented with this decision retired from the preliminary parliament, and a few of them, of republican sympathies, called the population of Upper Baden to arms. The rising was put down by the troops of Baden, but it did considerable injury by awakening the fears of the more moderate portion of the community. Great hindrances were put in the way of the elections, but, as the Prussian and Austrian Governments were too much occupied with their immediate difficulties to resist to the uttermost, the

Frankfort assembly.

assembly was at last chosen, and met at Frankfort on the 18th May. The old diet broke up, and the national representatives had before them a clear field. There is no reason to doubt that if they had acted with promptitude and discretion they would have succeeded in the task they had undertaken. Neither Austria nor Prussia was for some time in a position to thwart them, and the sovereigns of the smaller states were too much afraid of the revolutionary elements manifested on all sides to give way to reactionary impulses. But the Germans had had no experience of free political life. Nearly every deputy had his own theory of the course which ought to be pursued, and felt sure that the country would go to ruin if it were not adopted. Learned professors and talkative journalists insisted on delivering interminable speeches, and on examining in the light of ultimate philosophical principles every proposal laid before the assembly. Thus precious time was lost, violent antagonisms were called forth, the patience of the nation was exhausted, and the reactionary forces were able to gather strength for once more asserting themselves. The very first important question brought out the weaknesses of the deputies. This related to the nature of the central provisional executive. A committee appointed to discuss the matter suggested that there should be a directory of three members, appointed by the German Governments, subject to the approval of the assembly, and ruling by means of ministers responsible to the latter body. This elaborate scheme found favor with a large number of members, but others insisted that there should be a president or a central committee, appointed by the assembly, while another party pleaded that the assembly itself should exercise executive as well as legislative functions. At last, after a vast amount of tedious and useless discussion, it was agreed that the assembly should appoint an imperial vicar who should carry on the government by means of a ministry selected by himself; and, by the decision of a large majority, the archduke John of Austria was chosen for the office. With as little delay as possible he formed an imperial cabinet, and there were hopes that, as his appointment was generally approved both by the sovereigns and the people, more rapid progress would be made with the great and complicated work in hand. Unfortunately, however, it was necessary to enter upon the discussion of the fundamental laws, a subject presenting many opportunities for the display of rhetoric and intellectual subtlety. It was soon obvious that beneath all varieties of individual opinion there were two bitterly hostile tendencies—those of the republicans, and those of the constitutionalists. These two parties attacked each other with constantly growing animosity, and in a few weeks sensible men outside the assembly gave up all hope of their dealing satisfactorily with the problem they had been appointed to solve.

Schleswig-Holstein.

In the midst of these disputes the attention of the nation was occupied by a question which had arisen before the outbreak of the revolutionary movements,—the so-called "Schleswig-Holstein question." In 1846 Christian VIII. of Denmark had officially proclaimed that Schleswig and the greater part of Holstein were indissolubly connected with the Danish monarchy. This excited vehement opposition among the Germans, on the ground that Holstein, although subject to the king of Denmark, was a member of the German confederation, and that in virtue of ancient treaties it could not be severed from Schleswig. In 1848 the German party in the duchies, headed by Prince Frederick of Augustenburg, rose against the Danish Government. Frederick VII., who had just succeeded Christian VIII., put down the rebellion, but Prussia, acting in the name of the confederation, despatched an army against the Danes, and drove them from Schleswig. The Danes, who were supported by Russia, responded by blockading the Baltic ports, which Germany, having no navy, was unable effectually to defend. By the mediation of England an armistice was concluded, and the Prussian troops evacuated the northern districts of Schleswig. As the Danes soon afterwards took possession of Schleswig again, the Prussians once more drove them back, but on the 26th of August an armistice of seven months was agreed upon at Malmoe.

Disputes in the Frankfort assembly.

The new Frankfort Government disapproved the conditions of this armistice; but, as it had empowered Prussia to act for it, it was obliged to accept what had been done. The majority of the assembly, furious at an arrangement which was denounced as a national humiliation, decided that the armistice should not be sanctioned. The ministry resigned; but, a new combination being impossible, it was replaced, and the assembly unwillingly agreed to accept the armistice, on the understanding that the Government should lose no time in negotiating for peace on fair terms. A large minority, however, was intensely dissatisfied, It was composed of the republicans and other radical sections; and when defeated, they appealed from the assembly to the people. The Government kept its place, but was unable to prevent a rising which led to the murder of two unpopular representatives. There were also temporary republican agitations in Baden and Würtemberg.

The revolution in Austria.

While these events were in progress, it seemed not impossible that the Austrian empire would fall to pieces. Bohemia and the Italian states were in revolt, and the Hungarians strove with passionate earnestness for independence. Towards the end of 1848 Vienna, was completely in the hands of the revolutionary party, and it was retaken only after desperate fighting. A reactionary ministry, headed by Prince Schwarzenberg, was then raised to power, and in order that a strong policy might be the more vigorously pushed forward, the emperor Ferdinand resigned, and was succeeded by his nephew Francis Joseph.

Reform in Prussia.

The prospects of reform were not much more favorable in Prussia. The assembly summoned amid the revolutionary excitement of March met on the 22d May. Demands for a constitutional system were urged with great force, and they would probably have been granted but for the opposition due to the violence of politicians out of doors. The aristocratic class saw ruin before it if the smallest concession were made to popular wishes, and it soon recovered from the terror into which it had been plunged at the outbreak of the revolution. Extreme antagonism was excited by such proposals as that the king should no longer be said to wear his crown "by grace of God;" and the animosity between the liberal and the conservative sections was driven to the highest pitch when, in the midst of the struggle between the populace and the Government in Vienna, it was proposed that Prussia should support the cause of freedom. The motion, although at first rejected, was passed in a modified form. Before this, ministry after ministry had been appointed, but none had been so decidedly reactionary as to preclude the hope of a settlement. Now the king resolved to break finally with the liberals, and, notwithstanding a solemn warning addressed to him by a deputation from the assembly, he called to office a cabinet about whose intentions there could be no misunderstanding. On the pretext that fair deliberation was impossible in the capital, the assembly was ordered to meet in Brandenburg, troops were concentrated near Berlin, and a state of siege was proclaimed. In vain the assembly protested and continued its sittings, going even so far as to forbid the payment of taxes while it was subjected to illegal treatment. It was forced in the end to submit, but the discussions in Brandenburg were no more successful than those in Berlin. At last, on the 5th December, the king dissolved the assembly, granted a constitution about which it had not been consulted, and gave orders for the election of a representative chamber.

Frankfort assembly and the new constitution.

About the time that the Prussian parliament was thus created, and that the emperor Ferdinand resigned, the Frankfort assembly succeeded in formulating the fundamental laws, which were duly proclaimed to be the fundamental laws of Germany as it was now to be constituted. The principal clauses of the constitution then began to be discussed. By far the most difficult question was the relation in which Austria should stand to the Germany of the future.

Germany and Austria.

There was a universal wish that the Austrian Germans should be included in the German state; on the other hand, it was felt that if all the various nationalities of Austria formed a united monarchy, and if this monarchy as a whole were included in the confederation, it would necessarily overshadow Germany, and expose her to unnecessary external dangers. It was therefore resolved that, although a German country might be under the same ruler as non-German lands, it could not be so joined to them as to form with them a single nation. Had the assembly adopted this resolution at once, instead of exhausting itself by pedantic disquisitions on the abstract principles of jurisprudence, it might have hoped to triumph; but Austria was not likely to submit to so severe a blow at the very time when she was strong enough to appoint a reactionary Government, and had nearly re-established her authority, not only in Vienna, but in Bohemia and in Italy. Prince Schwarzenberg took the earliest opportunity to declare that the empire could not assent to any weakening of its influence. Bitter strife now broke out in the assembly. Two of the ministers resigned, and one of those who took their place, Herr von Gagern, proposed that, since Austria was to be a united state, she should not enter the confederation, but that her relations to Germany should be regulated by a special act of union. This of course meant that Prussia should be at the head of Germany, and recommended itself to the majority of the constitutional party. It was resisted by the Austrian members, who were supported by the ultramontanes and the democrats, both of whom disliked Prussia, the former because of her Protestantism, the latter because of her bureaucratic system. Herr von Gagern's proposal was, however, adopted. Immediately afterwards the question as to the character of the executive was raised. Some voted that a directory of princes should be appointed, others that there should be a president, eligible from the whole German nation; but the final decision was that the headship of the state should be offered by the assembly to some particular German prince, and that he should bear the title of emperor of the Germans.

Proposed empire.

The whole subject was as eagerly discussed throughout the country as in Frankfort. Austria firmly opposed the idea of a united German state, insisting that the Austrian emperor could not consent to be subordinate to any other prince. She was supported by Bavaria, but on the other side were Prussia, Brunswick, Baden, Nassau, Mecklenberg, and various other countries, besides the Hanseatic towns. For some time Austria offered no counter scheme, but she ultimately proposed that there should be a directory of seven princes, the chief place being held alternately by a Prussian and an Austrian imperial vicar. Nothing came of this suggestion, and in due time the assembly proceeded to the second reading of the constitution. It was revised in a democratic sense, but the imperial title was maintained, and a narrow majority decided that it should be hereditary. Frederick William IV. of Prussia was then chosen emperor.

Frederick William IV. declines the imperial crown.

All Germany awaited with anxiety the reply of Frederick William. It was thought not improbable that he would accept the honor offered him, for in the early part of his reign he had spoken of German unity as enthusiastically as of liberty, and, besides, the opportunity was surprisingly favorable. The larger number of the North German states were at least not unwilling to submit to the arrangement; and Austria, whose opposition in ordinary circumstances would have been fatal, was paralyzed by her struggle with Hungary. Frederick William had not, however, the courage of his opinions; the deputation which waited upon him was dismissed with the answer that he could not assume the imperial title without the full sanction of the princes and the free cities.

End of Frankfort assembly.

This answer was in reality a deathblow to the hopes of German patriots, but the assembly affected to believe that its cause was not yet lost, and appointed a committee to see that the provisions of the constitution were carried out. A vigorous agitation began in the country for the acceptance of the constitution by the Governments. The king of Würtemberg was forced to accede to it; and in Saxony, Baden, and Rhenish Bavaria armed multitudes kept the sovereigns in terror. Prussia, which, following the example of Austria, had recalled her representatives from Frankfort, sent her troops to put down these risings, and on the 21st May, 1849, the larger number of the deputies to the assembly voluntarily resigned their seats. A few republican members held on by it, and transferred the sittings to Stuttgart. Here they even elected an imperial Government, but they had no longer any real influence, and on the 18th June they were forcibly dispersed by the Würtemberg ministry.

The Union.

Although Frederick William had refused to become emperor, he was unwilling to miss altogether the opportunity afforded by the difficulties of Austria. He invited the states to send representatives to Berlin to discuss the condition of Germany; and he concluded a treaty with the kings of Saxony and Hanover. Two days afterwards the three allies agreed upon a constitution which was in many respects identical with that drawn up by the Frankfort assembly. The functions of the executive were, however, extended, the electoral law was made less democratic, and it was decided that, instead of an emperor, there should be merely a supreme chief aided by a college of princes. This constitution was accepted by a number of states, which assumed the name of "The Union," and on the 20th March, 1850, a parliament consisting of two houses met in Erfurt. Both houses accepted the constitution; and, immediately after they broke up, the members of the Union assembled in Berlin, and a provisional college of princes was elected. By that time, however, the whole situation of Germany had changed. In the autumn of 1849 Austria had succeeded, by the help of Russia, in quelling the Hungarian insurrection, and she was then in no mood to let herself be thrust aside by Prussia. Encouraged by her, Hanover and Saxony had severed themselves from the Union, and Saxony, Würtemberg, and Bavaria arrived at an understanding as to a wholly new constitution. Afterwards all four states, with several others, accepted the invitation of Austria to consider the propriety of re-establishing the Confederation. The representatives of the states favorable to this proposal came together in Frankfort on the 4th September, 1850, and acted as the restored diet.

Austria and Prussia.

Thus the issue to which the events of about a century had been pointing was apparently raised; Germany was divided into two hostile parties, one set of states grouping themselves around

1850-1855.

Disturbance in Hesse-Cassel.

Austria, another around Prussia. A difficulty which arose in Hesse-Cassel almost compelled the powers to bring their differences to the test of war. In this small state the liberal movement of 1848 had been followed by reaction and the elector ventured to replace Hassenpflug, the unpopular minister who had been driven from power. Hassenpflug, being detested by the chamber, dissolved it in June, 1850; but the new one was not less hostile, and refused to sanction the collection of the taxes until it had considered the budget. For this offence it also was dissolved, and orders were issued for the raising of the taxes without its consent. Many officials refused to obey; the judges remained loyal to the constitution; and when attempts were made to solve the difficulty by the army, the officers instructed to act resigned in a body. Meanwhile, Hassenpflug had appealed to the representatives in Frankfort who claimed to be the restored diet, and under the influence of Austria they resolved to support him. Prussia, on the other hand, announced its determination to carry out the principles of the Union, and to maintain the Hessian constitution. Austrian and Bavarian troops having entered Hesse, a Prussian army immediately occupied Cassel, and war appeared to be imminent. Prussia, however, shrank from the conflict. Radowitz, the foreign minister, who had so far pursued a vigorous policy, retired, and was replaced by Manteuffel, who, although the whole Prussian army was mobilized, began by making concessions. The Union was dissolved; and after Austria had despatched an ultimatum formulating her demands, the new minister met Prince Schwarzenberg at Olmütz, and virtually yielded everything he insisted upon. The difficulty in Hesse was to be left to the decision of the German Governments; and as soon as possible ministerial conferences were to be held in Dresden, with a view to the settlement of the German constitution.

Conference at Olmütz.

Diet restored.

These conferences began in the last days of 1850. The Austrian government strove to secure the appointment of a stronger executive than had hitherto existed; but its proposals met with steady opposition from Prussia. Every Prussian scheme was in like manner resisted by Austria. Thus, from the sheer inability of the assembled ministers to devise a plan on which all could agree, Prussia and the states that had joined her in the Union were compelled to recognize the Frankfort diet. From the 12th June, 1851, its sittings went on as if nothing had occurred since it was dispersed.

Schleswig-Holstein.

This wretched fiasco was hardly less satisfactory to the majority of Germans than the manner in which the national claims in Schleswig-Holstein were maintained. The armistice of Malmoe having expired in March, 1849, the war with Denmark was resumed. A considerable army was despatched against the Danes by the Frankfort Government, but on the 10th July an armistice was signed at Berlin for six months, and a year afterwards Prussia concluded peace. The inhabitants of the duchies, however, continued the war. During the interview at Olmütz between Count Manteuffel and Prince Schwarzenberg it was agreed that, like the affairs of Hesse-Cassel, those of Schleswig-Holstein should be submitted to the decision of all German states, but that, in the meantime, Prussia and Austria should act together. By the intervention of Austrian troops peace was restored; and when, early in 1852, the Government of Denmark, in providing a constitution for the whole monarchy, promised to appoint separate ministers for Schleswig and Holstein, and to do equal justice to the German and the Danish populations, the two powers declared themselves satisfied, and the Austrian forces were withdrawn. The diet also, after some delay, professed to be content with this arrangement. While it was discussing the subject, a conference of the European powers met in London, and settled that Frederick VII. of Denmark should be succeeded by Christian, duke of Glücksburg, and that the duchies should be indissolubly united to the Danish monarchy. Austria and Prussia accepted the protocol setting forth these results, but it was not signed by the diet.

Austria and the customs union.

In all these later events the first place had been taken by Austria. The temporary dissolution of the customs union in 1851 gave her an opportunity of trying to extend her influence; she demanded that a union should be formed of which she should be the leading member. A congress of all German states, with the exception of Prussia and one or two states which sympathized with her, was held in Vienna; and it was followed by several other congresses favorable to Austrian pretensions. Prussia, however, being here on strong ground, refused to give way; and not only was the customs union restored in accordance with her wishes, but Austria concluded with her in 1853 a treaty of commerce which embodied some important concessions.

Political reaction.

Germany had now fairly entered a period which, although it did not last very long, was, in some respects, as humiliating as any in her history. The popular movement, from which great things had been hoped, had on some occasions almost touched its goal; and, as might have been expected, a reaction set in, which the princes knew how to turn to the fullest advantage. The Austrian Government, after the subjection of Hungary, withdrew every concession it had made under pressure, and established a thorough despotism, trampling upon the rights of the individual nationalities, and forcing all its subjects into a common political mould. In Prussia the parliament, summoned by the king on the 5th December, 1848, met early in the following year. Although the democrats had declined to vote, it was not conservative enough for the court, and not till the 31st January, 1850, was an understanding arrived at respecting the constitution. The system thus established was repeatedly revised, and always with the same object—to reduce to a minimum the power of the national representatives, and to exalt and extend that of the Government. At the same time the ministry persecuted the press, and allowed hardly a whisper of discontent to pass unpunished. The smaller states followed with alacrity in the steps of the two leading powers. The liberal ministries of 1848 were dismissed, the constitutions were changed or abolished, and new chambers were elected under a severely restricted suffrage. Had the battle been fairly fought out between the Governments and the people, the latter would still have triumphed; but the former had now, in the Frankfort diet, a mightier instrument than ever against freedom. What it could do was seen too clearly from the case of Hesse-Cassel. After the settlement of Olmütz, federal troops occupied that country, and federal execution was carried out with shameful harshness. Martial law was everywhere proclaimed; officers, and all classes of officials who had incurred the displeasure of the Government, were subjected to arbitrary penalties; and such was the misery of the people that multitudes of them were compelled to emigrate. The constitution having been destroyed by the bund, the elector proclaimed one of his own making; but even the chamber elected under the provisions of this despotic scheme could not tolerate his hateful tyranny, and there were incessant disputes between it and the Government. The bund interfered in a like spirit in Hanover, although with less disastrous results, after the accession of George V. in 1851. For the whole of Germany this was emphatically the period of petty despotism; and not only from Hesse but from all parts of the country there was a vast stream of emigration, mainly to the New World.

Crimean war.

The outbreak of the Crimean war profoundly moved the German nation. The sympathies of Austria were necessarily with the Western powers, and in Prussia the majority of the people took the same side; but the Prussian Government, which was at this time completely under the control of Russia, gave its moral support to the czar. It did, indeed, assent to a treaty—afterwards signed on behalf of the bund—by which Prussia and Austria guaranteed each other, but it resolutely opposed the mobilization of the confederate army. The Prussian people were keenly irritated by the cordial relations between their court and the most despotic power in Europe. They felt that they were thus most unjustly separated from the main stream of Western progress.

During the Crimean war the political reaction continued with unabated force. In Prussia the Government appeared resolved to make up for its temporary submission to the popular will by the utmost violence on which it could venture. A general election took place in the autumn of 1855, and so harshly was the expression of opinion restrained that a chamber was returned with scarcely a single liberal element of serious importance. The feudalists called for a still further revision of the constitution, and urged that even the reforms effected by Stein should be undone. In Bavaria a chamber elected about the same time as that of

Prussia was rather less docile; but the Government shared to the full the absolutist tendencies of the day, and energetically combated the party which stood up for law and the constitution. The Hanoverian government, backed by the Frankfort diet, was still more successful in its warfare with the moderate reformers whom it was pleased to treat as revolutionists; and in Austria the feudalists so completely gained the upper hand that on the 18th August, 1855, the Government signed a concordat, by which the state virtually submitted itself to the control of the church.

Prussia and Switzerland.

Liberalism in Prussia.

The German people seemed to have lost both the power and the will to assert their rights; but in reality they were deeply dissatisfied. And it was clear to impartial observers that, in the event of any great strain upon the power of the Governments, the absolutist system would break down. The first symptom that the reaction had attained its utmost development displayed itself in Prussia, whose attention was for a time distracted from home politics by a quarrel with Switzerland. The Swiss authorities had imprisoned some foolish royalists of Neuchâtel, in which the house of Hohenzollern had never resigned its rights. War was threatened by Prussia, but when the prisoners were set free, the two states entered upon negotiations, and in the summer of 1857 King Frederick William withdrew all claims to the principality. Soon after this, the mental condition of the king made it necessary that his duties should be undertaken by a substitute, and his brother, the Prince of Prussia, took his place for three months. In October, 1858, the prince became regent; and as he was unfavorable to the policy which had hitherto been pursued, he appointed a new ministry of a moderately liberal character. A general election was ordered; and, the free action of the constituencies being in no way interfered with, they returned a parliament in which the feudalists held the place that had belonged to the liberals in the previous chamber. No more thorough proof could have been given of the liberal sentiments of the population, and the effect was soon seen in the growing hopefulness of the liberal party in every German state.

Franco-Austrian war in Italy.

The Italian war of 1859, in which Austria found herself opposed by France and Sardinia, excited vehement interest in Germany. A section of the liberal party would have been pleased had Prussia taken the occasion to reconstitute the confederation by excluding Austria; but Prussia was so far from attempting this that she put herself in a state of readiness for war with France. After the battle of Magenta she mobilized part of her army, and gave her assent to the placing of confederate troops on the upper Rhine. These measures induced the emperor Napoleon to conclude a hasty peace; but Austria was bitterly offended because she had not received the open support both of the bund and of Prussia.

The misfortunes of Austria in this war brought to light the instability of the absolutist system which had been maintained since the crushing of the revolution of 1848. The army had fought without enthusiasm, and after the restoration of peace voices were everywhere raised for reform. Petty concessions were at first attempted, but in December, 1860, the emperor changed his ministers, promising that the constitutions of the various provinces should be revised, and that a Reichsrath, with the right of initiating legislation, should be freely elected by the provincial diets. Although this arrangement was far from pacifying the populations, it was a great advance on any previous proposal, and stirred the hope of still larger concessions.

Revival of national movement.

Another result of the Italian war, of far greater importance for the general progress of Germany, was the revival of the old desire for national unity. The Germans could not persuade themselves that that which the Italians had attained was unattainable by them; and they believed that, if they acquired the same measure of unity, there would soon be an end of despotism. After the war, a number of leading politicians, having held repeated conferences, founded what they called the National Union, an organization intended to promote the national cause; and it had a profound effect in maintaining and stimulating public interest in its object. The governments, seeing the strength of the movement, sought to give it a direction suitable to their own interests. Prussia and Austria entered into negotiations, but failed to arrive at an understanding. The Saxon minister, Baron Beust, then came forward with a proposal, whose aim was to play off the two great states against one another, and to enable the smaller states to hold the balance. Austria was not unwilling to be persuaded: but Prussia would have nothing to say to a scheme which would have effected a change without improving her position. In 1863 the emperor Francis Joseph invited the German princes to a congress in Frankfort, for the purpose of settling the question. A settlement proposed by him was unlikely to be acceptable to Prussia; and she held aloof. When the Austrian emperor's plan was unfolded, its aim, as every one expected, was seen to be the confirming of his own authority. It was, therefore, with equal decision, rejected by the Prussian government and by the German liberals.

William I. of Prussia.

Meanwhile, changes had taken place in Prussia which were destined to lead to a solution of the long-discussed problem, as complete as it was unexpected. On the death of Frederick William IV. on the 2d January, 1861, the prince regent assumed the crown of Prussia as William I. Within ten years Germany was united, and this amiable king was proclaimed emperor.

Bismarck.

This result was the issue of a vast series of historical causes; but it is indissolubly associated with the name of King William's great minister, Bismarck, who was made Prussian premier in 1862. No more remarkable figure has arisen in the history of Germany. Before he became prime minister he had acted as Prussian plenipotentiary at the confederate diet, and as Prussian ambassador in Paris and St. Petersburg; he was, therefore, familiar with the conflicting political currents of the time. When raised to the highest post in the State under the crown, he soon formed the fixed resolution of adding to the power of Prussia, and placing her at the head of united Germany. Having something of Cromwell's superstition as well as Cromwell's strength, he apparently regarded this as a sort of religious mission; and in many respects he could hardly have been better adapted to the task. A rough, despotic, vehement nature, he was undeterred by scruples which might harass ordinary statesmen; having set up a goal, he marched to it by the straightest path. The solemn traditions of diplomacy, to the astonishment of Europe, he laughed out of court. He respected treaties exactly in so far as they were capable of being defended, and produced by boisterous frankness the effects which other men achieve by mystery and deceit. With little faith in the action of moral causes, he took care to have behind him those big battalions which destiny is said unduly to favor. Prussia at once recognized that she had in him a statesman of commanding type,—a bold and resolute spirit, with narrow but intense vision, and a will created to go crashing through difficulties, and to fashion a world to its liking.

When Bismarck was made premier the government was engaged in a hot dispute with the representative chamber. The latter refused to sanction a great scheme of military reform, and the ministry was compelled, in direct opposition to the constitution, to trust to the upper house for supplies. Bismarck carried on the contest with cynical audacity; and he was in no way shaken when the country, over and over again, proved that its sympathies were with his opponents. The military reforms were executed, and the nation was tolerably plainly told that its approval was of secondary importance.

Schleswig-Holstein.

An opportunity for stirring up the chaotic elements from which the Prussian premier proposed to evolve a cosmos of his own was soon afforded by the revival of that most complicated of "questions," the question of Schleswig-Holstein. Ever since the settlement of 1852 it had from time to time engaged attention. The tendency of Danish policy, according to the Germans, was to subject Holstein and Schleswig to wholly different treatment, and, in the application of the general constitution of the kingdom, to pay insufficient respect to the rights of Holstein as a member of the German confederation. Soon after the duke of Glücksburg, in accordance with the London protocol, mounted the Danish throne (1863), federal troops were despatched to the duchies, nominally to secure that the new king should fulfil his predecessor's engagements. In reality, however, their presence gave rise to demonstrations among the German population

1863–1867.

in favor of Prince Frederick of Augustenburg, who, although his father had renounced his rights, claimed to be the true duke of Holstein. Prussia and Austria, having signed the London protocol, professed to disapprove his pretensions, and towards the end of 1863 proposed in the diet that they should be empowered to occupy Schleswig, so that justice might be done both to the Danish king and to the duchies. The proposal was rejected, and had Austria been acting alone, there is no reason to believe that she would have pushed her demands farther, if indeed she would ever have advanced so far. But Prussian policy was determined by a statesman who had vast ulterior ends to serve; and by his influence Austria was induced to join Prussia in declaring that, since the bund would not follow their counsel, they were forced to act independently. In the war which followed the Danes distinguished themselves by their courage and military skill; but they could not very long contend single-handed with two such enemies, and on the 1st August, 1864, a treaty was signed in Vienna, by which Denmark ceded to the conquerors Schleswig, Holstein, and Lauenburg. All Europe disapproved these harsh conditions; but the Prussian minister did not trouble himself about disapproval which found utterance only in words.

Danish war.

Dispute between Austria and Prussia.

Before the outbreak of war, Prussia had been engaged in a serious dispute with Austria. In 1862, in the name of the customs union, the former power had concluded with France a treaty of commerce, based mainly on the principles of free trade. Most of the small states, strongly objecting to the treaty, refused to sign it; and they were supported by Austria, which had never given up the hope of taking precedence of Prussia in the commercial as well as the political relations of Germany. She protested against the treaty, and demanded admission into the customs union. Prussia maintained her original position, insisting that if the treaty with France were rejected she would regard the union as no longer existing. After the war Bismarck not only succeeded in obtaining the signatures of the small states, but induced Austria to conclude a commercial treaty, essentially the same as that of 1853; and about the same time treaties were signed, owing to his exertions, between the union and England and Belgium. These triumphs unmistakably indicated the rising influence of Prussia.

It was not long before grave difficulties sprang from the results of the Schleswig-Holstein war. Prussia was of opinion that there was no longer any need for the troops of the bund in Holstein; and although this view was hotly contested, the diet was compelled in the end to act upon it. Still more important was the question, what should now be done with the duchies. Austria favored the claims of the prince of Augustenburg; and the bund by a small majority decided to request the two powers to invest him with the sovereignty of Holstein. Prussia protested that the matter was beyond the competence of the diet. What she herself intended was plainly shown by the fact that the Prussian war minister explained in the Prussian parliament, in connection with a special demand for money, that it was to be devoted to the erection of a harbor at Kiel. Austria, which had the same right as Prussia to Kiel, refused her assent to this proposal; and an interchange of angry despatches took place, which made it highly probable that the spoilers of Denmark would soon be at each other's throats. War was for a time prevented by the Gastein convention, by which Austria handed over Lauenburg to Prussia, and it was agreed that the former state should in the meantime administer Holstein, the latter Schleswig.

Gastein convention.

Count Bismarck did not intend that the Gastein convention should seriously interrupt the development of his policy. He had made up his mind to force a quarrel on Austria, and to settle once for all the question, first raised by Frederick the Great, whether she or Prussia should prevail in Germany. The opportunity was so favorable that the like might never again offer itself. Although the Government and the parliament of Prussia were still engaged in a struggle which called forth much indignation on both sides, the mass of the population was thoroughly loyal; and, as events proved, the army had been reorganized with splendid skill. Never, perhaps, in the history of the world, were there better fighters than the Prussian soldiers of that day; and they were led by officers full of patriotic ardor, with almost unlimited influence over their men, and trained in the best schools of military science. In the Austrian empire, notwithstanding the reforms recently instituted, discontent was still almost universal. The Hungarians sullenly demanded independence, and among the Slavonic populations there were also dangerous agitations for local self-government. Although the army was composed of magnificent material, it was far behind that of Prussia in the mode of its administration, and grave doubts were entertained whether confidence could be placed in its loyalty. In these circumstances, no one familiar with the facts could hesitate as to the side on which victory would declare itself in the event of war, and to Count Bismarck the facts were intimately known. With well-considered boldness he advanced rapidly to his aim. The Austrian governor of Holstein encouraged, as he had a perfect right to do, the pretensions of the prince of Augustenburg. In January, 1866, Count Bismarck made this the subject of a bitter despatch to the Vienna Government; and Count Mensdorf, the Austrian foreign minister, replied in the same tone. Both powers now began to make active preparations for the worst. The majority of the small states sided with Austria; but Prussia found means of more than counterbalancing this advantage. Now that Italy was partially united, the Italians felt humiliated at Venetia remaining in the hands of Austria. Count Bismarck offered, if she would conclude an alliance with Prussia against their common enemy, to obtain for her this magnificent prize. The Italian Government saw that it could never have a better chance, and signed the proposed treaty.

Alliance of Prussia and Italy.

Seven weeks' war.

The occasion for which Count Bismarck waited presented itself when the Austrian governor of Holstein summoned the assembly of the states. Holstein was at once occupied by Prussian troops, and those of Austria were driven from the duchy. The Austrian Government indignantly protested against this outrage; and on the 14th June, 1866, its proposal that the forces of the bund should be mobilized against Prussia was adopted by a majority of the diet. The Prussian plenipotentiary withdrew after submitting a scheme for the reconstitution of Germany; and the war immediately began. Its events followed each other with startling rapidity. Within a fortnight Prussia had in her grasp Hanover, Hesse-Cassel, and Saxony; and on the 3d July was fought the great battle of Königgrätz, which laid her chief enemy at her feet. The power of Austria was shattered by the swift and mighty blows directed against it; and on the 26th July she was glad to accept the preliminaries of Nicolsburg, which were soon afterwards followed by the peace of Prague.

Peace of Prague.

The result of this war was the final exclusion of Austria from Germany. Prussia annexed Hanover, Hesse-Cassel, Nassau, Frankfort, and Schleswig-Holstein. By the fifth clause of the treaty of Prague, indeed, the inhabitants of the northern districts of Schleswig were to be reunited to Denmark, if, when freely consulted, they expressed a wish for this result; but the engagement, which was never seriously intended, was abrogated by secret treaty between Austria and Germany on the 11th October, 1878. All states to the north of the Main, including the northern half of Hesse-Darmstadt, were compelled to form a North-German confederation under the leadership of Prussia. The four South-German states, Baden, Hesse-Darmstadt, Würtemberg, and Bavaria, were left independent, but with the right, if they chose, to form a South-German confederation and to unite with that of North Germany. By secret treaties, as Count Bismarck announced at a critical moment soon afterwards, they undertook to place their armies at the disposal of Prussia in time of war.

Northern confederation.

Confederate constitution.

King William, who had accompanied his troops, returned in triumph to Berlin, and the nation was so elated by his victories that the newly-elected house of representatives willingly consented to forget past disputes. On the 24th February, 1867, the constituent diet of the confederation, elected by universal suffrage and the ballot, met in Berlin, and soon accepted in its essential features the constitution submitted to it. It was arranged that the headship of the confederation should be hereditary, that it should belong to the king of Prussia, and that legislative functions should be exercised by a federal council, representative of the various Governments, and by a diet elected by the whole people.

National liberals.

The confederate parliament began at once the task of consolidating the new institutions. In the sessions of 1869 and 1870 it established a supreme tribunal of commerce, sitting in Leipsic, and passed a new penal code. Great as were these results, they did not satisfy the aspirations of patriotic Germans, who, having so suddenly and so unexpectedly approached unity, longed that the work should be completed. A party called the "national liberals" was formed, whose main object was to secure the incorporation of south with north Germany, and it at once entered into peculiar relations with the great minister at the head of the country. The members of this party, believing, as sincere liberals, that the German people were ripe for free institutions, desired from the outset to give larger power to the popular element of the constitution both in Prussia and in Germany. With these ideas Prince Bismarck had no sympathy. Throughout his career he has consistently manifested contempt for parliamentary forms of government. He cannot tolerate that a minister should be thwarted or hindered by political critics, and fancies that the community would be much better off if it allowed itself to be directly governed by the statesmen who are good enough to devote themselves to its service. But his achievements in the cause of German unity have more than counterbalanced, in the esteem of the liberals, his dislike of national freedom.

Customs parliament.

South-German hostility to union.

An important step towards complete unity was supposed to be taken in 1867, by the conclusion of a treaty with the southern states, by which it was agreed that all questions of customs should be decided by the federal council and the federal diet, and that, for the consideration of such questions, the southern states should send representatives to Berlin. In reality, however, the customs parliament was of no service beyond the strict limits of its special activity. The mass of the South Germans were bitterly opposed to the idea of union with the north. The democrats detested Prussia more than any other country, and looked upon Count Bismarck as the incarnation of all that was most objectionable in its aristocratic and military system of government. Among the ultramontanes there was a not less vehement dislike of a nation which continually boasted that it was the headquarters of Protestantism and free thought. Hence, in the election to the customs parliament in 1868, Würtemberg did not return a single deputy who was favorable to the national cause; in Bavaria the anti-nationalists had a large majority; and even in Baden and Hesse-Darmstadt, where the opposition to Prussia was less severe, a powerful minority of the deputies had no liking for the Prussian premier. Thus the customs parliament was kept rigidly to the objects for which it was founded, greatly to the disappointment of patriots who had not doubted that it would become an effective instrument for the attainment of far larger purposes. Even in regard to the army, notwithstanding the secret treaties giving Prussia the command of the southern forces in the event of war, a spirit of bitter opposition to the northern confederation was manifested. Baden and Hesse-Darmstadt reorganized their armies in accordance with the Prussian system, but Bavaria and Würtemberg were more obstinate, and in both countries there was an agitation for military arrangements by which the secret treaties should be virtually annulled.

Irritation of France.

Had the completion of unity depended wholly on internal causes, it certainly would not have been soon achieved; but other forces, not altogether unexpectedly, came to Count Bismarck's aid. France had been irritated by the enormous increase of Prussian power, and even before the treaty of Prague was signed the emperor Napoleon III. indicated a wish to be "compensated" with the left bank of the Rhine. Not being in a position to make war, he was compelled to suppress this desire. Soon afterwards he proposed a secret arrangement by which Belgium was to fall to France, while Prussia was to have free scope elsewhere. Finding that if not decisively rejected his plan was at least not accepted, Napoleon next sought to restore the balance by concluding a treaty with the king of Holland, in 1867, for the purchase of Luxembourg. Prussia protested; and it was on this occasion that Count Bismarck first made public the secret treaties with the South-German states. War appeared almost inevitable, but the emperor, being still uncertain as to the state of his forces, allowed the question to be settled by a conference, which declared Luxembourg a neutral state, its neutrality being guaranteed by the great powers.

Franco-German war.

The idea of a war with Prussia was not given up by Napoleon. Whether he felt the necessity of strengthening the claims of his dynasty by military glory, or whether, as many Germans believe, he was urged forward by a powerful ultramontane intrigue, he seems to have resolved in 1870 to undertake the long-delayed struggle. A pretext was found in a proposal of the Spaniards to raise to their throne Prince Leopold of Hohenzollern. There is no evidence that the French people were in the least disturbed by this scheme; certainly, if they had been left to their own free judgment, they would never have thought of going to war about it. But the imperial ministry, managing to get up a little artificial excitement among a noisy section of the Parisians, angrily protested; and Prince Leopold announced that he would not accept the Spanish crown. Stimulated by this diplomatic triumph, the emperor next required that Prussia should give a general engagement that no Hohenzollern prince should in future become king of Spain. Prussia declined to humble herself so far, whereupon, on the 15th July, 1870, France declared war against her. A telegram from Ems, falsely stating that the French ambassador had been publicly insulted by King William, caused considerable sensation in France; and enemies of Bismarck often assert that he caused it to be despatched for the purpose of making war unavoidable. Although this is a mere assertion, he was not unwilling to accept the challenge, coming as it did in a manner that would have rendered any shrinking from it disgraceful. He believed that, whatever policy she adopted, Prussia would one day have to defend her conquests; and he could not but foresee the enormous advantages which would spring from a triumphant war with France.

Napoleon, as we now know, had reason to suppose that he might trust to the aid of Austria and Italy, and his diplomatic agents in South Germany had left no doubt in his mind that the South Germans would hail his approach as that of a deliverer. He was cruelly undeceived. After his first reverses, Italy and Austria resolved to hold aloof; and the South Germans did not for an instant hesitate; they loyally kept their engagements with Prussia. The French emperor did not realize how bitter, in South, as well as in North Germany, were the memories of the sufferings caused by his uncle. However energetically the various states might fight among themselves, in the presence of "the hereditary enemy" their disputes were forgotten; they remembered only their common origin and their common speech. There is no parallel in German history to the enthusiasm called forth by the French declaration of war. Its absolute universality was a new phenomenon, and its intensity probably could not be surpassed.

Sedan.

The course of the war went far beyond the expectations of the most sanguine patriots. In battle after battle the armies of France were smitten to the ground; her strong places, one after another, delivered themselves to the enemy; and her brave sons were sent by hundreds of thousands as prisoners to Germany. At last, on the 1st September, after the disastrous battle of Sedan, the emperor yielded his sword to the Prussian king.

Peace of Frankfort.

It was the opinion of many impartial observers that the war ought now to have stopped, and there were Germans who had the courage to express this conviction. But the nation as a whole wished to see France thoroughly humbled, and applauded the advance on Paris. In vain M. Gambetta sought to infuse into his countrymen his own impulsive and vigorous spirit; they did what they could, but the German armies were irresistible. On the 28th January, 1871, Paris surrendered, and on the 6th May the peace of Frankfort was signed. By this treaty France engaged to pay the enormous indemnity of five milliards of francs, and to restore to Germany Alsace and the German portion of Lorraine.

1871–1878. German empire.

Amid the glowing pride of the Germans in the unsurpassed achievements of their armies the difficulties which had hitherto prevented complete unity seemed altogether to vanish. In the autumn of 1870 negotiations were opened between the southern Governments and the northern confederation; and in the course of November treaties were signed by which the North-German confederation became the German confederation. Bavaria insisted upon some highly important reservations, such as the maintenance of her own diplomacy, of her postal, telegraph, and railway systems, of her military administration, and of certain valuable taxes. Baden, Hesse-Darmstadt, and Würtemberg also maintained special rights. But all this was thought of comparatively little moment; and the treaties were readily sanctioned both by the confederate parliament and by the southern parliaments. Thus Germany become a united state. The king of Bavaria then proposed to the other German sovereigns and to the free cities that the head of the confederation should be declared emperor. The suggestion was approved; and on the 18th January, 1871, in the Hall of Mirrors in the palace of Versailles, the king of Prussia was proclaimed, in presence of a brilliant assembly of German princes and officers, emperor in Germany.

Imperial diet.

On the 21st of March, 1871, the first diet of the empire met in Berlin. The constitution of the northern confederation was extended so as to be applicable to the changed circumstances of Germany, but no alteration was made in its essential character.

Since the conclusion of the treaty of Frankfort Germany has been at peace, but as she believes that the French may one day seek to regain their lost provinces and to avenge their recent humiliations, she has maintained the vast military system to which her victories have been due.

Foreign policy.

The main object of Prince Bismarck's foreign policy appears to have been to isolate France. While not unfriendly to England, he has assiduously cultivated the friendship of Austria and of Russia. In 1872 the czar and the Austrian emperor visited Berlin, and during their stay the three emperors concluded an alliance, the exact limits and conditions of which are not known. Soon afterwards Victor Emmanuel, the Italian king, also visited the German capital, and the emperor William went for a short time to Italy, where he was received with manifestations of hearty friendship. It is understood that after the reopening of the Eastern question in 1875 Prince Bismarck made repeated attempts to enter into close relations with England; but in his public acts, both before and after the signing of the treaty of Berlin in 1878, he mainly supported Russia. He also encouraged Austria to extend her influence in the east by occupying Bosnia.

Church and state.

In her home politics the attention of Germany was for some years mainly occupied with a great struggle between the state and the church in Prussia. After the close of the Franco-German war—in the course of which the dogma of papal infallibility was proclaimed—Prince Bismarck persuaded himself that the empire was imperilled by ultramontane intrigues; and with his usual promptitude he took vigorous precautions against his supposed enemies. He began in 1872 with the expulsion of the Jesuits. This was followed in 1873 by the famous May Laws, introduced by Dr. Falk, the energetic minister of public worship. By these laws it was required that candidates for the clerical office should undergo a certain amount of secular training at the universities, and that every ecclesiastical appointment should receive the sanction of the secular authorities. A royal tribunal for ecclesiastical matters was also set up. This legislation, which the pope denounced as invalid, was disregarded by the Catholic bishops; and Prince Bismarck, supported by Dr. Falk, imposed penalty after penalty in order to establish the supremacy of the state. Refractory bishops were imprisoned, deposed, and banished; the contributions of the Government were withdrawn from the clergy who incurred its displeasure; religious orders were dissolved; the administration of church property was taken from the clergy and invested in bodies of laymen. It may be that these stern measures were rendered necessary by facts of which the world is insufficiently informed; but they have alienated from Prince Bismarck, and from the empire founded by him, the sympathies of the vast majority of the German Catholics.

Socialism.

The period which has followed the war with France has been remarkable, not only for the ecclesiastical struggle in Prussia, but for the rapid growth of socialism throughout the empire. Socialism first became a power in Germany through the labors of the ardent scholar and publicist, Ferdinand Lassalle. He began his brief and noisy public career by addressing large audiences of workmen in Berlin and Leipsic in 1862, and in less than two years he had formed a party which regarded him with boundless reverence and admiration. He himself was a man of fortune, with luxurious habits; but he had in an unusually intense degree the desire, shared by all truly modern men, for the elevation of the depressed and suffering masses. The theory of which he had convinced himself was that, with existing social relations, workmen as a class can never improve their position; that their sole chance is to form productive associations which shall enable them to secure the whole benefit of their labor; and that it is the duty of the state to provide such associations with capital to see that justice is done to their members, and to regulate the markets of the world. After the death of Lassalle, this theory became a sort of evangel among his followers; but many of them stated it in violent terms, and openly aimed at the equal division of property, if possible by peaceful agitation, if necessary by revolution. At the time of the formation of the party Herr von Bismarck was engaged in his struggle with the liberals in the Prussian parliament, and he did not scruple to damage his opponents by encouraging Lassalle, who detested them more vehemently than did the premier himself. Soon after the war with France the condition of the country was in the highest degree favorable to the progress of the movement. Intoxicated by the national triumphs, and having a vague impression that the French indemnity must be an inexhaustible source of wealth, many of the German middle class indulged in wild speculation, and contracted habits of reckless expenditure. At the same time the resources of the nation were drained by the most costly military system the world has ever seen. The inevitable result was that in a short time trade was depressed beyond all recent experience; wages fell, and large numbers of workmen were deprived of employment. Socialism found its opportunity; multitudes of the sufferers eagerly listened to instructors who depicted for them a brilliant future that might be easily attained. In England no considerable body of men has ever been deeply impressed by socialist schemes; but in Germany the conditions of political life are altogether different. There the Government is the greatest of all powers. At every stage of a man's life it makes itself felt; it creates around the community a sort of political atmosphere from which there is no escape, in which every one moves and breathes. Thus to an uninstructed German there seems to be hardly any limit to the feats of which the state is capable. It professes to be so nearly omnipotent that he appears to himself to be within his right in asking it to make all poor men suddenly rich.

At each successive general election the numbers of socialist deputies to the imperial parliament increased; and in 1877 it was calculated that although only twelve members of the party were returned, about a tenth of the entire body of voters were socialists. Some alarm was excited by these facts, but no one thought of putting down the movement by force until one day in May, 1878, a shot was fired at the aged emperor in Berlin, as he drove along the Unter den Linden with his daughter, the grand-duchess of Baden, by his side. The criminal, a youth named Hödel, boasted of his socialist opinions and aims. A wave of anger swept over the nation; and the reactionary party, fancying it had an opportunity of laying a rough hand on far more than socialism, succeeded in inducing the imperial Government to draw up without delay a severe measure, directed nominally against the socialists, but in reality against all politicians obnoxious to the conservatives. The bill was hurried through the federal council and submitted to the diet. By that time the majority of the liberals had recovered their self-control; and with the aid of the centre party they threw out the proposed scheme by an immense majority. Parliament was prorogued, and it was uncertain whether there would be any further attempt at repression.

Attempts on the emperor's life.

Suddenly the announcement came that the emperor had again been shot at, and that this time he had been wounded. For some days Germany was convulsed with rage and horror, and on all sides the cry was raised that now at last socialism must be sternly dealt with. Taking courage, the Government dissolved parliament, and pressure of every kind was put upon the electors to secure a thoroughly reactionary diet. The country, however, reflected that although it was necessary to protect society, it might not be necessary to sacrifice the liberties which it had with so much difficulty conquered. Accordingly, when the new parliament assembled in August, 1878, it was found that the liberals had not sustained very serious losses. **Repressive legislation.** The progressists bitterly opposed the measure introduced by the Government; but by some means Prince Bismarck managed, as he had often done before, to overcome the objections of the national liberals. By their support a law was passed which gave the police of the empire, for two years and a half, enormous special powers. These powers were at once rigidly enforced; and socialism appeared to vanish from the land. Whether, however, it may not spring up in some great national crisis, all the stronger for the sufferings of its adherents, is a point that can be determined only when some great national crisis occurs.

National unity. The socialists and the ultramontanes, without having anything else in common, have joined in opposition to measures for promoting the national unity. They have been aided by the Polish deputies, by the members for Alsace and Lorraine, and by the so-called particularists, conservative politicians ardently attached to the ancient customs and rights of the individual states. Notwithstanding this formidable band of allies, considerable progress has been made in the task of transforming a loose confederation of countries into a true nation. Between 1872 and 1875 utter anarchy in important departments of life was brought to an end by laws relating to imperial coinage, imperial paper money, and the system of banking. And in 1877 thorough investigation resulted in the appointment of a supreme imperial tribunal (Reichsgericht). It was proposed that this tribunal should sit in Berlin; but many liberals having no desire that that city should assume in Germany the place which belongs in France to Paris, a large majority decided for Leipsic. This was taken as a hint that, while Germany wishes to be united, she will not voluntarily see herself transformed into a magnified Prussia.

In spite of their military strength, their victories, and the establishment of their empire, the Germans are not, politically, a contented people; and the reason is that they have outgrown their institutions. While a statesman of extraordinary genius and authority stands in the way, a progressive system may be impossible; but the more intelligent classes have never lost the desire to add to the hardly-earned national unity the crowning triumph of unfettered representative government.

Bibliography.—Luden, *Die Geschichte des deutschen Volks*; Leo, *Vorlesungen über die Geschichte des deutschen Volks und Reichs*; Giesebrecht, *Geschichte der deutschen Kaiserzeit*; Waitz, *Deutsche Verfassungsgeschichte*; Mayer, *Deutsche Geschichte*; Souchay, *Geschichte der deutschen Monarchie*; Sugenheim, *Geschichte des deutschen Volks und seiner Cultur.* (J. SI.)

PART III.—LANGUAGE.

In its ordinary sense the name German Language or *Deutsche Sprache* is now generally used to denote, in all their stages from the earliest time to the present day, the different languages and dialects of Teutonic origin spoken in the German and Austrian empires and in Switzerland, not including, however, the Frisian language, which once was spoken, and still in a few remnants survives, on the shores and islands of the German Ocean, nor the dialects of the Danish population of northern Schleswig. Flemish and Dutch, although very closely connected with German, are likewise excluded. But the word *Deutsch* has also been, and still continues to be, used in a wider sense. Jacob Grimm introduced it, in his famous *Deutsche Grammatik*, as a comprehensive name for that family of the so-called Indo-European or Aryan languages, for which English writers generally use the name of "Teutonic," and of which the principal branches are represented by Gothic, the Scandinavian languages, English, Frisian, and German. In this Grimm has had many followers, but scarcely anywhere out of Germany; and even there the fact that the name, in this application, besides being incorrect from an historical point of view (as the word has never been used thus by any one of the people to whom it has been applied by Grimm), is also liable to be misunderstood, has caused a growing tendency towards confining it again to its original meaning described above, and using *Germanisch*, or *Germanic*, in the collective sense of the English "Teutonic." But even in the stricter sense the designation *Deutsch* is not of very long standing, nor has the word always been a real proper name for a distinct people or tribe. In Bishop Ulfilas's Gothic version of the Bible we find the adverb *thiudisko* (ἐθνικῶς), Gal. ii, 14, which is clearly a derivative from *thiuda* (ἔθνος), meaning primarily "after the manner of the people." German writers of the earlier centuries were therefore as fully justified in calling their own language *diutisc*, or in a Latinized form, *theudiscus*, *theotiscus*, that is, their popular or vernacular language, as were those mediæval Latin writers of all nations who distinguished their national languages by the name of *lingua vulgaris* from Latin, the only literary language fully acknowledged in their time. It was not until the 10th century that another Latinized form frequently used in later times, viz., *teutonicus*, began to be used instead of the older *theotiscus*, of which the only rivals in former times had been such local names as *franciscus* (*frenkisc*) or *saxonicus*, which were no doubt derived from the names of single tribes, but were often also used in the same comprehensive sense as *theotiscus*, without necessarily implying any allusion to dialectal differences between the languages of the tribes they properly belonged to. The last name we have to mention here is the Latin *Germanus*, with its different derivatives in the modern languages, including the English form *German*. Many attempts have been made to elucidate the origin of this word, but as yet nothing can be taken for certain beyond the fact that it is neither of Latin nor of German origin. Most probably it was a Celtic word, and, according to what Tacitus says in his *Germania* (ch. ii.), it was originally the name of a Celtic tribe, from which, by some strange error of the Roman and Greek historians, it has been transferred to the non-Celtic inhabitants of Germany. Accordingly the name has never been used by the Germans themselves except in imitation of its use in the works of Latin writers.

As to its geographical extension the German language has undergone very great changes in the course of the last two thousand years. At the dawn of history no Germans were to be found to the left of the Rhine, and even to the right of it Celtic tribes occur in the earliest times. There were Celts also in the south of the present Germany as far north at least as the Danube and the Main; Bohemia, too, derives its name from an early Celtic population, the Boii. Only the midland and north were inhabited by Germanic nations or tribes, stretching as far east as Poland, and perhaps covering even parts of the adjoining territories of Russia, where Slavonic and Finnish tribes were their neighbors. But of these Germanic tribes and their languages some have left no equivalents in our modern German tribes and dialects. We have mentioned the Frisian language as not belonging to German in its proper sense, although the Frisians have kept their original residence up to the present day, and have always been in constant connection and frequent intercourse with their "German" neighbors. Many other tribes have wandered from their seats and colonized other countries. It was as late as the middle of the 5th century that the Jutes, Angles, and Saxons began their voyages of conquest to England, where they founded a new people and a new language,[1] leaving their native soil open to Danish invasions. Much earlier the midland tribes had already been slowly pushing on to the west and south, and expelling or subduing and assimilating the Celtic owners of the territories they invaded. But what was gained in these parts was counterbalanced by great losses in the north and east. The territories about the lower and middle Elbe, Oder, and Vistula, abandoned by the Lombards, the Burgundians, the Goths, and some other Germanic tribes, as well as Bohemia, which for some short time had been in the possession of the German Marcomans, were soon filled up by the immigration of numerous tribes of the great Slavonic family. Without going into details of the facts which are well known to the student of history,[2] we may simply state that, since about 500 A. D., when the great migration of the nations had come to an end so far as Germany was concerned, no further change of any great importance has taken place in the western and southern parts. In the east the German population at this time did not go beyond a line that may be drawn from about Kiel to the Böhmerwald, passing near Hamburg, Magdeburg, Naumburg, Coburg, and Baireuth. As is well known, it is in later centuries that almost all the eastern districts have been recovered for the German language.[1]

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[1] See the article ENGLISH LANGUAGE, vol. viii. p. 349 *sqq.*

[2] For fuller particulars see C. Zeuss, *Die Deutschen und die Nachbarstämme*, Munich, 1837.

In the 6th century the remains of the numerous smaller Germanic tribes, mentioned before and during the migration of the nations, had consolidated into seven larger bodies or aggregations of tribes. The Frisians still held the extreme north of Holland and Germany. Their midland and eastern neighbors were then called by the new name of Saxons, borrowed from the Saxons who had left the Continent for England. In the main parts of the Netherlands and Belgium, along both sides of the Rhine, and across Germany to the Thuringian and Bohemian Forests, the powerful Frankish confederation had established itself, and it soon incorporated the smaller and less vigorous tribes of the Hessians and Thuringians, which were surrounded by the midland or eastern Franks, the Saxons, and the Slavs. Alsatia, Switzerland, and South Germany eastward to the river Lech were occupied by the Alemannians, while the inhabitants of the remaining districts of the present Bavaria and Austria bore the collective name of Bavarians.

The history of the German language cannot be severed from the history of these tribes, for Frisian, Saxon, Frankish (Hessian, Thuringian), Alemannian, and Bavarian are the leading dialects of the Continental branch of the Teutonic family. What Dr. J. A. H. Murray has pointed out about the origin of the principal English dialects[2] may equally well be said of these Continental idioms. Having no specimens of the languages of the Continental tribes for nearly three centuries after their final settlement, we cannot tell to what extent they originally agreed with or differed from each other, although there must have been some dialectal differences to begin with, which were afterwards increased and multiplied, partly by phonetic changes (most probably resulting from scarcely discernible phonetic peculiarities, which, even in the earliest times, must have prevailed in those idioms), and partly by such alterations of the inflexional systems as are known to occur frequently in all languages whose character is not merely literary. But, however scanty our means of illustrating the earliest history of these idioms may be, there is no doubt that they were not all of them related to each other in the same degree. Three main groups are easily distinguishable:—(1) Frisian and Saxon, whose nearest relation is English; (2) Frankish, Hessian, and Thuringian; and (3) Alemannian and Bavarian. Frisian is generally considered as a separate language. From Saxon the later Low German dialects (*Niederdeutsche Mundarten*) have sprung. The members of the third group (generally designated as *Oberdeutsch*, or Upper German), combined with *Mitteldeutsch*, or the midland dialects, viz., Thuringian, Hessian, and part of the Frankish dialects, are the sources of the latter *Hochdeutsch* or High German. The greatest difference prevails between the first and third groups; the second may be characterized as containing various transition dialects. The southern Frankish dialects are very closely akin to the adjacent Upper German idioms, while Dutch, the utmost offshoot of the Frankish language to the north, does not very materially differ from Saxon or Frisian in the earliest period. The most striking phonetic feature of the languages of the first group is their regular dropping of the nasal sounds before the spirants *f*, *th*, *s*, accompanied by subsequent lengthening of the preceding vowels. Thus we have in Anglo-Saxon or Old English *fíf*, *óðer*, *cúð*, *gós* (Mod. English *five*, *other*, (*un-*)*couth*, *goose*), in Old Frisian *fíf*, *óthar*, *cúth*, *gós*, in Old Saxon *fíf*, *óthar*, *cúth*, *gós*, corresponding to such Gothic forms as *fimf*, *anthar*, *kunths*, or the ordinary High German *fünf*, *ander*, *kund*, *gans*. Since, however, Dutch partakes of this peculiarity to some extent, we cannot easily form a decisive opinion as to the value of this fact as a distinctive mark; but more stress may be laid on a very remarkable difference in the inflexional system of the verb. Here the languages of the first group have melted together the forms of the three persons of the plural number, thus *wé*, *gé*, *hie findað* or *fundon*, we, you, they find, or found, in Old English; *wí*, *gí*, *hia*, *findað*, or *fundon* in Old Frisian; *wí*, *gí*, *sia findað*, or *fundon* in Old Saxon. The corresponding Old High German forms are *wir findam*, *ir findat*, *sie findant* for the present, *wir funtum*, *ir funtut*, *sie funtun* for the perfect tense. Old Dutch joins, in this case, the German branch; from *werthan*, to become, for instance, are derived *wí werthun*, *gí werthið*, *sia werthunt*, etc. The declension of the substantives shows another remarkable difference. While the languages of the first group have retained the original *s* in the nominative plural of such words as Old English *dagas*, days, Old Saxon *dagos*, or changed it to *r*, as Old Frisian *dagar*, Dutch and German have dropped it altogether, the corresponding forms being *daga* and *taga*. These facts must be taken for decisive, as it seems to be certain that they existed before any distinction of Low and High German in their modern sense (a distinction chiefly dependent on subsequent changes in their mute system) could be thought of. From a purely grammatical point of view, Dutch, although generally considered a separate language (which no doubt it is, with regard to its literary and political position), is entitled to claim a closer relation to High German than even Low German, whose non-literary character, taken along with the political union of northern and southern Germany, has led to the current opinion that it is only a dialect of "German" in its narrower sense. We do not mean to deny that there is, at present, a more conspicuous conformity between Dutch and Low German than between Low German and High German; but this is only due to the fact that High German, after the final settlement of the German tribes, has deviated much more from its original features than either Dutch or Low German. The most striking peculiarities of High German, as opposed to all other Teutonic idioms, have mainly been caused by the second or High German "Lautverschiebung," or change of mute consonants, which forms part of a long series of sound-changes generally comprehended under the name of Germanische Lautverschiebung or Grimm's Law. This Lautverschiebung began, perhaps as early as the 7th century, in the south, and thence slowly spread northward, but with decreasing vigor and consistency, Dutch and Low German not being touched at all. It was only thus that the idiom of the Netherlands Franks of the later centuries was separated from the dialects of their "German" relations. Before, however, the first literary documents are met with, this separation is complete; and we may therefore restrict ourselves here to a short history of High and Low German alone.

The German language presents, as do most of the cognate tongues, three main stages of development,—Old, Middle, and Modern,—distinguished by their inflexional and literary character. In accordance with Mr. Henry Sweet's description of the stages of the English language,[3] Old German may be defined as the period of *full* inflections (Old Low German, *dages*, *dage*, *dagu*; *dagôs*, *dago*, *dagun*; Old High German, *tages*, *tage*, *tagu*; *tagâ*, *tago*, *tagum*), while the Middle period is that of *levelled* inflections (Middle Low German, *dages*, *dage*, *dagen*; Middle High German, *tages*, *tage*, *tagen*); but it is chiefly the literary character that distinguishes Modern High German from Low German and its own earlier stages. A special form of High German is established in this period for all literary purposes, supplanting the dialects both of Low and of High German that formerly were freely used in literary intercourse. Assuming two periods of *transition* besides, we have the following divisions, with the approximate dates:—

Old High German..................	to 1050
Early Middle High German......	1050 to 1150
Middle High German......................	1150 to 1350
Late Middle High German.............	1350 to 1500
Modern High German..................	1500 onward.

The same divisions have to be made for Low German, but the scheme cannot be so fully carried through, as the time between 1000 and 1200 is almost destitute of literary monuments.

Old German.—The inflexional characteristics of Old German are almost identical with those of Old English. Nouns had the same five cases,—nominative, accusative (only in a few instances kept distinct), genitive, dative, and instrumental. Strong and weak declensions of nouns and their subdivisions are likewise the same. The dual of the first and second personal pronouns is almost extinct in Old High German, but is quite common in Low German. In the verb we find the same distinction of the subjunctive from the indicative mood, and the same two inflected tenses, present and past,—the former also used for the future, the latter for all shades of past time. The order of the sentence corresponds generally to the modern use, but is not kept so strictly as now, especially in the oldest prose texts, which are often materially influenced by the Latin sources from which they have been derived or translated.

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[1] See G. Wendt, *Die Nationalität der Bevölkerung der Deutschen Ostmarken vor dem Beginne der Germanisierung*, Göttingen, 1878.

[2] See ENGLISH LANGUAGE, as above, p. 350.

[3] See article ENGLISH LANGUAGE, vol. viii. p. 350.

The earliest extant specimen of Low German belongs to the beginning of the 9th century. It is a short formula of renunciation of the devil to be used before the ceremony of baptism.[1] It begins thus:—"Forsachistu diobole? et respondeat: ec forsacho diabole. End allum diobolgelde? respondeat: end ec forsacho allum diobolgelde. End allum dioboles uuercum? respondeat: end ec forsacho allum dioboles uuercum and uuordum, Thuner ende Uuoden ende Saxnote ende allum them unholdum the hira genotas sint." "Forsakest thou (the) devil? I forsake (the) devil. And all devil-sacrifice? And I forsake all devil-sacrifice. And all (the) devil's works? And I forsake all the devil's works and words, Thuner and Woden and Saxnot and all the uncouth (beings) that their companions are."

We cannot, unfortunately, tell what special dialect of Low German this piece belonged to, nor even whether it was originally written in German, as several forms occurring in it have rather an Old English look. No more certain are the place of origin and the dialect of the most important relic of the Old Saxon language, the great poem of the *Hêliand*, or the History of our Saviour, composed in the old alliterative verse by a Saxon cleric or monk, about the year 830. We quote as a specimen the following lines from the Munich MS.[2]:—

"Quamun managa
Iudeon an thene gastseli; uuard im thar gladmod hugi,
blidi an iro breostun: gisahun iro baggebon
uuesen an uunneon. Drog man uuin an flet
skiri mid scalun, scenkeon huurbun,
gengun mid goldfatun; gaman uuas thar inne,
hlud an thero hallu, helidos drunkun."

"(There) came many Jews to the guest-hall; became to them there glad (their) mind, blithe in their breasts: (they) saw their ring-giver be in joy. Wine was borne into (the) hall bright in cups; cup-bearers walked about, went with golden vessels, joy was therein loud in the hall, the knights drank.

Much more numerous and various in age and dialect are the documents of Old High German, some of which date as far back as the 8th century. Welcome as they may be to the student of grammar, not much can be said for their intrinsic value. Almost all the prose pieces are mere translations (many of them could not be worse) from the Latin; and even such poetical works as Otfrid's *Life of Christ*[3] are no more than prose thoughts forced into bad verse. Only a very few relics of true poetry have reached us, among which the *Hildebrandslied* (in a mixed dialect), the fragments of the *Múspilli* (a poem about the Last Judgment, in the Bavarian dialect, belonging, like the *Hildebrandslied*, to the beginning of the 9th century, and also written in alliterative verse), and the *Ludwigslied* (881 or 882, in one of the Frankish dialects) may be mentioned here.[4]

High German, as already hinted, is chiefly distinguished from the other Teutonic languages by a certain transformation of its mute system. The ordinary changes,—that is to say, those received in the modern High German literary language,—are the following:—*d* is changed to *t* in all positions; *t* to *z* (either pronounced *ts* or *ss*); *p* to *pf*, *ff*, or *f* according to its position in the word; *k* initial and following a consonant is kept, but after a vowel *k* passes into *ch* (pronounced as Scotch or Modern German *ch*). Thus we get the following comparisons:—

Old English.	Old Saxon.	Old High German.	Modern High German.	Modern English.
dón	dón	tuon	thun	do
tó	tó	zuo	zu	to
sealt	salt	salz	salz	salt
settan	settian	sezz	setzen	set
etan	etan	ezzan	essen	eat
pund	pund	pfunt	pfund	pound
hearp	harpa	harpfa, harfa	harfe	harp
slǽpan	slápan	sláffan	schlafen	sleep
cyning	kuning	kuning	könig	king
thencan	thenkian	thenken	denken	think
macian	makon	machon	machen	make

This is the state of things in the High Frankish or Eastern Frankish dialect, spoken in the south-east of the Frankish territory. In the earliest period, as may be seen from the above list, it still preserved the *th* sound in many cases; in the later stages *d* is found to have been substituted, as in Modern High German. The Upper German dialects show the same change at a much earlier time, and, in addition to this, they have also changed *k* initial and following a consonant into *ch*, and *b* and *g* initial into *p* and *k* (representing most likely voiceless soft stops, as still pronounced in South Germany and Switzerland); Bavarian admits *p* for *b* even in the middle of words. Thus we have, for instance, *denchen* for Frankish *thenken*, to think; *pitten* for Frankish *bitten*, to bid; *keban*, or Bavarian *kepan*, for Frankish *geban*, to give. In illustration of these distinctions and some other variations of spelling we may quote three contemporaneous versions of the Lord's Prayer which have fortunately been preserved[5]:—

Frankish Version.	*Alemannian Version.*	*Bavarian Version.*
Fater unser thu in himilombist, giuuihit si namo thin. Queme richi thin. Uuerdhe uuilleo thin samaso in himile endi in erthu. Broot unseraz emezzigaz gib uns hiutu. Endi farlaz uns sculdhi unsero samaso uuir farlazzem scolom unserem. Indi ni gileiti unsih in costunga, auh arlosi unsih fona ubile.	Fater unsar thu pist in himile, uuihi namun dinan. Qhueme rihhi din. Uuerde uuillo diin samaso in himile sosa in erdu. Prooth unsar emezich kip uns hiutu. Oblaz uns sculdi unsaro so uuir oblazem uns sculdikem. Enti ni unsih firleiti in khorunka, uzzer losi unsih fona ubile.	Fater unser, du pist in himilum. Kauuihit si namo din. Piqhueme rihhi din. Uuesa din uuillo samaso in himile est, sama in erdu. Pilipi unsraz emizzigaz kip uns eogauuanna. Enti flaz uns unsro sculdi samaso uuir flazzames unsrem scolom. Enti ni princ unsih in chorunka, uzzan kaneri unsih fona allem sunton.

It is impossible to give here a sufficient idea of the variability of Old High German, as, indeed, out of several hundred pieces that have come to our knowledge, there are not two representing exactly the same dialect to all its shades or at least in exactly the same spelling. We shall therefore restrict ourselves to a short notice of the more important documents. South-western Frankish is best represented by a very old translation of a treatise by Isidorus Hispalensis, *De Fide Catholica*,[6] and Otfrid's *Life of Christ*, mentioned above. The chief source of Eastern Frankish is a translation of the *Harmony of the Gospels* erroneously ascribed to the Syrian father Tatianus.[7] For Bavarian we may quote some old glossaries,[8] for Alemannian the interlineary versions of the Benedictine Rule[9] and some Latin church hymns,[10] besides several glossaries. For later Old High German, the works of Notker Labeo, or Teutonicus, a monk of St. Gall who died in 1022, are the fundamental sources.[11] What Ormin did for English phonetics, Notker may be said to have done, even more completely, for those of Germany. He not only carefully marks the quantities of vowels, but also points out the phonetic difference between such diphthongs as *ei*, *ou*, *iu*, and *ie*, *uo* by his way of accentuating them (*éi*, *óu*, *íu*, and *îe*, *ûo*); even such phonetic minutiæ as the change of initial voiced stop consonants into voiceless stops after a pause or a voiceless consonant are duly registered, as may be seen from the following specimen. "Sanctus paulus kehîez tîen dîe in sînên zîten uuândon des sûonetagen, taz er êr nechâme êr romanum imperium zegîenge únde antichristus rîchesôn begóndi. Uuér zuîuelôt romanos íu uuésen állero rîcho hêrren únde íro geuuált kân ze énde dero uuérlte?"—"St. Paul assured those who in his time expected the day of judgment that it would not come before the Roman Empire was dissolved, and Antichrist began to reign. Who doubts that the Romans are the masters of all kingdoms, and that their power reaches to the end of the world?"

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[1] It has been published along with all the minor pieces of Old Saxon still extant, by M. Heyne, *Kleinere altniederdeutsche Denkmäler*, 2d edit., Paderborn, 1877. See also K. Müllenhoff and W. Scherer, *Denkmäler deutscher Poesie und Prosa*, 2d edit., Berlin, 1873.

[2] This MS. gives the poem in a pure Saxon dialect, while the dialect of the Cotton MS. in some respects resembles the Frankish idiom. Both texts are printed in the latest edition by E. Sievers, Halle, 1878.

[3] Otfrid, a monk of Weissenburg, in Alsace, formerly a pupil of Hrabanus Maurus, at Fulda, wrote his work (in the South-Frankish dialect) in 867 or 868. It is for the most part due to him that the rhymed stanza (imitated from that of the Latin Church hymns) was introduced into German poetry, instead of the earlier alliterative metre. The latest editions are by J. Kelle, Ratisbon, 1856, 1869, and by P. Piper, Paderborn, 1878.

[4] The minor pieces of Old High German, both verse and prose, are collected in Müllenhoff and Scherer's *Denkmäler*, 1873.

[5] Ten different versions of The Lord's Prayer (down to the 14th century) are given in a synoptical order, by Massmann, *Die deutschen Abschwörungs-, Beicht-, und Betformeln*, Quedlinburg and Leipsic, 1839, p. 158 *sq.*

[6] K. Weinhold, *Die altdeutschen Bruchstücke des Bischof Isidorus von Sevilla de fide Catholica*, Paderborn, 1874.

[7] Latest edition by E. Sievers, Paderborn, 1872.

[8] E. Steinmeyer und E. Sievers, *Althochdeutsche Glossen*, i., Berlin, 1879.

[9] H. Hattemer, *Denkmahle des Mittelalters* i., St. Gall, 1844.

[10] E. Sievers, *Die Murbacher Hymnen*, Halle, 1874.

[11] Hattemer, *op. cit.*, vols. ii., iii.

It will be clear from what has been said above that the main feature of the Old High German period is the total absence of a common literary language. No voluntary modifications of the form of speech are to be found, but such as are naturally involved in any attempt to adapt a spoken idiom to literary use. Nevertheless it has been suggested by K. Müllenhoff[1] and others that idioms of a more refined character than the ordinary popular dialects were spoken at the principal courts of the empire, and especially at the imperial court itself, and that the authority of these *Hofsprachen* was great enough to exercise a modifying influence on the literary productions throughout the empire, or in those parts at least where High German was the vernacular speech. But how these suppositions can be proved does not appear, or how they can be reconciled with the fact that all literary documents of the period *are* dialectal.

Middle German.—The transition to Middle High and Low German is conspicuously marked by a decided improvement in the poetic faculties of the nation.[2] While the 10th century has left only a very few specimens of poetry, and these of poor quality, the number of poems (mainly of a theological bearing) dating from the 11th century is not inconsiderable, and the 12th century shows a rapidity of literary development almost unparalleled. At first indeed religious and legendary poetry is still prevalent, but soon literature begins to take a more historical or epic turn. This tendency is clearly visible in the *Kaiserchronik*, or Emperor's Chronicle, in which the first attempt is made to give a survey of universal and German history in a poetical form. The romantic tales of Alexander the Great and of the battle of Roncesvalles were translated from the French,—the *Alexanderlied* by the Pfaffe Lamprecht, the *Rolandslied* by the Pfaffe Konrad; while old national traditions contributed fitting subjects for such epic poems as that concerning the adventures of the Lombard King Rother. Lyric poetry, hitherto altogether neglected, sprang suddenly into vigor in the remote east of Austria about the middle of the century, and soon found its way to other countries. But the most decided advance was not made till about 1180, when the new forms of social life that had crept in among the more cultivated classes, in imitation of the laws and customs of French chivalry, began to exercise a powerful reforming influence on all branches of poetry. The example set by the Netherlands poet, Heinrich von Veldeke (who for some time lived, and partly wrote, in Germany), in his *Eneit* or *Æneid*, was soon followed by the three great epic masters of the period, Hartmann von Aue, Gottfried von Strasburg, and Wolfram von Eschenbach. About the same time the *Nibelungenlied* and other compositions of a more national character were composed, while lyric poetry was raised to a height of excellence never attained at any other period of the Middle Ages, and best represented in the songs of Walther von der Vogelweide. It is true enough that this new chivalrous poetry was not always very original in thought; indeed, most epic poems of this class, and many lyric stanzas, have been directly copied from French models; but its influence on the culture of the language was immense. It was then for the first time that Germany possessed a real literary language, undoubtedly homogeneous as far as style and metre are concerned. Whether a similar unity of the outer form of speech had already been reached at that period is a point very difficult to decide. The question was raised for the first time as early as 1820, by Karl Lachmann, in his *Auswahl aus den hochdeutschen Dichtern des XIII. Jahrh.* Lachmann's opinion was that the poets of the 13th century spoke a definite, unchangeable sort of High German, a few minor dialectal peculiarities being excepted, and that uneducated scribes had been guilty of introducing older or corrupt forms of the common speech into our manuscripts. These views were at the time unanimously accepted, and are still held (though in a somewhat modified form, admitting two literary idioms, one in the south, the other in the midland) by a majority of the German philologists of the present day. As a consequence of this, most of the "critical" editions of Middle High German poetry that have appeared since Lachmann's time do not reproduce the original readings of the manuscripts, but give the texts in a "corrected" form, commonly called "correct Middle High German," which is assumed to appear in its purest form in the works of Hartmann von Aue. It is chiefly Alemannian, or Swabian, with some Frankish peculiarities of spelling in the use of the consonants, in order to produce a greater resemblance to ordinary Modern High German orthography. No manuscript, however, is known to be written in exactly the same language or orthography; nor are there any poets, except those of Swabia, who do not clearly show by their rhymes the existence of dialectal forms in their speech. All incongruities in the rhymes disappear when they are transferred to the forms peculiar to the local dialects of their authors.[3] It was therefore but natural that a reaction against Lachmann's views should ultimately have set in;[4] and this reaction appears to have been right in denying that dialectal forms were purposely and studiously avoided, even by the classic authors of the period, with a view to the approximation of their language to a certain universal idiom never existing anywhere but in the fancy of certain modern writers. How injurious to the study of Middle High German dialects the views of Lachmann, had they prevailed, must have been, it is easy to see; but on the other hand it must not be forgotten that the only method of investigating the dialects of the single authors was that followed by Lachmann, viz., to reconstruct them by a careful study of the rhymes, for the dialects of the manuscripts are often, nay in most cases, clearly different from those of the writers themselves, as shown by the rhymes. It is therefore not so much the principle of reconstruction that has been resisted by Lachmann's opponents as the way in which this reconstruction has been practically carried out. For prose writings of course no such reconstruction is possible; still, prose documents, especially such as were destined for local use only (charters, etc.), and therefore less liable to adulterations of the original, are often the main sources for German dialectology.

The prominent feature of German (Low German included) in this period is the levelling of the unaccented vowels of the inflexional and some of the derivative syllables already mentioned. As to the former there is only one exception, viz., the retaining of the termination *iu* (pronounced as Modern German *ü* or French long *u*) for the nom. sing. fem. and the nom. and acc. plur. neutr. of the adjectives (*blindiu*, while all other cases have the levelled *e*); and even this seems to be a specialty of Upper German, the corresponding Midland form being *blinde* as in Modern German. The unaccented *e* is frequently dropped in all dialects, especially in the south, where the dropping is almost regular after an *r* or *l* closing the short syllable, as in *bern*, *steln*, for *beren*, *stelen*, to bear, to steal; Old High German, *beran*, *stelan*. In the Midland dialects *i* is often written for this *e*, thus *berin*, *stelin*. The accented vowels of the root syllables are greatly changed in this period by the "Umlaut," or mutation of sounds, being an assimilation of these vowels to an *i* or *y* originally following. Thus *a*, *ā*, *o*, *ō*, *u*, *ū*, *uo* are changed to *e*, *æ*, *ü* or *ö*, *œ*, *ü*, *iu* (long *ü*), *üe* as may be seen in the following instances:—*hant*, hand, pl. *hende*; *rāt*, council, pl. *ræte*; *golt*, gold, *güldîn*, golden, or *mohte*, I might, subj. *möhte*; *grōz*, great, *grœze*, size; *kus*, a kiss, *küssen*, to kiss; *mūs*, mouse, pl. *miuse*; *guot*, good, *güete*, goodness. The Umlaut, however, is not always expressed in the spelling of the manuscripts, though it must have existed in the living language. Of the diphthongs, *iu* has been changed into long *ü*, but the old spelling is often retained in the MSS. (*liute*, modern *Leute*, Old High German *liuti*, people). As to the consonants, the *th* sound had nearly disappeared at the beginning of the period, and was lost entirely in its course; *sk* has passed into the *sh* sound, written *sch* as in Modern German. Spelling in general is simpler, and in some points more rigidly phonetic than in Old German. Final voiced consonants, as *b*, *d*, *g*, are generally changed into the corresponding voiceless sounds, as *p*, *t*, *c* (in High German *grap*, grave, gen. *grabes*, *pfat*, path, gen. *pfades*, *tac*, day, gen. *dages;* in Low German *graf graves*, *pat pades*, *dach dages*). Double consonants are simplified in the same position, as in Old German (*bal*, ball, gen. *balles*). The use of the letter *v* has greatly increased; in High German it means simply *f*, and is therefore quite superfluous; in Low German its pronunciation is *f* at the beginning of words, while in the middle of words it has the same sound as English *v*.

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[1] See his *Denkmäler*, Introduction.

[2] See W. Scherer, *Geschichte der deutschen Literatur im XI. und XII. Jahrhundert*, Strasburg, 1875.

[3] This has been exemplified in a most masterly manner by W. Braune, in his *Untersuchungen über Heinrich von Veldeke*; see *Zeitschrift für deutsche Philologie*, iv. p. 279 *sqq.* Braune has conclusively shown that Heinrich von Veldeke never tried to write German (although he wrote for German readers), as had generally been supposed before, but simply wrote in his familiar Netherlands dialect.

[4] See especially H. Paul, *Gab es eine mittelhochdeutsche Schriftsprache?* Halle, 1873. Paul seems, however, to go too far in denying the existence of some peculiarities of style pointed out by Lachmann and his followers.

The leading dialects of the period are those of Old German, the most noteworthy difference being the accession of the dialects of the kingdom of Saxony (*Obersächsisch*, or Upper Saxon) and Silesia to the midland dialects, and those of some eastern provinces of Prussia (*Niedersächsisch*, or Low Saxon) to Low German, in consequence of the German colonization of these countries. Low German, to begin with, has retained the phonetic structure of its consonantal system unaltered, except by the loss of the *th* sound. The spelling of the vowel system is very imperfect. Umlaut is not expressed in the older manuscripts, except in the case of *a* and *e*. A long *e* corresponds to both High German *ei* and *ie*, a long *o* to High German *ou*, *öu*, and *uo*, *üe*, the only diphthong generally admitted being *ou* before a *w*, as in *houwen*, to hew. The pronunciation of *ē* and *ō* must, however, in these cases have been different according to their etymological values, for all the High German sounds mentioned above are distinctly kept asunder in the modern Low German dialects, and *ei* and *ů* or u are often written for *ē* and *ō* where they stand for High German *ei* and *uo* or *üe*, but never otherwise. It is most likely, judging from the present state of things, that open *e*, *o* were the equivalents for High German *ei*, *ou*, *öu*, while close *e*, *o* corresponded to High German *ie*, *uo*, *üe*. The prefix *ge* is dropped, as in English and in the Scandinavian languages (thus *bort*, birth, High German *geburt*). But the most remarkable fact in the history of Low German sounds is the restoration of *nd* or *nn* for *th* after a dropped nasal sound (see above, p. 462), as in *ander* or *anner*, other, for Old Saxon *óthar*, or in *munt*, mouth, for Old Saxon *múth*. This transition cannot be explained by any phonetic laws, but must necessarily be ascribed to High German influence. As to the inflexional system, a similar influence seems to have introduced the High German terminations of the plural of verbs (*wi geven*, *gi gevet*, *se geven*, we, you, they give). The Old Saxon -*s* in the nominative plural has been dropped, as in High German. The following lines quoted from the municipal laws of the town of Hamburg (written 1270) may be taken as a fair specimen of 13th-century Low German:—"Dat nement syn erue verkopen schal, he ne bede id erst synen negesten. So we syn erue vorkopen wil, dat bynnen desser stad vnde bynnen dessem wicbelde belegen is, de schal id beden twen synen negesten vrunden, dar syn erue vp vallen mach, vnde wil it erer nen kopen, so mot he syn erue wol vorkopen deme de eme dar vmme allermest geuen wil." "That nobody shall sell his inheritance, unless he offer it first to his nearest (relations). Whosoever is willing to sell his inheritance, that is situated within this town and within these precincts, shall offer it to two his nearest friends (relations), to whom his inheritance may fall, and if neither of them is willing to buy it, he must (may) well sell his inheritance to him who is willing to give him most for it."

The differences of the main dialects of High German are not very striking during the first stage of this period. Alemannian is best characterized by its rigidly keeping its original vowel qualities, some of the modern Swiss dialects showing exactly the same system as about 1200. Swabian is easily discovered by its frequent use of *au* for *ā*, as in *gaun*, to go, for *gān*. A very important change of vowel qualities is found to have taken place, at a very early time, in the Bavarian dialect. While *ie*, *uo*, *üe* were preserved as in Alemannian, *ei*, *ou*, *öu* were changed into *œi* (or *ai*), *au*, *eu* (or *aͤu*), and three new diphthongs, *ei*, *ou*, *eu*, sprang up from the long vowels ī, ū *iu* (ǖ). In the Midland dialects again, *ei*, *ou*, and ī, ū, ǖ were kept, as in Alemannian (although *ü* is generally not distinguished from *u* in writing, as in most Midland manuscripts no special signs for the Umlaut vowels are used, except *e*), but *ie*, *uo*, *üe* were contracted to simple *ī*, *ū* (*ǖ*), differing from the old *ī*, *ū*, *iu* only in their open quality. The system of these changes may be illustrated by the following list:—

Alemann.	diep	guot	süeze	mīn	hūs	miuse	stein	boum	fröude
Bavarian	diep	guot	süeze	mein	hous	meuse	stain	paum	freude
Midland	dīp	gūt	sūze	mīn	hūs	mūse	stein	boum	freude
Low Ger.	dēf	gōd	sōte	mīn	hūs	mūse	stēn	bōm	froude
English	thief	good	sweet	mine	house	mice	stone	beam	(joy)

As to the consonants, Alemannian and Bavarian still clung to the use of *ch* or *kch* for ordinary *k*, as *chomen*, for *komen*, to come. *P* initial for *b* is especially Bavarian, and was rather more frequent in the 14th and 15th centuries than before; *w* initial is often expressed by *b* in Bavarian manuscripts since the 13th century; thus we find *paideu*, both, for *beidiu* or *peidiu* in Alemannian, or *beide* in the Midland dialects, and *beip*, wife, or even *zbai*, two, for ordinary *wīp*, *zwei;* *k* initial for ordinary *g* went altogether out of use. In Midland orthography the two sounds of Old High German *z*, viz. *ts* and *ss*, were expressed by *cz* or *zc*, and *z* or *zz* respectively. The following specimens of the language of this period are taken from the *Schwabenspiegel*, or Swabian Law, for Alemannian (13th century); the *Spiegel deutscher Leute*, or Mirror of German People, for Bavarian (14th century); and a Midland version of the *Sachsenspiegel*, or Saxon Law[1]:—

Schwabenspiegel.	*Sp. deutscher Leute.*	*Sachsenspiegel.*
Dem pabest ist gesetzet in bescheidenlicher zit ze rihten vf einem blanchen pherde, vnd der cheiser sol dem pabest den stegreif haben, daz sich der satel nit entwinde. Daz bezeichent daz, swaz dem pabest widerste des er mit geistlichem gerihte niht betwingen mac, daz sol der cheiser vnd ander weltliche rihter betwingen mit der ehte.	Dem babst ist gesetzet ze richten ze beschaidener zeit auf einen blanchem rosse, vnd der chaiser sol im den stegraif haben durch daz sich der satel icht entwende. Ditz ist dev beschaidenunge: swaz dem babest widerste, daz er mit geistleichem gerichte nicht betwingen müge, daz sol der chaiser vnd ander wertleich richter mit der æchte betwingen vnd das geistleich sol twingen mit dem panne.	Deme babste ist ouch gesaczt zu ritene zu bescheidener zcit uf eime blanken pferde, und der keiser sal im den stegereif halden, durch daz der satel nicht enwinde. Daz ist die bezcechenunge: swaz deme babste widerste, des her nicht mid geistlichem gerichte getwingen mag, daz ez der keiser mit werltlichem gerichte twinge deme babste gehorsam zu wesene.

"To the pope it is set (ordained) that he shall judge at a certain time, (sitting) on a white horse, and the emperor shall hold the stirrup to the pope, that the saddle may not slide off. This means that whatsoever resists the pope, so that he cannot overcome it with spiritual censure, the emperor and other secular judges shall overcome with the proscription (and the spiritual [court] shall exercise discipline with the ban)."

In the 14th and 15th centuries the development of the dialects rapidly advanced. The greatest changes were those occurring in the vowel system. The new diphthongs *ei*, *ou*, *eu*, for older *ī*, *ū*, *iu*, which had originated in the south-eastern parts of the Bavarian district, gradually spread to the north and west; even some of the South Midland dialects, as Bohemian and Silesian, began to partake of this change, while the north Midland dialects and Alemannian remained unaltered. Short root syllables ending in a single consonant began to be lengthened in almost all dialects, as *gēben*, *nēmen*, for *gĕben*, *nĕmen*, to give, to take. Unaccented *e* was dropped in the southern dialects, especially in Bavarian, to the utmost extent possible. Such forms as *pschœch*, *gtorst*, *kœrt*, for *beschœhe*, happened (subj.), *getorste*, I durst, *gehœret*, heard (part.), began to be quite familiar. Even before a final *l* or nasal sound *e* was now and then dropped in Bavarian, as in *gebm* for *geben*, to give, *gegnt* for *gegende* country, which are exactly the forms still used in our time. Midland and Low German dialects continued to be much more conservative in all these respects. In the consonantal system we have to mention the loss of the *z* sound in all dialects, where it was a simple spirant (not *ts*); although the letter *z* was still often preserved in spelling, it was frequently confounded with *s* in the rhymes, a thing which never occurred in the earlier centuries. Alemannian is chiefly distinguished by its constant change of *sm*, *sn*, *sl*, *sw*, *sp*, *st* into *schm*, *schn*, *schl*, *schw*, *schp*, *scht*, as in *schmit*, smith, *schne*, snow, *schlahen*, to slay, *schwimmen*, to swim, *geschprochen*, spoken, *geischtlich*, "ghostly," spiritual. Late Bavarian favors such spellings as *chrankch*, *pekch*, for *krank*, *becke*. Spelling in general was much neglected, although it was not quite so bad as often in the 16th century, when there was a strong tendency towards crowding as many letters into a word as possible.

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[1] The editions whence the extracts are taken are—for the *Schwabenspiegel*, that of Lassberg, Tübingen, 1840, p. 5; for the *Spiegel deutscher Leute*, that of J. Ficker, Innsbruck, 1859, p. 35; and for the *Sachsenspiegel*, that of Hildebrand, Leipsic, 1870, p. 3.

While the 15th century was thus marked by great divergencies of the spoken dialects, important steps towards gaining a greater uniformity of literary speech were made in the same period by the invention of the art of printing, and by the development of certain *Kanzleisprachen*, or literary idioms of the imperial and other chanceries. There is no need to explain how the habit of reading books printed in dialects not familiar to the reader must have obliged the learned public of the time to acquire a certain amount of knowledge of dialects in general, and must have made them better aware of the peculiarities of their own idioms than was either necessary or possible at the time when manuscripts written expressly in the local dialects of the readers were the only means of conveying literary information. Besides, writers as well as printers must soon have found it profitable to publish their works in a language readily understood by readers in all parts of the country. The principal work, however, was done in Germany by the chanceries. Among these the imperial chancery naturally held the most prominent position; and, inasmuch as its public acts were addressed to readers of all dialects existing throughout the empire, it obviously had also the greatest interest in calling into existence a general idiom. In the 14th century no difference between the language of the imperial chancery and the local idioms of the particular emperors was yet visible.[1] The public Acts of Louis of Bavaria (1314-1347) were written in the Bavarian dialect. The succession of Charles IV. (1347-1378) was accompanied by the introduction of the Bohemian dialect into the imperial charters. This dialect, as was natural from its local position, was neither purely Southern nor purely Midland. *Ei*, *ou*, *eu* for *ī*, *ū*, *iu* were frequently adopted from the Southern dialects, but *ch* for *k* and *p* for *b* were generally rejected; unaccented vowels were preserved to about the same extent as in Midland German. In the reign of Wenceslaus of Bohemia (1378-1400) the same state of things was maintained; but in the charters of Rupert, the elector palatine (1400-1410), we find the Midland dialect of the Palatinate. Sigismund (1410-1437) reintroduced the Bohemian dialect, which by this time had, with the exception of a very short period, prevailed for nearly a hundred years in the imperial chancery. It was therefore but natural that Duke Frederick of Austria should exchange the Austrian dialect of his ducal chancery (which abounded with *kch*, *kh*, *kg* for *k*, and *p* for *b*) for the Bohemian chancery dialect of his predecessors, when he succeeded to the imperial throne (1470-1493). His example was followed by Maximilian (1493-1519), but only so far as public Acts were concerned. In charters destined for local Austrian use as well as in his private correspondence he always kept his vernacular Austrian dialect, showing thus that no change of the spoken idioms had been caused as yet by the introduction of the new artificial language. In the same manner and at the same time the Midland dialect of the electoral chancery of Saxony came to be better adapted for general use by the adoption of the Southern *ei*, *ou*, *eu* for *ī*, *ū*, *iu*, and the abolition of several prominent Midland peculiarities.

Modern High German.—In the preceding paragraph we have tried to give a short sketch of the origin of literary Modern High German; and it is this very idiom of the imperial and Saxon chanceries that Luther made afterwards popular by his translation of the Bible and his numerous other writings. We may quote his own words in confirmation:—

> "Ich habe keine gewisse, sonderliche, eigne sprache im deutschen, sondern brauche der gemeinen deutschen sprache, das mich beide Ober- und Neiderländer verstehen mögen. Ich rede nach der sechsischen cantzlei, welcher nachfolgen alle fürsten vnd könige in Deutschland; Alle reichsstedte, fürstenhöfe schreiben nach der sechsischen vnd vnsers fürsten cantzeley. Darumb ists auch die gemeinste deutsche sprache. Kaiser Maximilian vnd churfürst Friderich, hertzog von Sachsen, haben im römischen reiche die deutschen sprachen also in *eine* gewisse sprach zusammengezogen."[2]

Luther's language, again, was soon acknowledged by German grammarians, as Sebastian Franck (1531) and Johannes Clajus (1578), and was accordingly imitated, as the best pattern of High German. It is true that in the 16th century many writers, especially in Switzerland and Lower Germany, still clung with great pertinacity to their native dialects. But about 1600 Luther's language was fully established as the only idiom of literary intercourse throughout Germany.[3] The changes the language has undergone since Luther's time mostly concern the inflexional system. In the strong verbs the differences between the singular and plural and the indicative and subjunctive of the past have been levelled in the course of time; thus, *ich fand*, *wir fanden*, I, we found, subj. *ich fände*, or *ich schnitt*, *wir schnitten*, I, we cut, for *ich fand*, *wir funden*, *ich fünde*, or *ich schneit*, *wir schnitten*. At present the verb *werden*, to become, is the only specimen left of the old regular inflexion:—*ich ward*, *wir wurden*, *ich würde*; but even here a new irregular form, *ich wurde*, has come into use and almost superseded the more archaic *ich ward*, which is now chiefly confined to poetry. Many other vowel changes have taken place besides, as in *webe*, *wob*, *gewoben*, weave, wove, woven, for Middle High German *wibe*, *wap*, *geweben*, so that the old system of "Ablaut," or vowel change in the root syllables of the strong verbs has often become quite indistinct. A great number of verbs have passed from the strong inflexion to the weak, and *vice versa*. The declension of substantives has also been greatly altered. Umlaut is now regularly used as a plural sign with most monosyllabic and many dissyllabic masculine words, as in *baum*, *bäume*, or *nagel*, *nägel*, for Middle High German *boum*, *boume*, and *nagel*, *nagele*; originally it was confined to a much smaller number of words (*i*-stems, as *gast*, *gäste*, Middle High German *gast*, *geste*). Other masculine words have adopted the plural *-er*, together with Umlaut of the root syllables, from the neuter declension, as *mann*, *männer*, *geist*, *geister*, besides frequent exchanges between the strong and weak declensions, which cannot be specified here. The strong and the weak declension of feminine words originally ending in *e* have been melted together, one form (ending in *e* or a consonant) being used for all singular, and one (ending in *en* or *n* after a consonant) for all plural cases, as *gabe*, *gaben*, *zahl*, *zahlen*, *zunge*, *zungen*, for Middle High German *gābe*, *gābe*, gen. and dat. *gāben*; *zal*, *zal*, gen. and dat. *zaln*; *zunge*, gen. dat. and acc. *zungen*, pl. *zungen* throughout. As to phonology, no change of vowel quality is noticeable in literary German. Modern High German still has the Midland sounds ī (often spelt *ie*), ū, ǖ, for Southern *ie*, *uo*, *üe*, as well as the Bavarian diphthongs *ei*, *au*, *eu* (*äu*), for the older sounds ī, ū, *iu*, the latter not being distinguished either in spelling or in educated pronunciation from the older diphthongs, *ei*, *ou*, *öu*. We have thus *zwei*, *drei*, *baum*, *haus*, *freude*, *häuser*, *leute*, for Middle High German *zwei*, *drī*, *boum*, *hūs*, *vröude*, *hiuser*, *liute*. Change of vowel quantity is the most prominent phonetic feature of Modern High German when compared with the earlier stages of the language. All root-syllables ending formerly in a short vowel followed by a simple consonant have now become long, either by lengthening the vowel or by doubling the consonant, thus *tāg*, *tāge*, *sāl*, *bōte*, or *gott*, *gottes*, *blatt*, *blätter*, for Middle High German *tăg* (or *tăc*), *tăge*, *săl*, *bŏte*, *gŏt*, *gŏtes*, *blăt*, *blĕter*. The rules for dropping unaccented vowels have often been changed accordingly. It must not be forgotten, however, that all these rules are only applicable to the literary idiom; the dialects, and even those of the educated people, often differ very materially from the rules laid down above. There is, indeed, no such thing as a generally recognized standard pronunciation of German, except perhaps on the stage, which no doubt has exercised and still exercises a certain influence on the current opinions as to how one ought to pronounce, but has not been powerful enough to abolish all dialectal peculiarities in the case of even the highest classes. Only a very few general rules can be given. Englishmen will do well to pronounce the vowels as in Italian: *ü* and *ö* are rounded or labialized *i* and *e* sounds, formed by pouting the lips while trying to pronounce *i* or *e*. Long vowels are always pronounced simple, never as diphthongs (which is frequently the case in English, especially with *a* and *o*). Unaccented *e* is invariably dropped in the terminations *el*, *en*, the real pronunciation of such words as *handel*, *bitten*, *lippen*, *haben*, *nehmen* being *handl*, *bittn*, *lippn* or *lippm*, *hābn* or *hābm*, *nēm* (with a lengthened *m*).[4] Among the peculiarities of the consonantal system we may mention the sound of *ch* (in two distinct varieties as in *ach* and *ich*), the *z*, which is a combination of *t* and *s*, and the *r*, which ought to be trilled with the tip of the tongue, but is often pronounced as a uvular or guttural sound. *S* initial is generally sounded like the English *z*, in stage pronunciation, but not usually elsewhere; *st* and *sp* initial are never pronounced on the stage like English *st* or *sp*, but are always *sht*, *shp*, as in *stein*, *spiel*, pronounced (to use English spelling) as *shtine*, *shpeel*. The English *w* ought to be avoided. The German *w* sound is more like English *v*, but somewhat softer; in Midland pronunciation a sound intermediate between English *w* and *v* takes its place. German *v* is simply *f*.[1]

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[1] The particulars which follow are chiefly taken from an able sketch by Dr. E. Wülcker, *Die Entstehung der kursächsischen Kanzleisprache*. See *Zeitschrift des Vereins für thüringische, Geschichte*, ix. p. 349.

[2] *Tischreden*, ch. 69. Dr. Wülcker assigns these words to the year 1545.

[3] For fuller particulars readers are referred to H. Rückert, *Geschichte der neuhochdeutschen Schriftsprache*, 2 vols., Leipsic, 1875.

[4] Foreigners are easily detected by their generally inserting a real vowel-sound before the *l*, *n*.

The varieties of the German dialects of the present are too numerous to be described here. It may suffice to state that the old divisions of Low German, Midland, and Upper German dialects are still applicable. Among the first, the Western or Westphalian dialects are distinctly marked by the pronunciation of *g* initial as a *gh*, or voiced *ch* (sometimes even voiceless), and the use of numerous diphthongs, both long and short, instead of simple vowels. The principal sub-divisions of Midland German are the Lower Rhenish or Middle Frankish dialect (including the German dialects of Transylvania), South-Western and Eastern or High Frankish, Hessian, Thuringian, Saxon, and Silesian. Alemannian is divided into the three main groups of Swabian, Alsatian, and Swiss, while Bavarian is constituted by several sub-dialects spoken in Bavaria and Austria. The study of these dialects has been carried on in Germany for a considerable time,[2] but not always very successfully, especially so far as phonology is concerned; for many observers, while well-trained in all the disciplines of the older school of philology, have been totally ignorant of the simplest laws of phonetics. It is only within the last few years that the value of phonetic studies (although they began in German researches) has been duly recognized in the country of their origin, and dialectology has not hitherto gained much by the more theoretical study of general phonetics. Some excellent beginnings indeed have been made, among which Dr. Winteler's book on his native Swiss dialect holds by far the foremost rank;[3] but it is probable that a long time must yet elapse before Germany can possess so well trained and independent a school of phonetists as that which already exists in England headed by Mr. A. Melville Bell and Mr. Alexander J. Ellis. Not till then, however, can a real history of the German language be written. (E. SI.)

PART IV.—LITERATURE.

Ancient poetry.

There is a deep vein of poetry in the Teutonic nature, and it appears to have revealed itself in the earliest ages. According to Tacitus, the Germans of his time had ancient songs relating to the god Tuisco, his son Mannus, and the three forefathers of the Teutonic race. They had also poems in honor of Arminius, the original subject of which was probably the god Irmin, whose pillar Charles the Great overthrew long afterwards in his first campaign against the Saxons. A song called "barditus," celebrating the greatness of the war-god whom Tacitus calls Hercules, was sung or chanted by the freemen as they advanced to battle. The name "barditus" led some ingenious writers of the 18th century to speculate respecting an order of bards among the ancient Germans; but there is no evidence that any such order existed. "Barditus" meant in the first instance a shield, and was transferred to the song because, while the singing went on, the shield was held to the mouth to make the sound more terrible. It is the opinion of many critics that the stories of "Reynard the Fox" and "Isengrim the Wolf" may be traced back to these remote times. If so, the probability is that they were brought by the Teutons from Asia, and were originally common to the Aryan family. There is every reason to believe that some elements of the *Nibelungenlied* belong to the prehistoric age. The legend of Siegfried has all the marks of extreme antiquity, and it seems to have had at first a purely mythological character. Of the rhythm in which these primitive conceptions were embodied we have no certain knowledge; but as the most ancient poems which have been preserved are in alliterative verse, it is reasonable to assume that this had grown up long before writing came into use.

Opposition of the clergy.

I. *The Early Middle Age.*—When the German tribes began to accept Christianity the clergy everywhere opposed the native poetry, and strove to replace its rude conceptions by the milder images of the gospel. Among the Goths of the 4th century Bishop Ulfilas took the most effectual means of achieving his purpose by preparing a clear, faithful, and simple rendering of the Scriptures,—a translation which has been of inestimable value in the scientific study of the Teutonic languages. No clergyman of like genius arose in Germany itself; but there, too, pagan compositions were steadily discouraged. Charles the Great was the first to check this hostile movement. He showed his love of his native speech, not only by beginning to put together a German grammar, but by issuing orders for a collection of old German poetry. Louis the Pious had little sympathy with the taste of his father, but he could not efface the impression produced by the great emperor. Many of the clergy ceased to dislike that which so mighty a friend of the church had approved, and in some monasteries there were ardent collectors of ancient epic fragments and ballads.

Pagan literature.

These treasures of Old High and Low German literature are nearly all lost, but from the small portions which have come down to us, and from hints in Latin chronicles, we can at least make out the themes with which many of them dealt. Ermanrick, or Ermanaricus, the famous Gothic king of the 4th century, was the subject of a large number of poetical legends. Siegfried continued to be a great epic hero, and from about the 7th century he appears to have been no longer treated as superhuman. The legend of the overthrow of the Burgundian king, Gundicarius or Günther, by Attila assumed many forms, and was at a later time connected with the story of Siegfried. Around the name of Theodoric the East Goth, as Dieterich, several legends soon grouped themselves; and from about the 9th century he was associated with Attila, with whom in history he had nothing to do. Unfortunately, the fragments which have been preserved—all of which are alliterative—do not treat of these supreme heroes; their subjects are of subordinate importance and interest. The *Hildebrandslied*, which was written from traditional narratives early in the 9th century, and is in a mixed dialect, introduces us to a follower of Dieterich. Hildebrand, returning from the wars carried on by his lord, is compelled to fight his own son; but we are left in uncertainty whether father or son is conqueror. The *Ludwigslied* is a ballad of the latter part of the 9th century, written in honor of a victory gained over the Northmen by Louis III., the West-Frankish king. The author was probably a monk who had been a favorite at the court of Charles the Bald. There is also an Old High German ballad celebrating the reconciliation of Otto I. with his brother Henry; and similar ballads are known to have kept up the fame of Duke Ernest of Swabia, who rebelled against Conrad II., and of many other popular heroes. Walter of Aquitania, who flies with his bride from the court of Attila, and at Worms fights King Günther and his warriors, is the hero of a Latin poem of the 10th century, written by a monk of St. Gall, whose materials were evidently taken from a more vigorous German original. The *Merseburger Gedichte*, two songs of enchantment, were written in the 10th century, but must have come down from a much more remote period. They are chiefly interesting for the light they throw upon the religious beliefs and customs of ancient Germany.

Minstrels.

The old ballads, which were intended to be sung as well as recited, were handed down from generation to generation and necessarily underwent many changes. They were preserved from an early period in the memory of the people by professional minstrels, who were held in considerable honor in the time of Charles the Great, but were afterwards rather tolerated than encouraged by the higher classes. Many of them were blind men, and in their solitary wanderings the ancient stories must often have assumed in their minds new shapes. They usually accompanied their singing with the zither or the harp.

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[1] For more accurate descriptions of the German sounds see E. Sievers, *Grundzüge der Lautphysiologie*, Leipsic, 1876.

[2] A very full list of books referring to German dialectology has been given by C. H. Herrmann, *Bibliotheca Germanica*, Halle, 1878, p. 67 *sqq.*

[3] J. Winteler, *Die Kerenzer Mundart des Kantons Glarus*, Leipsic, 1876. This is indeed the only work that can be justly compared with Dr. J. A. H. Murray's *Dialect of the Southern Counties of Scotland*, published in 1873.

Religious poetry. Of the works with which the church sought to counteract pagan influences very few remain. The most important is *Heliand*, a Low German poem in alliterative verse said to have been written by a Saxon at the request of Louis the Pious. It is a narrative of the life of Christ, and follows closely the Four Gospels, whose separate accounts it attempts to harmonize. The author has considerable force and freedom of expression, and seems to have been so absorbed in the grandeur of his theme as to have deliberately rejected rhetorical ornament. The so-called *Krist* of Otfrid, a High German poet, who dedicated his work to Louis the German, has the same subject, but is not nearly so effective. It is the first rhymed German poem, and the necessities of rhyme often compel Otfrid to fill out his line with words and phrases which obscure his meaning. His lyrical passages are too didactic to rank as genuine poetry. The fragment of *Muspilli*, a Bavarian poem of the 9th century on the Last Judgment, indicates power of a much higher order. Its form is alliterative; and reminiscences of paganism are strangely mingled with its Christian ideas.

Monastic learning. During the reigns of Charles the Great and Louis the Pious secular learning was zealously cultivated in the monasteries of Germany as well as in those of other portions of the Frankish empire. The school established by Hrabanus Maurus in the famous abbey of Fulda vied with that of Tours, where Hrabanus had been a pupil of Alcuin, in the excellence of its teaching. In the wars with the Northmen, with the Magyars, and with the Slavs under the later Carolingian kings, many of the ecclesiastical institutions were destroyed; but they sprang up again under the protection of Henry I. From the time of his son Otto I. the Germans stood in direct relation with Italy; the marriage of Otto II. with the princess Theophano brought them into connection with the learning and refinement of the Byzantine court; and Gerbert, the friend of Otto III., afterwards Pope Silvester II., introduced them to some of the achievements of Arabian science. These influences quickened the energies of enlightened churchmen, and originated an intellectual movement which to some extent continued during the vigorous reigns of the first two Franconian sovereigns, Conrad II. and Henry III. The chief subject of study was the scholastic philosophy, to which, however, in its earlier stages, Germany made no supremely important contribution. The Neo-Platonic tendencies of Scotus Erigena were opposed by Hrabanus Maurus, who remained loyal to Aristotle and Boetius; and his example was generally followed, not only by his successors in Fulda, but by the members of all other German schools. The school of St. Gall was exceptionally active, and one of the monks, Notker Labeo, who died in 1022, wrote some original philosophical books, and translated into German the *De Consolatione* of Boetius and two of Aristotle's works. In pure literature very little was done; but there are several well-written Latin histories belonging to the 11th century. The best thought of the age was manifested in its Romanesque architecture, and in the then subordinate arts of painting, sculpture, and music.

Hohenstaufen period. II. *The Age of Chivalry.*—The reign of Henry IV., during which the struggle between the empire and the papacy began, had a disastrous effect on the national culture; and the evil was not remedied under the disturbed rule of his two immediate successors. But under the Hohenstaufen dynasty, during the period of Middle High German, the country passed through one of the greatest epochs of its literature. The more learned of the clergy interested themselves deeply in the development of scholasticism through the nominalists and the realists; and in the 13th century Albertus Magnus, a native of Swabia, produced the first systematic exposition of Aristotle, in the full light of Arabian research. It was, however, in poetry that Germany achieved the highest distinction; and her most important poets were members of the knightly class, which at this time rose to its utmost power and fame. There were many reasons why the members of this class became sensitive to the higher influences of the imagination. In the first place, they had the elevating consciousness of a life shared with a vast community which set before itself the loftiest aims. Historians sometimes take a malicious pleasure in contrasting the mean performance of many knights with their high vows; but these vows at any rate introduced into the life of rough nobles an ideal element, and inclined them to take interest in the gentler and nobler aspects of existence. In the Italian wars of Frederick Barbarossa the German knights saw more than they had ever before done of Southern civilization, and their minds were continually stimulated by the varying fortunes of their adventurous emperor. Of still greater importance was the influence of the crusades, in which the Germans first took an active part under Frederick's predecessor, Conrad III. The crusaders had a remote and unselfish aim, connected with all that was most sacred and most tender in their religious ideas; and this alone would have created a sentiment favorable to poetic aspiration. But, besides this, the far-off Eastern lands, with their strange peoples and mystical associations, awoke dreams which could not have other than harmonious utterance, and on the return of the warriors they stirred the fancy of their friends with reports of a new and greater world. While the crusades lasted, the knights were forced into intimate acquaintance with the clergy, whose refined culture inevitably to some extent softened their rudeness; they also formed friendships with representatives of French chivalry. In France the works of the troubadours and the trouvères formed one of the most prominent elements of the national life, and the French nobles did not forget in Palestine the songs and romances of their home. The better minds in the German armies caught the inspiration, and longed to distinguish themselves by like achievements. And their desire was deepened when, by the acquisition of the Free County of Burgundy, Frederick Barbarossa opened a new pathway by which intellectual influences might pass from the western to the eastern bank of the Rhine.

The poetic impulse which thus entered Germany affected a wide circle; the highest princes as well as the humblest knights felt its power. Even the emperor Henry VI. himself is said to have been moved by the prevailing feeling, and to have composed verses. At the imperial and princely courts poets were encouraged to give expression to their genius; and the ladies whose beauty and virtues they delighted to praise stimulated their endeavors by marked appreciation. Thus the national imagination found in the whole temper of the age an atmosphere well adapted to the blooming of its first spring-time.

Poetical romances. The most characteristic outcome of this active era is the series of poetical romances produced in the 12th and 13th centuries. The German poets might have found magnificent material in their old, native legends; but for the most part they preferred subjects which had already been artistically wrought by the trouvères, whose methods and style they also closely imitated. Among the themes they selected may be mentioned the legends of Alexander the Great, of Charles the Great and his paladins, of Arthur and the knights of the Round Table, with the allied legend of the Holy Grail. The fortunes of Tristram and Iseult also exercised a powerful charm over many minds. These and all other chosen subjects were treated wholly in the spirit of chivalry. The poets of the Middle Age had no idea of being true to the characteristics of a particular epoch; their own time was the only one they attempted to understand. Ancient heroes became in their hands mediæval knights; men who had died long before the rise of Christianity were transformed into devoted servants of the Church. And in every romance the supreme aim was to present an idealized picture of the virtues of knighthood.

Romance writers. One of those who prepared the way for the chief romance-writers was Conrad, a priest in the service of Henry the Proud, who, before 1139, composed the *Rolandslied*, setting forth, in imitation of the French *Chanson de Roland*, the overthrow of Roland, the favorite paladin of Charles the Great, in the pass of Roncesvalles. He was followed by another priest, Lamprecht, who, also working upon a French original, relates in the *Alexanderlied* the deeds of the Macedonian hero. Greater than either of these was Heinrich von Veldeke, the first of the poets who may claim to rank as German trouvères. His great work was the *Eneit*, written between 1175 and 1190. It is not only in armor and in dress that Virgil's characters are here changed; in thought and feeling they are recreated. The language of the poem is so carefully chosen, and the incidents are narrated with so much spirit, that it is still possible to understand the immense popularity it once enjoyed. Hartmann von Aue, in *Der Arme Heinrich*

Hartmann von Aue.

and other poems, selected themes that are extremely repulsive to modern feeling; but he was endowed with genuinely plastic force, and interests us by touching certain mystical aspects of mediæval sentiment.

Wolfram von Eschenbach.

The master in whom these aspects were most fully represented was Wolfram von Eschenbach, a member of a noble family of Franconia, who was born during the reign of Frederick Barbarossa and died during that of his grandson, Frederick II. He was one of a group of poets who established themselves at the Wartburg, the court of the brilliant landgrave Hermann of Thuringia; and his chief poem, *Parzival*, was composed there towards the end of the 12th century. Germany did not produce during the Middle Ages a more truly poetic mind, and it is curious to observe how exactly he anticipated some of the qualities for which she long afterwards became famous. He has all the dreaminess, the sentiment, the passion for the ideal, which are, or rather at one time were, her most attractive characteristics. The hero, trained by his mother amid circumstances of idyllic simplicity, suddenly passes into a world of movement and adventure, and he is brought by accident to the gorgeous palace of the Holy Grail, of whose kingdom he ultimately becomes lord. The object of the poem is evidently to depict the strivings of a restless but noble spirit, dissatisfied with passing pleasure, having always before it a high and spotless aim. It is difficult for modern readers to detect the spiritual significance of many of the scenes; the poet seems to escape from us into a far-off region, whence his words reach us rather as dim echoes than as clear, ringing sounds. And some of the descriptions are in themselves tedious and superfluous, while advance from one stage of the tale to another apparently proceeds according to the arbitrary whim of the moment. Nevertheless, the character of Parzival is a true conception of genius, and enables us to understand, better than any other imaginative creation of mediæval Germany, that discontent with life as it is, that sense of being haunted by visions of spiritual loveliness, which, throughout the Middle Ages, existed side by side with unrestrained delight in the outward world.

Gottfried of Strasburg.

A complete, almost a dramatic contrast to Wolfram von Eschenbach is found in Gottfried of Strasburg, the greatest of his literary contemporaries. These two men are representatives of a distinction which incessantly recurs,—that between the poet who fashions spirits of a finer mould than those we actually know, and the poet who contents himself with penetrating into the innermost recesses of existing character. Gottfried's theme is Tristram and Iseult; and the charming tale, which unfortunately he did not live to carry to the end, was perhaps never more beautifully told. There are no mystic longings in the men and women he presents to us: they love the earth and the sky, with their gorgeous colors, graceful forms, and happy sounds; they care not to inquire what may lie behind these, or whether in the scheme of things there is a place for moral law. Few poets have set forth so powerfully the fascination of youthful passion. In his glowing pictures we find no shadowy figures like those of Wolfram, with step so light that they appear to be the figures of a dream; his images are clear, sharply cut, like those of the world from which they are taken. And although psychological analysis was unknown to him, the actions of his characters display keen insight into the secrets of human hearts when entangled in the most confused meshes.

Mediæval romance bore its richest fruit in the works of these two great poets; and most of their successors imitated one or other of them. Those who followed in Gottfried's steps came nearest to a happy result, for Wolfram was one of those lonely and daring spirits in whose remote path it is given to few to tread without stumbling. The best known of Gottfried's imitators was Conrad von Würzburg, who wrote on the Trojan war and many other subjects, and is considered one of the most artistic of mediæval writers. Towards the end of the 13th century the movement showed signs of exhaustion, and romances began to make way for rough popular tales and rhymed chronicles.

Fortunately the poets of the age of chivalry did not all occupy themselves with the subjects of French romances. A few, whose names we do not know, turned towards the rich material in the metrical legends of their native lands. Of these poets, the most important was he who collected and put into shape the ancient ballads which make up the *Nibelungenlied*. How far he modified them we cannot tell.

Nibelungenlied.

In the form in which we possess them, they probably owe something of their force to his genius; but he needed rather to arrange and to curtail than to invent, and although a genuine poet, he was not at all times competent for his task. The work includes the legends of Siegfried, of Gundicarius, or Günther, king of Burgundy, of Dieterich, and of Attila; and the motives which bind them into a whole are the love and revenge of Kriemhild, the sister of Günther and Siegfried's wife. She excites the envy of Brunhild, the Burgundian queen, whose friend Hagen, one of Günther's followers, discovers the vulnerable point in Siegfried's enchanted body, treacherously slays him, and buries in the Rhine the treasure he has long before conquered from the race of the Nibelungen. There is then a pause of thirteen years, after which Kriemhild, the better to effect her fatal purpose, marries Attila, king of the Huns. Thirteen years having again passed, her thirst for vengeance is satiated by the slaying of the whole Burgundian court. The Germans justly regard this great epic as one of the most precious gems of their literature. It has little of the grace of courtly poetry; its characters are without subtlety or refinement; we are throughout in the presence of vast elemental forces. But these forces are rendered with extraordinary vividness of imagination, and with a profound feeling for what is sublime and awful in human destiny. The narrative begins with epic calmness, but swells into a torrent and dashes vehemently forward, when the injured queen makes a fearful return for her wrongs, and is herself swept away by the tragic powers she has called to her service. In the management of the story there are occasional traces of mediævalism; but its spirit is that of a more primitive time, when the German tribes were breaking into the Roman empire, when passions were untamed by Christian influence, and when the necessities of a wandering and aggressive life knit closely the bonds that united the chief to his followers. Deliberate villainy hardly appears in the poem; the most savage actions spring either from the unrestricted play of natural feeling, or from unquestioning fidelity to an acknowledged superior. Here and there we come upon touches which indicate that the poet who preserved the ancient legends was not incapable of appreciating finer effects than those at which he generally aims. The sketch of the hospitable and chivalrous Rüdiger, who receives the Burgundians on their way to the court of Attila, and afterwards dies while unwillingly fighting them in obedience to his queen's command, is not surpassed in the most artistic of the mediæval romances.

Gudrun.

Gudrun is another epic in which a poet of this period gave form to several old legends. They had for centuries been current along the coasts of Friesland and Scandinavia, and the society they represent is essentially the same as that of the *Nibelungenlied*,—a society in which the men are rude, warlike, and loyal, the women independent and faithful. Although full of serious episodes, *Gudrun* is as happy in its ending as the greater poem is tragic; and we feel throughout that the beautiful Princess Gudrun of Seeland, whom the Northmen have carried from her home, and on whom the cruel Queen Gerlind heaps indignities, will at last be restored to King Herwig, her brave and passionate lover. The characters stand out clearly in their rough vigor; and several happy strokes call up a vision of the bleak coasts and changeful northern sea which are the scenes of their adventures.

Heldenbuch.

In the 15th century a German writer brought together in a single volume which he called the *Heldenbuch*—the "Book of Heroes"—a number of old legendary tales that must have been frequently on the lips of the people and of the wandering minstrels, while the knightly poets were singing of Tristram or of Arthur. This work, which was partly written by Kaspar von der Rhön, will not compare in imaginative force with its more famous rivals. The most powerful of the stories is probably the "Grosser Rosengarten," in which a monk, Ilsan, displays a very unclerical, but truly Teutonic, passion for war.

Minnesänger.

The age of chivalry was remarkable not only for its romances and epics but for its lyrics. All the leading writers of the time exercised themselves in lyrical poetry, and it was laboriously cultivated by multitudes who did not feel equal to the task of a prolonged effort. Among those who gained more or less distinction may be named Heinrich von Morungen, Reinmar der Alte, and Gottfried von Neifen. The poets of this class were known as Minnesänger, because their favorite theme was Minne or love. They began by imitating the troubadours, whose metres they often reproduced when not penetrated by the emotion which originally found in these forms a genuine expression. At a later stage it was considered a point of honor for each poet to invent a stanza of his own, whether or not those already existing were appropriate to his feeling. Thus many of the minne songs produce an impression of unreality and coldness, seeming at best to be but clever pieces of handiwork. But when the utmost deduction has been made, it is surprising how much of what was achieved by these ardent writers still appeals to us. The best among them strike notes which respond in every age to a master's touch; and they do it with a fine sense of beauty, a trained instinct for the appropriateness of words, and an evident delight both in simple and in subtle melody.

Perhaps no group of writers has ever had a deeper undertone of sadness than is to be detected in the greatest of the minnesänger. They had a vivid consciousness of the evanescence of human pleasure, an abiding feeling that corruption lurks behind the gayest forms and brightest colors. But they caught with proportional eagerness the passing rapture, letting no drop escape from the cup that would soon fall from their grasp. This intensity of feeling is reproduced in their lays, yet it was purified and generalized as it passed from the fleeting reality to the permanent realm of art. Their treatment of love, although sometimes, according to modern ideas, extravagant and fantastic, often displays genuine elevation of sentiment. They sing also in impassioned strains the loyalty of the vassal to his lord, the devotion of the Christian to his church. If they do not exhibit the soaring spiritual ambition of Wolfram's *Parzival*, they have a kind of pathetic memory of a lost paradise, a vague longing, by some distant difficult service, in battle with the infidel, to attain to a world in which the discords of the present life may be forgotten or harmonized. And behind all their images is the background of nature, whose loveliness they do not the less appreciate because they refrain from elaborately describing it. To the dwellers in dreary towers winter had often a cheerless and melancholy aspect; but this made all the more enchanting the new life of spring. It is in hailing the returning warmth and color of the young season that the minnesänger attain their happiest triumphs.

Walther von der Vogelweide.

Of all the minnesänger the first place belongs without question to Walther von der Vogelweide, probably of Tyrol, whom Gottfried of Strasburg praises as heartily as he slyly depreciates Wolfram von Eschenbach. Walther lived some time at the Wartburg, and was the friend of King Philip and Frederick II.; he died on a little estate which the latter gave him in fief. Other Minnesänger lavished praise on generous princes; Walther was of a more manly character, and seems always to have maintained an independent bearing. Besides the usual themes of the lyrical poetry of his time, he wrote with enthusiasm of his native land; he also frequently alludes to the strife between the spiritual and secular powers, and sternly rebukes the ambition of the papacy. Beyond all his rivals he gives us the impression of writing with ease and delight. The structure of his stanzas does not hamper the movement of his feeling; it appears to provide the conditions of perfect freedom. Such a lyric as his *Unter der Linden an der Heide*, with its musical refrain *Tandaradei*, although a master-piece of art, is exquisite in its childlike simplicity; it has the unaffected grace of a flower, the spontaneity of a bird's song.

Ulrich von Lichtenstein.

As the expression of all that was fantastic and ridiculous in the age of chivalry, must be mentioned the *Frauendienst* of Ulrich von Lichtenstein, a work which was written about the middle of the 13th century, and had a certain popularity in its time. It is an autobiography, with a number of lyrics interwoven to give variety and animation to the narrative. The solemn gravity with which the author relates the amazing tasks imposed upon him by his mistress shows how easily the worship of womanhood degenerated into almost incredible childishness. Ulrich is sometimes compared to Don Quixote, but this is to do extreme injustice to Cervantes's hero. Amid all his illusions the fictitious knight maintains a certain pathetic dignity; the knight of reality passes from absurdity to absurdity without a touch of idealism to redeem his folly. And his lyrics are the tasteless manufacture of a thoroughly prosaic spirit.

Didactic poets.

Several of the minnesänger, Walther von der Vogelweide especially, display at times a strongly didactic tendency. From the beginning of the period this tendency was developed by writers who took little interest in poetry for its own sake, and it became more and more prominent as the purely lyrical impulse passed away. The didactic poet, however significant his labors may be to his contemporaries, has necessarily the stamp of commonplace for posterity; and the gnomic writers of the 13th century form no exception to this rule. But several of them have at least the interest that attaches to sincerity and earnestness. There is genuine enthusiasm for pure morality in the *Welsche Gast* of Thomasin Zerklar; and the *Bescheidenheit* of Freidank expresses so high a conception of duty, and expresses it so well, that the work was ascribed to Walther himself. Reinmar von Zweter and Heinrich Frauenlob came a little later, and they were followed by Hugo von Trimberg, whose *Renner* sets forth unimpeachable lessons in homely and satirical verses. A higher tone is perceptible in *Der Winsbecke*, a collection of sayings in which we find an echo of the reverence for noble women that marked the epoch at its dawn. Among didactic writings must be classed the well-known *Der Krieg auf der Wartburg* ("The Contest at the Wartburg"). It includes the verses supposed to have been sung at a tournament of poets attended by Heinrich von Ofterdingen, Walther von der Vogelweide, and Wolfram von Eschenbach.

Beginnings of prose.

As Latin continued to be the speech of scholars, and the passion for metrical expression pervaded the higher classes, there was not much scope for the growth of prose. Nevertheless, it is in this age that we find the first serious attempts to secure for German prose a place in the national literature. The *Sachsenspiegel* and the *Schwabenspiegel*, two great collections of local laws, although of a scientific character, and mainly interesting because of their social importance, had considerable influence in encouraging the respect of the Germans for their own language. The preachers, however, were the principal founders of prose style. Preaching became about the middle of the 13th century an agency of great power in the life of Germany. A number of the clergy, dissatisfied with the technicalities of scholasticism, and with the mere forms under which spiritual aspiration was often crushed, strove to attain to a fresh vision of religious truth, and to kindle their own enthusiasm in the minds of others. Of this generous band the most popular was Brother Berthold, a Franciscan monk, a man of a noble and commanding temper, and an orator of the highest rank. Love for the poor was his dominant motive, and he sometimes expressed it in language a modern socialist might envy. Having something of the imaginative glow of the minnesänger, he gave such color to his abstract teaching as made it at once intelligible and attractive. Of a less poetical nature than Berthold, Master Eckhart, the next early master of religious prose, was more deeply philosophical. Although familiar with the scholastic systems, he broke away from their method, and became the founder of the mystical school which was one of the most potent factors in preparing the way for the Reformation. Eckhart's reasonings are sometimes hard to follow, but he is not a confused thinker; his obscurity arises rather from the nature of his themes than from his mode of handling them. He occasionally touches profound depths in the spiritual nature of man, and it is refreshing to pass from the formal hair-splitting of the scholastic philosophers to the large conceptions of a mind which obeys its own laws and is evidently in direct contact with the problems it seeks to solve.

Decline of chivalry.

III. *The Later Middle Age.*—After the fall of the Hohenstaufen dynasty the age of chivalry in Germany virtually came to an end. The breaking up of the old duchies set free a large number of petty nobles from their allegiance to mediate lords; and as there was no longer a strong central authority, either to hold them in check or to provide them with such outlets for their energy as they had found in the crusades and in the imperial expeditions into Italy, nearly the whole class sank from the high level to which it had temporarily risen. Many knights became mere robbers, and thought themselves honorably employed in taking part in the innumerable little wars which shattered the prosperity of the nation. Men of this kind were not very likely to inherit the free and poetic spirit of Walther von der Vogelweide. In the course of the 14th and 15th centuries attempts were still made by Wolkenstein, Muskatblüt, and other writers to imitate his style; but in their hands the lyre of the minnesänger gave forth only feeble or discordant notes. For a long time the princes were no more inclined to literature than the nobles; they were too much occupied with mutual jealousies, and with incessant attempts to shake themselves free of the crown, to give heed to anything so removed from practical interests as poetry.

Literature in the cities.

Meistersänger.

It so happened that during this period the cities rose to a position of higher importance than they had ever before occupied. There was a while when it even seemed possible that by their leagues, and by alliance with those emperors who had insight enough to recognize their strength, they might become the preponderating element in the state. Driven from the castles of the princes and the towers of the nobles, literature took refuge in these young and growing centres of a vigorous life. Not one or two here and there, but multitudes of honest citizens, became possessed by the desire to distinguish themselves in the arts in which they had been so much surpassed by the nobles of a previous generation. Unfortunately, they had no literary training; they were not familiar with any great models; few of them had leisure for the cultivation of style; and the character of their daily employments was not such as to kindle thoughts that demand poetic utterance. At that time every trade had its guild; and they now formed guilds of poetry, the task of whose members was in intervals of leisure to produce songs according to a body of strict rules, as in hours of business they produced shoes or loaves. The rules were called the "Tabulatur," and the rank of each member was determined by his skill in applying them. The lowest stage was that of a man who had simply been received into the guild; the highest, that of a master, who had invented a new melody. Between these were the scholar, the friend of the school, the singer, and the poet. Literature produced under such conditions could not have much vitality. It amused the versifiers, and developed a certain keenness in the detection of outward faults; but the spirit of poetry was wanting, and there is hardly a "meistersänger" whose name is worthy of being remembered.

Beginnings of the drama.

Miracle plays.

Much more important than these tedious manufacturers of verse were the unknown authors of the earliest attempts at dramatic composition. In the 10th century Hroswitha, the abbess of Gandersheim, wrote Latin imitations of Terence; but they were without influence on the progress of culture. The real beginnings of the modern drama were the crude representations of scriptural subjects with which the clergy strove to replace certain pagan festivals. These representations gradually passed into the "Mysteries" or "Miracle Plays," in which there was a rough endeavor to dramatize the events celebrated at Easter and other sacred seasons. They were acted at first in churches, but afterwards in open courts and market places; and for many hours, sometimes day after day, they were listened to by enormous audiences. The fragment of a Swiss "Mystery" of the 13th century has survived; but the earliest that has come down to us in a complete form is a play of the first half of the 14th century, treating of the parable of the ten virgins. Like those of France and England, these mediæval German dramas display little imagination; and they are often astonishingly grotesque in their handling of the most awful themes. Along with them grew up what were known as "Shrove Tuesday Plays," dialogues setting forth some scene of noisy fun, such as a quarrel between a husband and wife, with a few wise saws interspersed. They were declaimed without much ceremony in the public room of an inn, or before the door of a prominent citizen, and gave ample occasion for impromptu wit. Nuremberg seems to have been particularly fond of "Shrove Tuesday Plays," for one of its poets, Hans Rosenblüt, who flourished about the middle of the 15th century, was the most prolific author of them. A little later he was extensively imitated by Hans Folz, a Nuremberg barber and meistersänger.

Mystics.

By far the most interesting writers of the 14th century were the mystics, who continued the movement started by Eckhart. Johannes Tauler of Strasburg (1300–61) had not the originality and force of his predecessor, but the ultimate mysteries of the world had an intense fascination for him, and his tender and sensitive spirit opened itself to lights which find no way of entrance into more robust and logical intellects. He did not in the main pass beyond the speculations of Eckhart, but he added grace and finish to their expression, and made them a greater popular power than they could have become through the master's writings. Heinrich Suso, of Constance (1300–65), who has been called "the minnesänger of the love of God," made the doctrines of Eckhart an occasion for the outpourings of a full and sometimes extravagant fancy. Eckhart's teaching was also put into shape by an unknown author, whose work was afterwards published by Luther under the title *Eyn deutsch Theologia.* To all these writers the phenomenal world is in its nature evil, but it is also unreal; the only reality they recognize is a world outside the limits of space and time, in union with which man rises to his true life. They are chiefly of importance in the history of speculative thought, but even from the point of view of literature they were of high service in the development of a rich and vigorous prose.

Prose chronicles.

A plain narrative prose style was cultivated in the chronicles which began at this time to be written in different parts of Germany. The Limburg Chronicle written between 1336 and 1398, the Alsace Chronicle about 1386, and the Thuringian Chronicle, by Rothe, a monk of Eisenach, about 1430 have all considerable historical value; and the fact that they are in German, not like previous chronicles in Latin, proves the rising respect among the people for their native speech.

The Renaissance.

During the latter part of the 15th century there was in Germany, as in the other leading European nations, a great revival of intellectual life. And it was due to the same causes as prevailed elsewhere,—especially the re-discovery of Greek literature and the invention of printing. The movement was naturally most powerfully felt in the universities. The first of these institutions had been founded early in the 14th century by Charles IV. in Prague. Soon afterwards others were established in Vienna, Heidelberg, Cologne, and Erfurt; and in the 15th century universities were set up also in Rostock, Greifswald, Tübingen, Leipsic, and elsewhere. For a long time law and divinity were almost the only subjects studied; but when the Renaissance passed from Italy into Germany, university teaching became the instrument of a freer and larger culture. Scholastic philosophy fell into disrepute; the most active minds occupied themselves only with the intellectual treasures of the ancient world. The men devoted to the new studies were called "Humanists," and they carried on continual warfare with the more ignorant and intolerant of the clergy. Unfortunately they knew nothing of the value of their own language; they wrote, as the scholastic philosophers had done, solely in Latin, and they gave but slight and contemptuous attention to the movements of popular literature.

Popular literature of 15th century.

Yet the popular literature of their time was quite worthy of study, for the stir of new life had affected not only scholars but all classes of society, citizens and even peasants included. It is surprising how many books found their way to the public between 1450 and the outbreak of the Reformation; every one seemed anxious that the newly discovered process by which writers could appeal to so wide an audience should be turned to the utmost possible advantage. Of this great mass of literature a comparatively small proportion was created in obedience to the free impulses of the intellect. The problems of the time were mainly social and practical; men were less moved by ideal interests than by questions as to the tyranny of the princes, the greed and sensuality of the clergy, the worldliness of the papacy, the powerlessness of the crown to enforce peace and order. Multitudes of little tales in prose and verse appeared, in which the princes, the nobles, the clergy, and sometimes rich citizens, were held up to ridicule. The "Shrove Tuesday Plays," which now became extremely popular, also expressed the general discontent; and there were even "Miracle Plays" whose object was to reveal the wrongs of the people. In one of them the leading character of which was Joanna, the mythical female pope, a clerical author did not hesitate to pour contempt on the Roman see itself.

Reineke Vos. By far the greatest of these satirical writings was the epic narrative *Reineke Vos.* It has been already stated that the stories of "Reynard the Fox" and "Isengrim the Wolf" probably belong to prehistoric ages. They became current, through the Franks, in Lorraine and France; and from the 11th to the 15th century they formed the subject of many works in Latin, French, and German. The epic to which allusion is now made appeared in 1498, and was probably by Hermann Barkhusen, a printer of Rostock. It is in Low German, and its materials were obtained from a prose version of the tale which had appeared some years before in Holland, and of which Caxton printed an English translation. Originally, the story had no satirical significance; it was a simple expression of interest in what may be called the social life of wild animals. In the hands of the author of this Low German poem, it becomes an instrument of satire on some enduring tendencies of human nature. He does not lash himself into fury at the vices he chastises; he laughs at while he exposes them. His humor is broad and frank, and he did more than any one else to make Reynard the type of the resource and cunning which overmaster not only brute force but even truth and justice. There are several renderings of the poem into High German, the most important being the well-known work of Goethe in hexameters.

Brandt. Another popular satirical work was the *Narrenschiff* ("Ship of Fools") of Sebastian Brandt, published in Basel in 1494. It is an allegorical poem of more than a hundred sections, in which the vices are satirized as fools. This work passed through many editions, and was rendered into more than one Low German dialect, and into Latin, French, and English; it was even made the subject of a series of sermons by Geiler, of Kaisersberg, a well-known preacher of the day, who had himself some satirical talent. Brandt was personally of a mild and unassuming character, and the fact that he became a satirist in spite of himself is a striking proof of the confusion which had fallen upon both church and state. Now that the occasion of his book has passed away, it is difficult to realize that it once enjoyed almost unprecedented popularity. We cannot but feel that the writer was an honest man; but his allegories are without force or charm, and his moral lessons have been the commonplaces of every civilized society. **Murner.** A satirist of a bolder type was Thomas Murner, who, although he lived far into the age of the Reformation, belongs in spirit altogether to the preceding period. He was a preacher, and both in sermons and in secular writings attacked without mercy the classes who were the butts of his fellow-satirists. After the beginning of the Reformation he included Luther among the objects of his comprehensive dislikes. His laughter was loud and harsh, and can hardly have been favorable to any small buddings of charity that may have revealed themselves among the antagonisms of his generation.

Tyll Eulenspiegel. One of the favorite books of this time was *Tyll Eulenspiegel.* It was published in 1519, and the author (probably Murner) seems to have included in it many anecdotes already well known. According to the preface, Tyll was a Brunswick peasant of the 14th century, who went about the country perpetrating practical jokes. The force of his humor mainly consists in taking every word addressed to him in its most literal sense, and in giving it applications altogether different from those intended by the speaker. There are readers who still find amusement in his rough pleasantries.

Maximilian I. During the better part of this stirring period Maximilian I. was emperor, and he interested himself a good deal in the current literature. As in politics, however, so in poetry, his sympathies were altogether with an earlier age; and he attempted to revive the taste for mediæval romance. From a sketch said to have been prepared by him, Melchior Pfinzig celebrated in *Theuerdank* the emperor's marriage with Princess Mary of Burgundy. The work was splendidly printed, and attracted much notice; but romantic poetry, once so fascinating, produces in its pages the effect of an elderly coquette who, refusing to believe in the ravages of years, tricks herself out in the gay adornments of youth. An earlier book, the *Weiss Kunig*, an autobiography of Maximilian, written by his direction in prose by his secretary Treizsauerwein, has the excellence neither of a chronicle nor of a romance; it is for the most part the fantastic work of a mind which misunderstood its epoch and its own powers.

Popular poetry. Behind the strife and noise of contending sections there was slowly growing up an admirable intellectual product of Germany,—its popular poetry. One of the earliest writers who struck the note of the popular poets was Veit Weber, a Swiss who fought with his countrymen against Charles the Bold, and who celebrated in vigorous verses the battles of Granson, Murten, and Nancy. From this time the German people had always a living poetry of their own, created by unknown authors, but caught up by the masses, passed on from village to village till it was everywhere known, and handed down by each generation to its successors. This popular poetry ultimately reflected every aspect of daily life among the humbler classes; each section among them had its appropriate lyrics, and there were songs of youth, of age, and of middle life. There is no elaboration in these offshoots of the popular fancy, but many of them have an artless beauty which touches the fountains of smiles and tears, and which had an irresistible fascination for the poets of the greatest period of German literature.

Reformation period. IV. *The Century of the Reformation.*—It is possible that if there had been no Reformation the Renaissance would have revealed itself in Germany in a great literary movement, as in France and England, or in a great artistic movement, as in Italy. The conditions of both movements were present in the labors of the humanists on the one hand, and of the Holbeins, Albert Dürer, and Lucas Cranach on the other. But the questions of the Reformation were too profound and agitating for the mind of the nation to turn seriously to any task save that which they imposed. Thus it happened that the young shoots of the Renaissance withered almost before they were in leaf. It was settled that Germany must wait until a much later time for the full exercise of her highest energies.

Luther. In literature not less than in religion Luther (1483–1546) was the commanding spirit of the age; but he was so rather by accident than by choice. For form for its own sake he cared little; he studied it solely that he might the better produce the moral effect at which he aimed. It is hardly possibly for any one to sympathize now with the violence and the dogmatism of his tracts, addresses, and sermons; but they had the high merit of addressing the nation in a language it could understand. They are always clear, simple, warm with the glow of a passionate nature; and amid their noise and fury an attentive ear will sometimes catch the still small voice of a spirit touched to finer issues than mere party warfare. "My husk may be hard," he himself said, "but the kernel is soft and sweet." We do extreme injustice to Luther if we do not recognize in him a strongly poetic element,—an element which had free play only in the best of his private letters, and in his still popular hymns. By the highest of his literary achievements, his translation of the Bible, he made a truly splendid contribution to the spiritual life of his people. No body of literature has been so fortunate in its translators as the Scriptures; and Luther's rendering ranks with the best. Its absolute simplicity brings it to the level of a child's understanding; its strength and grace give it an enduring place as a work of art. Germany instantly felt its charm; and for three centuries it has been to innumerable millions the supreme consoler and sanctifier, the power associated with their tenderest, most pathetic memories, the one link which has connected sordid lives with noble and sublime ideas. And for the first time it gave the nation a literary language. Up to this stage every author had written in the dialect with which he was himself familiar; henceforth for the men of Swabia, of Bavaria, of Saxony, and of all other districts there was a common speech, which the writers of each state could use without any sense of inferiority to those of another. It is thus to Luther that the Germans owe the most essential of all the conditions of a truly national life and literature.

Ulrich von Hutten. The writer who deserves to stand next to Luther is Ulrich von Hutten (1488–1523). An accomplished humanist, he effectively attacked the enemies of the new culture in the *Epistolæ Obscurorum Virorum*, of which he was one of the chief writers. This was before the special work of Luther began; and at a still earlier period he had assailed in a series of fine Latin orations the tyranny of Duke Ulrich of Würtemberg, who was accused of murdering a member of Hutten's family. He had little real sympathy with Luther's religious aims; but he threw himself heartily into a movement by which it seemed possible to purge the state of the spiritual and secular ills which were in deadly antagonism to the progressive energy of humanism. His German writings are mainly short satirical poems and prose dialogues and addresses. Their style is direct, bold, and trenchant; but they are now interesting mainly because of the spirit of freedom which breathes through them, the lofty political ideals of the writer, and his generous ardor for the popular welfare.

Hans Sachs.

A far more voluminous author than Hutten or Luther was Hans Sachs, meistersänger of Nuremberg (1494–1576). He was, indeed, one of the most prolific of German writers, having composed, according to his own calculation, more than 6000 poems. Although extremely popular in his own time, Sachs was almost forgotten after his death. His memory was revived by Wieland and Goethe, and he is now universally admitted to have been the chief German poet of the 16th century. Every species of verse then known he freely cultivated, and there is no important element of his age which is not touched in one or other of his works. He had little of the culture of the schools, and many of his verses are excessively rude. But Hans, had considerable force of imagination, sly humor, and, in his happiest moments, a true feeling for melody. His best works are his "Shrove Tuesday Plays." It is true he makes hardly more attempt than Rosenblüt to develop a dramatic action, but his characters have life, and in many individual scenes are artistically grouped. His didactic dialogues and satirical tales present a remarkably vivid picture of the ideas, controversies, and moral sentiments of his generation; and some of his lyrics still live in the memory of the nation. The song in which he hailed the "Wittenberg Nightingale" gave fine utterance to the reverence of the Lutherans for their chief, and in his hymn, *Warum betrübst du dich, mein Herz?* he so happily met the spiritual need of the day that it was soon translated into eight languages, including English, French, and Greek.

Fischart.

If Hans Sachs was the most industrious poet of the century, Johann Fischart was beyond all comparison its greatest satirist. There was a distinctly Rabelaisian touch in this restless, bizarre, and effusive spirit,—a man of upright and manly character, keenly alive to the evils of his time, and continually opening fire at new points on his enemies. He was an enthusiast for the Reformation, and did it more lasting service among the middle class than half the theologians. His chief work was an adaptation of Rabelais's *Gargantua*, which he rendered with an insight into its purpose, and a fulness of sympathy with its methods, unsurpassed even by Urquhart. In the poem, *Das Glückhaft Schiff*, he gives evidence of a faculty for stirring narrative verse, but his prose is richer, fuller, and more free. Considering how imperfectly prose style was then developed, he had an astonishing command over the resources of the language. He delighted in new and complicated word-formations, and by means of them often succeeded, while dealing with his main theme, in casting side lights on its subordinate branches. Even he, penetrating and enlightened as he was, could not rise so far above his age as to condemn the burning of witches; but hardly another popular folly escaped his glance. From the evil practices of hypocritical priests to the impudence of astrologers and weather prophets every abuse found in him a watchful critic; and nothing of the kind could be more admirable than the skill with which he excites contempt while professing to write in a spirit of respect and credulity. The secret of his power lay also partly in his profound humanity, for this scathing satirist was at heart thoroughly genial; his mockery had its root in an abiding faith in justice.

Prose writers.

Several other cultivators of prose style deserve mention. Albert Dürer, whose paintings, drawings, and engravings gave to the age of transition between mediævalism and the modern world its most perfect artistic expression, wrote several scientific treatises, one of which, on the proportions of the human body, is a masterpiece of calm, clear, and systematic exposition. Johann Thurnmeier, called Aventinus (1466–1534), Sebastian Franck (1500–45), and Ægidius Tschudi, of Glarus (1505–72), wrote histories which, as ordered narratives, rank considerably above mere chronicles. The autobiography of Götz von Berlichingen, if its style is without merit, has an enduring interest as a sketch of the rude lives of the petty nobles at the time when the old social order was breaking up under the influence of new ideas. Huldrich Zwingli, the Swiss Reformer (1484–1531), could state an argument with logical precision, but his style is thin and weak in comparison with the nervous force of Luther. Johann Agricola (1492–1566) wrote some theological works on the Catholic side; he is chiefly important, however, for a collection of German proverbs, which afford important evidence as to the currents of popular thought.

Arndt.

Of a far higher class as a religious writer was Johann Arndt (1555–1621), who wrote the most widely read work of the 16th century, *Vier Bücher vom Wahren Christenthum* ("Four Books on True Christianity"). Soon after Luther's death the doctrines of the Reformation lost nearly all vitality; becoming the subjects of vehement controversy among contending theologians, they ceased to interest the masses, who turned to simpler and more congenial themes. Arndt, like Eckhart, Tauler, and Luther himself, being a man of religious genius, saw the futility of these noisy disputes, and brushing them aside went to the heart of Christianity as a power fitted to nourish spiritual feeling and to govern conduct. His work appeared in Magdeburg in 1610, passed through edition after edition, and was translated into eleven languages. It still has a place of its own, for beneath the forms of a past age there burns the fire of a true enthusiasm. Sebastian Franck, already mentioned as a historian, wrote some religious works in a spirit akin to that of Arndt; but he lacked the intensity, the power of touching the popular mind, which was possessed by the later writer.

Boehme.

Less practical in tendency, but incomparably deeper in philosophic thought, were the writings of the Görlitz theosophist, Jacob Boehme (1575–1624). Boehme is in many respects one of the most striking figures in the history of German speculation. A man of mild and humble temper, working in patient obscurity as a shoemaker, he spent his life in grappling with the vastest problems which perplex humanity. Starting from the dogmas of Christianity, he sought to ground them in the deepest reason; and although he often appears to darken counsel by words, yet his writings contain many bold suggestions, which have profoundly influenced later philosophical systems. There are times when one feels that his struggling thought is imperfectly uttered only because it is not expressed in poetic forms. For Boehme was one of those thinkers who occupy the borderland between philosophy and poetry, a fact often perceptible in the concrete shape which the most abstract ideas assume in his hands. There is a touch of poetry in the very title of his first and best known, although not perhaps his best, book, *Aurora*.

The secular poetry of this period, if we except the works of Hans Sachs and Fischart, is without value. An ambitious didactic poem by Rollenhagen, *Der Froschmäusler*, gained a certain reputation; but it stands far beneath *Reineke Vos*, of which it is partly an imitation.

Religious lyrics.

The religious lyrics of the age are, however, of high excellence; they, indeed, are the sole works in which a perfect marriage was effected between idea and form in the epoch of the Reformation. In his grand battle-hymn *Ein feste Burg ist unser Gott*, in his pathetic verses *Aus tieffer Not schrey ich zu dir*, and in other lyrics, Luther led the way; and he was, as we have seen, followed by Hans Sachs. Nicolaus Hermann in his *Erschienen ist der herrlich Tag*, Paul Eber in his *Wenn wir in höchsten Nöthen sein*, Philip Nicolai in his *Wie schön leucht uns der Morgenstern*, and several other writers not less distinguished, created, in moments of genuine inspiration, lyrics which must move men while religious instincts survive. The adherents of the Reformation everywhere opened their hearts to these beautiful poems, for in them alone, not in creeds or sermons or controversial treatises, were the deepest emotions of the time freely poured forth. Next to the translation of the Bible, nothing did so much as the popular hymns to unite the Protestants, to stimulate their faith, and to intensify their courage.

Growth of the drama.

During this century the drama made considerable progress. Besides the "Mysteries" and "Shrove Tuesday Plays," "School Comedies," in imitation of Terence and Plautus, were written and acted in the universities and public schools. Luther, with the large humanity characteristic of him when dogmatic disputes were not in question, encouraged these comedies, and was, indeed, friendly to dramatic effort of all kinds. To person who complained that modesty was often offended by the actors he replied that if they carried out their principle they would have to refrain from reading the Bible. When the Jesuits began to agitate in opposition to Protestantism they detected at once, with their usual tact, the importance of this element in popular life; and through their influence more attention was paid not only to the plays but to the manner in which they were represented. Towards the end of the 16th century Germany was visited by a band of English comedians, who went about acting in their own language. They appear to have produced a deep impression; and at least one of their importations, the clown, the "Pickelhäring" of the Dutch, survived in Hanswurst or Jack Pudding, who was for more than a century an indispensable character in every play designed to gratify the prevailing taste. In imitation of the English comedians, wandering companies, consisting largely of idle students, now began to be formed, and thrilled both rustic and city audiences with blood-and-thunder tragedies, and with comedies too coarse to deserve even the name of farces. About the middle of the century a theatre was built in Nuremberg, and Augsburg and other cities soon followed the example. Duke Julius of Brunswick (1564–1613) not only built a theatre in his capital but maintained a permanent company; and he amused himself by writing for it comedies and tragedies in the approved style of the day. It is significant of the stage of literary culture reached by Germany that she enjoyed the barbarous productions of this scribbling prince while English audiences were appreciating "Hamlet" and "Othello."

Thirty Years' War.

V. *The Period of Decay.*—The period at which we have now arrived is in many respects the most dismal in German history. From 1618 to 1648 the country was desolated by the Thirty Years' War, a struggle which—as Gustavus Adolphus, its greatest hero, declared—absorbed into itself all the other wars of Europe. It completed the disintegration of Germany, blurred every great national memory, fastened upon the people hundreds of petty despotisms, reduced the population by more than half, caused a whole generation to grow up in ignorance, accustomed all classes to an almost incredible brutality of manners, and put an end to the material prosperity which had been steadily growing during the 16th century. It is not surprising that pure literature drooped and nearly died out during the time which followed this tremendous war, for the conditions of pure literature were almost wholly wanting. Had a man of high genius arisen, the buds of his fancy must have faded for lack of light and air.

Religious lyrics.

The only species of literature for which the conditions were favorable was the religious lyric. Under the pressure of grinding care, with no hope that a better day would dawn for them in this world, meditative and gentle spirits devoted their thoughts to another life; and many of them linked themselves to the truest poets of the previous century by giving musical voice to their spiritual fears and joys. Their prevailing tone in regard to "things seen" is one of profound melancholy; but all the brighter are the strange lights from the invisible which break through the gloom. The greatest of these writers is Paul Gerhardt (1606-75), many of whose hymns—such as *O Haupt voll Blut und Wunden, O Welt sieh hier dein Leben*—penetrate to the essence of Christianity as the religion of humility, of sacrifice, and cf sorrow. He had worthy associates among the Protestants in Johann Rist (1607–67), Joachim Neander (1610–88), and Louise Henriette of Brandenburg, wife of the Great Elector (1627–67). Some of the wiser Jesuits also attempted the lyrical expression of religious feeling; and one of them, Friedrich von Spee (1592–1635), fell little short of the best among his Lutheran rivals. Spee was a man of admirable moral as well as literary qualities. Asked by the elector of Mainz how it happened that at the age of forty his hair was white, he answered, "It is because I have accompanied to the stake so many women accused of witchcraft, not one of whom was guilty."

Literary societies.

The standard of pure speech set up by Luther in his translation of the Bible had not been maintained by later writers. The innumerable dialects of Germany are an almost inexhaustible fountain for the renewal of the youth of her literary language; but when the literary language was less fixed than it is now, they were also a temptation to barbarism. In addition to the evils of excessive provinciality, the written speech had suffered from a too generous importation of Latin, Spanish, and French words. In the early years of the 17th century the prevailing laxity suggested to an enlightened prince, Louis of Anhalt-Köthen, that it would be desirable to introduce into Germany institutions resembling the Italian academies. Accordingly, in 1617, the "Fruchtbringende Gesellschaft" ("The Fruit-bearing Society") was established,—a union which took the form of an order, with a palm tree for its emblem, and the words "Alles zu Nutzen" ("Everything for use") for its motto. It immediately became fashionable for members of the highest classes of central Germany to belong to this society; and at a somewhat later time other societies were started in imitation of it. Of these the most famous was the "Order of the Pegnitzschäfer" ("Shepherds of the River Pegnitz") in Nuremberg, which to some extent took the place of the school of meistersänger on which honor had been reflected by Hans Sachs.

Weckherlin.

These societies were associated with much pedantic folly, and from none of them proceeded any great work of genius; but they did good service by at least protesting against unlawful forms of speech. One of the earliest writers who worked in their spirit was Weckherlin (1584–1651), who, being associated with the German embassy in London, became intimately acquainted with some of the many forms in which the English genius then revealed itself. He wrote a number of odes, idylls, and sonnets, with an evident desire to give them a careful artistic finish. To him belongs the doubtful honor of having introduced alexandrines into German poetry,—a measure totally unsuited to the national spirit, but which for more than a century was in general use. The fame of Weckherlin was soon overshadowed by that of Martin Opitz (1597–1639). The beginnings of modern German poetry are often dated from the publication of his critical book, *Die deutsche Poeterei*, which appeared in 1624, and enjoyed an astonishing popularity. It became a sort of secular Bible to the "Fruit-bearing Society," of which Opitz was a member, and was regarded by several generations of verse-makers as an almost infallible guide. In regard to merely outward forms, it deserved its reputation, for Opitz was the first German writer who attempted sharply to distinguish the different species of poetry, to bring together some of the external laws which govern them, and to insist with emphasis that purity of style is essential to high literary effect. He altogether missed the fact, however, that poetry must be the expression of an emotional life; it became in his exposition a mere handicraft, for excellence in which industry and familiarity with good models are alone necessary. The result is seen in his own lyrical and didactic poems, which are laudably correct in language and in metre, but are hardly once lighted up by the fire of intense feeling.

First Silesian school.

Opitz.

Opitz was born in Silesia; and from this circumstance the writers who shared his tendency or came under his influence are known as the first Silesian school. By far the most distinguished member of this so-called school was Paul Fleming (1609-40), the only secular German poet of the 17th century of whom it can be confidently said that he was endowed with true genius. He did not live long enough to reveal his full capacity; he confined himself to short rapid flights, and all his lyrics are contained in a moderately sized volume, *Geistliche und Weltliche Poemata.* This single volume, however, comprises enough to secure for him an enduring place in literature. He moves freely over the whole range of lyrical poetry, but his charm is at once strongest and most delicate in his love verses, which sometimes recall the gaiety of Herrick, although a touch of sentimentalism distinguishes the German writer from the more worldly Englishman. A fine spirit of manliness is the note of Fleming's sonnets; and in several hymns he almost equals the religious depth of Gerhardt. Even in its artistic qualities his best work is higher than anything achieved by Opitz; in its

Paul Fleming.

power of awakening permanent human sympathies it stands alone in its era.

Gryphius. Another writer of the first Silesian school was Andreas Gryphius (1616–64), who sought to create a drama in accordance with the laws laid down by Opitz. He was the first German dramatist who divided his tragedies—of which he wrote five—into five acts; but his characters are roughly conceived, and he produces his effects rather by violence and bombast than by the gradual evolution of a definite plan. His comedies, although also rude, have more life than his tragedies. In one of them, *Peter Squenz*, there are traces of Shakespeare's *Midsummer Night's Dream*, of which Gryphius appears to have had some knowledge through a third writer. **Logau.** Friedrich von Logau (1604–55) applied the principles of Opitz in epigram. He had a decided talent for terse, emphatic expression, and a considerable number of the vast collection of his epigrams have a keenness of edge which must have made him a dreaded enemy. His prevailing tone is satirical, and the chief object of his satire is the moral corruption of his time. Joachim Rachel (1618–69) was another satirist who strove by means of polished verses to castigate popular vices; but he lacked force and invention. There was much more vigor in the *Scherzgedichte* of Hans Wilmsen Lauremberg (1591–1659), who wrote in Platt Deutsch; he, however, can hardly be claimed as a member of the first Silesian school. Philip von Zesen (1619–89), a writer of some versatility, wrought in the spirit of Opitz by warring against foreign words which had intruded into German,—a warfare in which his zeal was not always as wise as it was patriotic. He founded in Hamburg, in imitation of the "Fruit-bearing Society," an association (the "Deutschgesinnte Gesellschaft") inspired by his enthusiasm for Teutonic purity of speech.

Pegnitz-schäfer. While the admirers of Opitz were striving, with the best intentions, to introduce a correct poetic style, a movement of a very different kind originated among the "Pegnitzchäfer" of Nuremberg. The members of this society, conscious of the barrenness of existing poetry, and not feeling in themselves the sources of a higher activity, turned for help to Italian literature. Instead of studying the great Italian poets they attached themselves to Marino and his extravagant school; and the chief result was a number of fantastic pastorals, the writers of which seemed to have no other aim than to show how much silly affectation the German language may be made to express. **Second Silesian school.** Their tendency was carried to its utmost development by the second Silesian school, whose leading representatives were Hoffmannswaldau (1618–79) and Lohenstein (1635–83). Hoffmannswaldau wrote odes, pastorals, and heroic epistles, which are marked by a childish foppery of manner, and whose tone affords startling evidence of the moral laxity of the society to which they were addressed. Lohenstein chiefly cultivated the drama, and he has the distinction of having written perhaps the worst plays ever accepted as literature by a modern community. They are so wild and bombastic that, even if presented as burlesques, they would now be condemned as ridiculously extravagant. The lyrics of this pretentious writer are not less crude and unnatural than his plays.

Court poets. As the century advanced, the German courts passed more and more under the influence of France. Pocket editions of Louis XIV. were to be found in all the little capitals, courtiers talked more French than German, and it was unfashionable not to know, or not to affect to know, contemporary French literature. It was, therefore, inevitable that some writers should turn away from the path of the second Silesian school, and compete for court favor by imitating the French style. This was done by Canitz (1654–99), Besser (1654–1729), König (1688–1744), and many other authors of the same class. These "court poets" took Boileau for their guide, and had, therefore, the negative merit of avoiding the absurdities of Lohenstein and Hoffmannswaldau. But they were, as a rule, tame, cold, and dull. In Canitz alone, who was a Prussian statesman and wrote for his pleasure, is there any evidence of original energy; the others were professional versifiers who produced appropriate odes and sonnets at the bidding of their employers.

During the greater part of the 17th century Germany produced few prose works that can now be tolerated. **Prose writers of 17th century.** Notwithstanding the efforts of the purists, the language became more and more corrupt, and most writers were either artificial, or pedantic, or coarse. **Grimmelshausen.** One of the small number whose power we can still feel was Grimmelshausen, whose *Simplicissimus* (1659) has qualities bordering upon genius. The hero is a peasant's son, who tells his own tale. Torn from his parents during the Thirty Years' War, he is brought up by a hermit; afterwards in the service of a commandant, he makes himself notorious for tricks like those of Tyll Eulenspiegel; he then becomes a soldier, rises to wealth and rank, but ultimately loses both, passes through many wild adventures, and retires from the world to a desert island, in which he devotes himself to religion. The value of the book consists in its graphic pictures of the horrors of the Thirty Years' War,—pictures relieved by touches of rough, sometimes of the coarsest, humor. **Moscherosch.** Another writer of great but insufficiently cultivated talent was Moscherosch, author of *Gesichte Philanders von Sittewalt* (1650), which is partly an imitation of the Sueños of Quevedo. It is made up of a number of visions or dreams, some of which, like passages of *Simplicissimus*, convey a vivid idea of the sufferings of Germany during her great struggle; in others the writer strikes with effect at popular follies, including the extravagances of the second Silesian school. Sigmund von Birken wrote a history of the house of Austria, which, although one-sided, is not without merit as a plain narrative; and an ecclesiastical history by Gottfried Arndt has some interest as an attempt to do justice to heretics condemned by the church. A very good book of travels was written by Adam Olearius, describing the adventures of a mission to Persia, of which the author and Paul Fleming were subordinate officials. **Schupp.** A Protestant pastor, Balthasar Schupp (1610–61), was the author of several didactic prose works, which, although rough in form, display native wit, and pour wholesome ridicule on the follies and barbarisms of contemporary writers. **Romances.** Against these more or less valuable prose writings we must set piles of enormous romances in the style of D'Urfé and Mademoiselle Scudéry. The favorite authors of these astonishing productions were Buchholtz, who wrote *Hercules und Valisca*, and *Herculiscus und Herculadisla;* Anton Ulrich, duke of Brunswick, whose *Octavia* was loudly applauded by aristocratic readers; and Von Ziegler, the writer of *The Asiatic Banise*, an incredibly foolish book which, published in 1688, took Germany by storm, and maintained its popularity for more than a generation. Lohenstein was also the author of a romance, dealing with the fortunes of Arminius and Thusnelda. It is hard to understand the interest which works of this class once excited; they are barren of every imaginative quality, with no kind of relation to life, and grotesque in style. They were ultimately driven from the field by imitations of *Robinson Crusoe*, which, notwithstanding the charm of their model, display no more talent than the romances. Various writers imitated *Simplicissimus*, but they succeeded only in reproducing in an exaggerated form its occasional brutalities. **Abraham a Sancta Clara.** Abraham a Sancta Clara (1642–1709), a Vienna priest, whose real name was Megerlin, revealed considerable power of satire in his *Judas der Erzschelm* ("Judas the Arch-Rogue"), and in pamphlets and sermons; but his naturally rich fancy was wholly uncontrolled, and his humorous passages are marred by a far larger number in which he is pedantic or vulgar.

State of the drama. No progress was made during the 17th century towards the formation of a national drama. At the courts the Italian opera was the favorite entertainment, and the wandering companies of actors represented for the most part barbarous plays of their own devising, in which Hanswurst was generally the popular character. Occasionally a man of some talent found his way into these companies; and one such actor, Velthen, showed so much insight as to include in his repertory some of the works of Molière. But the general tendency of what passed for the drama was from bad to worse, and the usual character of the plays to a considerable extent justified the hatred with which they were denounced by the clergy.

For a time it almost seemed as if Germany could never hope to emerge from the intellectual degradation into which she had sunk; but in reality the higher forces of the nation were rallying in preparation for a new era. One of the first symptoms of revival was presented by the remarkable

Pietism.

pietistic movement, which, although it ultimately led to the formation of the pettiest of petty sects, was in its origin noble both in aim and in method. Its originators were the ardent, generous, and eloquent Jacob Spener (1633–1705), and August Hermann Francke (1663–1727). The labors of these writers and preachers, who had close affinity to the mystics, not only gave more sincerity to religious forms, but did service to literature by quickening the popular intellect, and awakening emotions which could find no satisfaction in the tedious writings of the day. Of still greater importance were the beginnings of modern German philosophy.

Philosophy. Leibnitz.

It was in this dreary period that Germany gave birth to one of the most brilliant of her thinkers, Leibnitz (1646–1716). The prevailing style of the day—"Mischmasch," he called it—seems to have disgusted him with his own language, for nearly all his writings are in French or Latin. Nevertheless, he exercised a profound influence on the best minds of his generation. His monadology, his doctrine of the pre-established harmony, his theory of the best of possible worlds, while carrying on the central current of European thought, offered Germany new problems for solution, and helped to replace a rigid orthodoxy by a spirit of disinterested curiosity.

Wolf.

The task of giving shape to his ideas was undertaken by Wolf (1679–1754), who had none of Leibnitz's genius, and often crushed his fruitful suggestions under a burden of logical proofs. The disciple, however, so far taught in his master's spirit as to exalt the claims of reason over mere authority; he also encouraged habits of systematic thinking, and proved by his practice that serious writers had no excuse for clothing their doctrines in any other language than their own.

Thomasius.

Less philosophical than Leibnitz, and even than Wolf, Christian Thomasius (1655–1728) was an impressive popular thinker. He edited the first German periodical, a sort of monthly magazine, in which he vigorously attacked pedants and bigots. His style, although not pure or graceful, received glow and warmth from his moral earnestness. Through him literature became a great practical power, for it was mainly he who put an end to the burning of witches and to punishment by torture.

Wernicke.

Even in poetry, before the close of this period, there were a few glimmerings of dawn. Wernicke, a man of cultivated and severe taste, published a volume of epigrams (1697) in which he thrust home at the follies of Lohenstein and his followers; and that his mockery had effect was plain from the outcry of two noisy members of the school, Postel and Hunold.

Günther.

Günther (1695–1723), who died too soon for his genius, wrote lyrics in which the voice of nature was once more heard. "A poet in the full sense of the word," Goethe calls him; and no one can realize how great was his achievement without making some acquaintances with his truly dismal predecessors.

Brockes.

Brockes (1680–1747) had not Günther's fine spontaneity, but he had the merit of giving simple expression to unaffected pleasures—a virtue for which historians of literature, remembering the formality of the court poets and the insincere posturing of the second Silesian school, readily forgive his occasional flatness and garrulity. He was the first German poet who displayed some knowledge of English literature. Although unacquainted with Shakespeare, he directed his countrymen to Milton, Young, and Pope; and he appended to his chief work, *Irdisches Vergnügen in Gott*, a fair translation of Thomson's *Seasons*.

VI. *The Period of Revival.*—For five centuries there had been no great literary period in Germany which deserves to be named with the famous periods in the history of England, France, Italy, and Spain. The Reformation was a spiritual achievement of splendid originality, but in literature Germany had for the most part followed timidly in the footsteps of her neighbors. She was soon to make up amply for this tardy progress; and we have now reached the age in which she fairly awoke to a consciousness of her strength—an age mainly of preparation, but one which has also an independent interest, since it includes names that rank high in the history of European as well as of German culture. We have seen that in the midst of the period of decay there were already symptoms of revival. These became more and more numerous, and while they increased, Germany was suddenly startled by the appearance in her midst of a great warrior and statesman. It is impossible to estimate with any approach to exactness the impression produced by Frederick II.; but it is beyond doubt that he profoundly affected the intellectual life not only of Prussia but of Germany.

Frederick the Great.

After the Thirty Years' War the people had lost confidence in themselves. They forgot that they had a magnificent history; they only saw that the structure of society had been rudely battered, and that nearly every enterprise of the nation as a whole ended in failure. Frederick the Great restored to them faith in their own vigor; he convinced them that it depended on themselves whether or not they should rise to their ancient place in Europe; and by the prompt, faithful, and energetic discharge of his personal duties he set before them an example which was widely felt. Literature shared the impulse which penetrated the national life. It became stronger, more independent, and moved forward with the assured step of a power conscious of high destinies.

Classical study.

Several causes of a purely literary character contributed to promote this advance. One of these was the revival of classical study in the best sense. Classical study had been pursued with ardor by the humanists; but after them it became dry, pedantic, and tedious, and was subordinated to theological controversy. In the 18th century a number of scholars arose, who, ceasing to interest themselves in merely verbal criticisms, sought to pierce to the meaning of classical writers, to understand and enjoy their imaginative effects, their ideas, and their style. They also strove to construct what the Germans call "Alterthumswissenschaft," the science of antiquity—that is, to comprehend the life of the Greeks and Romans, their religion, art, and philosophy, and to interpret their literature in the light of this knowledge. The movement passed from one university to another and soon made itself felt in the public schools. Thus the best class of minds were familiarized with higher ideals than they had yet known, and received, almost without being aware of it, the germs of new activity. Another cause, which co-operated with the more intelligent study of the classics, was acquaintance with English literature.

Influence of English literature.

Hitherto the foreign influences which had affected the Germans had come from Italy, Spain, and, above all, France; but now they began to know something of contemporary English writers, and gradually worked their way back to Shakespeare. The English genius was instinctively recognized as more in harmony with that of Germany than any other, and its products stimulated the free exercise of the imagination and the reason, while the ancient classics led to the perception of the greatest laws of form.

Among the poets who helped to effect the revival of a truly national literature a place of honor belongs to Haller (1708–77), who, although chiefly famous as a man of science, revealed imagination and poetic sympathies in his descriptive and didactic poem *Die Alpen* ("The Alps"). Hagedorn (1708–54) was for a time the most popular poet of his day in virtue of his songs, odes, fables, and narratives in verse. He was of a genial and happy temper; and no author who preceded him was master of so clear, bright, and animated a style. One of the chief characteristics of the time was the tendency of writers to group themselves in schools.

Literary schools.

If two or three writers who lived in the same place happened to become friends, they forthwith called themselves a school; and the result was that they usually developed some marked common characteristics. These coteries inevitably became more or less narrow and exclusive; but they also stimulated each other to fresh effort, and the clash of their ideals sometimes helped the outside world to new points of view.

Saxon school. Gottsched.

The Saxon school, whose headquarters were in Leipsic, was for some years more prominent than any of its rivals. It was founded by Gottsched (1700–66), who, although he made himself ridiculous by pedantry and vanity, became the ruling literary man of Germany. He was appointed a professor in Leipsic in 1724, and founded there "The German Society," which soon became the centre of a number of similar bodies for the cultivation of literature. Gottsched aimed at nothing short of the complete reformation of German poetry. He had the sense to see that if he wished to reach the people he must begin with the drama, and he was fortunate enough to find in Frau Neuber, who had formed a company in Leipsic, an intelligent actress capable of giving effect to his ideas. With her help he banished Hanswurst from the stage; and she was forthwith supplied with plays by himself, by his clever wife Louisa Victoria, and by several disciples. He gave his attention chiefly to tragedy, and unfortunately he had but one idea in regard to it—that it had reached the utmost possible excellence in the classic drama of France. The English drama, he admitted, had some merit, but only in so far as it had modelled itself on the work of Corneille and Racine. Hence, in his chief tragedy *Der Sterbende Cato* ("The Dying Cato") he availed himself freely of Addison's *Cato;* the Elizabethan dramatists, of whom his direct knowledge was slight, he believed to be mere barbarians. His taste gave the law in nearly every theatre in which German plays were acted; and it was certainly a good consequence that Lohenstein fell into permanent disrepute, while even the groundlings began to feel that the uncouth works which actors themselves had hitherto produced were, to say the least, far from perfection. On the other hand, the German genius was forced to submit to arbitrary laws antagonistic to its true nature; and so long as its submission lasted, a genuinely native drama was impossible. It was not only in regard to drama that Gottsched insisted on absolute subservience to France. In regard to all species of verse his sympathies were with the court poets, and both by example and by critical precept he insisted that in poetry as in everything else the understanding must be supreme, and that clearness of statement, correctness in the management of figures, and logical arrangement are the highest literary virtues. Regarding the function of imagination and feeling in poetry he had no suggestion to offer.

Swiss School.

There were writers who instinctively felt that this could not be a complete theory; and of these the chief were Bodmer and Breitinger, the leaders of the Swiss school, which was formed in Zürich. These writers, although destitute of creative genius, had nourished their imagination on English poetry, especially on *Paradise Lost,* and it was incredible to them that a critical doctrine could be correct which left out of account or condemned their favorite writers. At first they were on friendly terms with Gottsched, but when the latter harshly criticised a translation of Milton's epic issued by Bodmer, his Swiss rivals prepared to defend themselves; and thus broke out a literary controversy which made much noise at the time, and in which the angry critics, to the edification of onlookers, pelted each other unmercifully with abusive epithets. Neither party was fully conscious of the significance of its attack, and sometimes the warriors seemed almost to change sides. But the general tendency of the dispute was that the Swiss school, amid much exaggeration, defended the claims of free poetic impulse, while the Saxon school, in a narrow and pedantic spirit, maintained those of conscious art. It is hard work now to follow their arguments, but at the time they interested a considerable public in literature, and opened fresh lines of investigation. One of the results was that Baumgarten, a disciple of Wolf, published a book which Germans regard as the beginning of modern æsthetics,—a branch of mental science to which their philosophers have ever since devoted thought and labor.

Bremer Beiträge.

While this warfare of critics was going on, there were in Leipsic a number of young writers who more or less attached themselves to Gottsched, but who gradually shook off his authority. They founded a periodical, the *Bremer Beiträge* (the "Bremen Contributions"), which had considerable influence in forming their own style, and in keeping alive the popular interest excited by the central controversy. After a while many of them were scattered over different parts of Germany, but they retained their original impulse, and continued to be known as members of the Saxon school. Gellert (1715–69) was by far the most famous of the circle. It is impossible to mention without respect this amiable writer. His plays are unimportant, but his fables and tales reveal so gentle and pure a spirit that we cannot wonder at his great popularity. He was a favorite among all classes, even Frederick the Great himself, who rarely condescended to notice a German author, declaring after a long interview that he was "the most reasonable of German scholars." His supreme defect was a tendency to weak sentimentalism and pious commonplace. Rabener (1714–71) acquired fame as a good-humored satirist. His prose is fresh and clear, but he has not sufficient grasp of any important principle to entitle him to very high rank among moralists. Christian Felix Weisse (1726–1804), the friend of Lessing's youth, failed as a writer of tragedy, but was a favorite author of comic operettas. He was also the first successful German writer for children, and edited for many years a periodical (the *Bibliothek der schönen Wissenschaften*) which had a favorable influence on popular culture. Johann Elias Schlegel (1718–49), uncle of the two Schlegels who became long afterwards leaders of the Romantic school, gave evidence of high dramatic talent, but died when he was beginning to be conscious of his power. Arnald Ebert distinguished himself by good translations from English; and Zachariä wrote with some success mock heroics in the style of *The Rape of the Lock.* Kästner, whose disputations at the Leipsic university were diligently attended by young Lessing, made himself feared as a biting epigrammatist. Cramer became one of the most eloquent preachers of the day, wrote popular religious odes, and edited *The Northern Guardian,* a well-meaning but rather commonplace imitation of the *Guardian* of Steele. These writers, who from being Gottsched's friends all became more or less hostile to him, have a clearness and grace of style which were unknown in the previous century. Another author who was from the beginning Gottsched's enemy, but who had no relation with this particular school, may be here mentioned,—Liscow (1701–60). His prose has nerve and animation, and few satirists have dealt severer blows at literary pretence.

Halle School.

The Halle school of poets was in some respects different both from the Saxon and the Swiss schools. Its original members were Gleim (1719–1803), Uz (1720–96), and Götz (1721–81). These three writers formed a friendship in their student days at Halle, where they came under the influence of the poets, Pastor Lange, and the tutor of his children, Immanuel Pyra, ardent disciples of Bodmer and Breitinger. The young students, while feeling sincere respect for the Swiss critics, did not attempt any very serious flight; they preferred to amuse themselves with lively little anacreontic verses, which they soon brought into high repute. Afterwards Gleim settled in Halberstadt, where he lived to an extreme age. His didactic poem *Halladat,* which he wrote, he himself modestly explained, in order to gratify a wish of his youth to produce a book like the Bible, has no vitality; but during the Seven Years' War he composed *War Songs of a Grenadier,* which were everywhere read, and have not yet lost their popularity. They were edited by Gleim's friend Lessing, who, however, protested against their patriotic vehemence. Gleim was one of the most kindly of men, and became the patron of young poets, several of whom he always had in his pleasant bachelor's home. He also kept up an extensive correspondence with other writers, which is now an important source of information respecting the movements of contemporary literature. One of his most intimate friends, who resembled him only in geniality of disposition, was the noble-hearted Ewald Christian von Kleist (1715–59), who was fatally wounded on the battle-field of Kunersdorf. He would still deserve to be remembered as the man whom, of all others, the equally noble Lessing most loved. His descriptive poem *Frühling* ("Spring") is partly an imitation of Thomson; but it is also the work of an independent lover of nature, who knew how to give beautiful utterance to true and simple feeling. Ramler (1725–98), another friend of Gleim, and the friend, too, of Kleist and Lessing, wrote spirited odes in Horatian metres, which, like the *War Songs of a Grenadier,* gave pleasure because of their strongly patriotic tone,—the direct result in both cases of Frederick's influence. Anna Louisa Karsch (1722–91), a poetess who owed much to Gleim's goodness, was a favorite among the literary men of the day, but her verses are ruder than they ought to have been at so late a date. Idyllic poetry, which Kleist and Götz to some extent cultivated, was taken up in earnest by Solomon Gessner (1730–87), whose prose idylls, *The Death of Abel, The First Sailor,* and others, were translated into French and English, and were better received in their foreign dress than in their original form. They are written in an easy style, and express much harmless although somewhat tedious sentiment. He was imitated by Xaver Bronner, a Catholic priest, whose idylls have not half the merit of his autobiography, which affords remarkable insight into the religious life of Catholic Germany about the middle of the 18th century.

Gleim.

Religious lyrics.

The religious lyric, which had shared the general decay during the latter half of the 17th century, displayed more vitality during part of this period. It owed its fresh life mainly to the pietists, who reopened fountains of spiritual feeling that had been apparently dried up by theologians. Among the best of this younger generation of hymn writers were Freylinghausen, Neumeister, and Tersteegen. Their fame was, however, less extensive than that of Count von Zinzendorf (1700-60), the founder of the sect of Herrnhüter or Moravian Brethren. Besides hymns he wrote religious works in prose, and made himself one of the most prominent figures of his time by ardent missionary zeal. His followers, like all deeply religious sects in Germany, delighted in hymns; and many of those they produced are remarkable for the sensuous, sometimes almost sensual, forms in which their emotions are expressed.

Fabulists. Fables were at this time an extremely popular class of writings, and nearly every imaginative writer sought to distinguish himself as a fabulist. The Swiss school, indeed, in their zeal for a combination of the wonderful and the useful in literature, maintained that the fable was the highest type of literature. As a rule, Lafontaine was taken as the model in works of this kind, but we look in vain among his German imitators for his exquisite grace and naiveté. Gellert stands at the head of the more sentimental fabulists; after him may be named Willanow and Lichtwer. The latter (1719-83) has humor as well as sentiment, and some of his fables have an artistic finish that indicates a faculty by which he might have won distinction in more important labors.

Popular philosophers. From about the middle of the 18th century onwards a number of prose writers, who may be classed together as popular philosophers, worked effectively for the enlightenment of ordinary readers. They attached themselves to some extent to Wolf; they also came under the influence, although not in any great degree, of the French Encyclopedists; and they were admiring students of the English deists, and of Locke, Shaftesbury, and Hutcheson. They are often condemned for the shallowness of their thought; and if we compare them with the great thinkers who followed them, the condemnation is just. They did not grasp the significance of the problems which had been handed down by Descartes, Spinoza, and Leibnitz, with which Hume was now grappling, and which were soon to enter upon a new phase in the critical philosophy of Kant. In regard to religion they had a very imperfect appreciation of every element that could not be expressed in clear logical statements; feeling and imagination were rigidly subordinated to the understanding. And they had not even a remote suspicion of what is now familiar as the historical spirit, so that they displayed amazing narrowness of vision in their treatment of past spiritual developments, and of contemporary creeds with which they did not happen to agree. But if we are to do justice to these popular philosophers, they must be compared rather with their predecessors than with their successors. An important place belongs to them in the movement by which vital human interests have been raised above theological disputes, by which morality has received a basis independent of dogmatic religion, and by which toleration has been secured for men of every faith. They were penetrated by a truly humane sentiment; and it must be counted a high merit that in a country which had been more or less dominated by pedants, and whose great writers of a later age have not always attempted to be both profound and clear, they sought to express themselves in unpretending and straightforward German. **Moses Mendelssohn.** The chief of the popular philosophers was Moses Mendelssohn (1729-86), not a deep or massive thinker, but a man of fine moral sympathies, an enthusiast for freedom—from the lack of which he himself, as a Jew, keenly suffered—and an incisive psychological analyst. **Nicolai.** His friend, Frederick Nicolai (1733-1811), the Berlin book-seller, had the misfortune to outlive his epoch. He had only words of contempt for Goethe and Schiller; and Kant, whom he did not profess to understand, seemed to him a sort of cross between a bungler and an impostor. These terrible mistakes have made poor Nicolai, notwithstanding his lifelong warfare against bigotry, the type of a narrow-minded bigot. Yet in his earlier days he was recognized by such a judge as Lessing, with whose friendship he was honored, as a writer of talent. And his *Bibliothek* ("Library"), the most important literary periodical of his day, did excellent service by providing the popular philosophers with a medium for the expression of their opinions on all the great questions which then agitated Germany. Other popular philosophers were George Sulzer (1720-79), who devoted himself to æsthetics in the spirit of the Swiss school, but with the advantage of later lights; Thomas Abbt (1738-66), whose style was one of uncommon vigor; Christian Garve (1742-98), who did not attempt any great original work, but in letters and articles examined many individual philosophic questions from new points of view; and Johann Jacob Engel (1741-1802), whose *Philosoph für die Welt* ("Philosopher for the World") interested a class of readers who would have been unable to follow a more adventurous guide. Zimmermann (1728-95) hardly deserves to be mentioned in such good company; but his *Betrachtungen über die Einsamkeit* ("Observations on Solitude") by its sentimentalism and rhetoric carried his name far beyond the bounds of Germany. **Liberal theologians** Some theologians, without exactly sharing the beliefs of the popular philosophers, were profoundly affected by them. Among these were Mosheim, the ecclesiastical historian; Spalding, the translator of Shaftesbury; and Jerusalem, the father of the young writer whose suicide suggested some elements in Goethe's *Werther*. These liberal theologians did not hold a very intelligible logical position, but they were of some importance by their attempts to introduce a freer and more polished style of eloquence than had hitherto marked the German pulpit. In regard to the permanent movements of thought, their influence was greatly inferior to that of Michaelis and Semler, whose labors heralded the approach of modern Biblical criticism.

Historians. In history Germany produced at this time at least one writer of high eminence, Justus Möser (1720-94), author of the *Osnabrückische Geschichte* ("History of Osnabrück") and *Patriotische Phantasien* ("Patriotic Fancies"). **Möser.** Möser was the first German historian who wrote a good style and attempted to penetrate to the meaning of events and to present them in the light of great principles. He also produced a strong impression by his enlightened patriotism and by his burning scorn of wrong. Schröck and Schlözer were prominent historians, and the latter made himself known as a clear writer on contemporary politics. Karl von Moser, of Stuttgart, applied to political subjects a faculty for wit and satire that was estimated highly in his own day.

It has been already stated that the revival of classical study was one of the chief causes by which the mind of Germany was awakened to new effort. Professors Christ and Ernesti, of Leipsic, who were the favorite teachers of many young students, including Lessing, were two of the chief writers to whom this revival was due. **Winckelmann.** Incomparably greater than either, however, was Johann Joachim Winckelmann (1717-68), whose *History of Ancient Art* (1764) opened a new era in the appreciation of ancient life. Later investigation has corrected Winckelmann on many points, but no critic has displayed a keener feeling for the beauty and the significance of such works as came within his knowledge, or a truer imagination in bridging over the gulfs at which direct knowledge failed him. And his style, warm with the glow of sustained enthusiasm, yet calm, dignified, and harmonious, was worthy of his splendid theme. What he did for ancient art was to some extent done for ancient literature by the untiring editorial labors of Christian Gottlob Heyne (1729-1812).

National literature. Important as were many of these writers, Winckelmann above all, they exercised slight influence on the national mind compared with the three men whom the Germans justly regard as the founders of their classical literature—Klopstock (1724-1803), Wieland (1733-1813), and Lessing (1729-1781).

Klopstock. Klopstock stood in direct relation to the Swiss writers. When a pupil at Schulpforta, one of the great Saxon schools which sent forth many of the best authors of the day, he was a diligent student of Bodmer, by whose critical principles he guided himself in reading Homer, Virgil, and Milton. The *Messiah*, on which his fame mainly rests, is now little read, and it is impossible even to glance through it without becoming conscious of glaring faults. Klopstock's genius was essentially lyrical; he lacked the plastic force of imagination necessary for a great epic. His central figure is nowhere presented in clear sharp outlines; it wavers between two distinct conceptions, that of a divine and that of a human character. And the facts to which he turns our gaze in the crisis of his narrative are not such as kindle the deepest sympathies; he exhausts the powers of language to convey an impression of the Messiah's sufferings, but we hear nothing of the qualities of soul which these sufferings rouse into action. The subordinate characters are innumerable, and except Abadonna, a repentant fallen angel, between whose character and whose fate there is an effective contrast, none of them can be said to live; they exist only as an excuse for the utterance of Klopstock's feelings. They talk incessantly, weep, embrace, and kiss, but they never do anything that exhibits more than a vast quantity of obtrusive sentiment. Notwithstanding its obvious defects, however, the *Messiah* has qualities which must still command admiration; it reveals a nature full of lofty aspiration and deep humanity, and it contains individual images of striking force and beauty.

It would be difficult to imagine anything more dreary than Klopstock's plays, the subject of three of which is Arminius, while the others deal with scriptural themes. He knew enough neither of life nor of the stage to be a true dramatist; his characters are mere names, and the incidents are grouped according to no principle of art. His odes, which he continued to write from the beginning to the end of his long career, are of far higher excellence. Those which derive their inspiration from Northern mythology are too remote from general sympathy and too obscure in construction to awaken interest; but the stamp of genius is upon several of the lyrics in which he expresses his passionate feeling for the grander phenomena of nature, his ardent patriotism, his enthusiasm for freedom, and his elevated sense of human worth and destiny. Both as an epic poet and as a writer of odes he had many imitators, who, like most others of their class, exaggerated the defects of their model and left his virtues alone. His influence upon the intellectual life of Germany was deep, and, on the whole, beneficent. He encouraged the self-respect of his countrymen, intensified their desire for an independent literature, and by handling high themes, sometimes powerfully, always seriously, suggested that the national imagination would reveal its full capacity only by undertaking greater enterprises than any it had yet attempted.

Wieland.

Although Klopstock was one of the central literary figures during two generations, he was not a prolific writer; Wieland, on the other hand, was one of the most prolific of German authors. He was continually at his desk, and in the course of his career produced a considerable library. Of his many works the romantic poem *Oberon* is by far the most famous, and the only one that really pleases modern readers. *Agathon* is perhaps the best of the prose romances in which he endeavored to depict ancient Greek life. He was not endowed with great vividness of imagination, and his prevailing tendency is to extreme diffuseness; but some of his descriptive passages, especially those in *Oberon*, have a touch of ideal grace which enables us to return to them with fresh relish. He had a fine appreciation of style, and by the study of Greek and French masterpieces persistently strove to acquire lightness, clearness, and ease. Even yet few German writers will compare with him in these qualities. In all his works he had a strongly didactic tendency, but his teaching was the opposite of that inculcated by most modern writers who deliberately aim at ethical effect. Above all, he differed from his great contemporary, Klopstock. Writing at first as a strict pietist, he ultimately became a pronounced Epicurean in the popular sense, and made it his object to proclaim an Epicurean theory of life, discouraging enthusiasm, laughing at such aspirations as those of his own youth, exalting the claims of the senses, and placing the highest virtue in kindliness and good humor. This tendency often conducts him to more slippery ground than any on which a German writer of his standing would now venture; but it also gives him innumerable occasions for the play of a gentle and refined irony.

Lessing.

Whatever may be the excellences of Wieland and Klopstock, both are essentially writers of the past. This cannot be said of Lessing, the third great German of this period; he is still a living influence. He is, indeed, the only writer before Goethe whom Germans can now read without feeling themselves in a world foreign to their sympathies. Throughout his career he strove to renew and fructify the intellectual life of his nation, and he achieved his aim by important creative activity, and by the clearest, freest, and most drastic criticism of the 18th century.

As an imaginative writer he was chiefly distinguished in the drama, and his most important dramatic work is *Minna von Barnhelm*. If it cannot be said that this is, in the highest sense, a comedy of genius, it is at any rate a comedy which contains elements of permanent interest. The characters are vividly presented; the plot is systematically, yet naturally, unfolded; the dialogue is clear, fresh, and animated. And the work has the high merit of giving artistic shape to elements taken by the dramatist from the living world around him. *Emilia Galotti* is marred by a deep flaw in the conception of the central figure; but every other character in the tragedy is conceived with bold imaginative force, and it is possible for a competent actress to soften, if not to harmonize, even the clashing elements in Emilia herself. No drama making even a distant approach to the excellence of these two plays had been produced in Germany; they thus gave literature in its highest department a fresh start.

But valuable as were Lessing's imaginative creations, they were inferior to his labors as a thinker. Here he was absolutely supreme among his contemporaries; and in some respects he has not since been surpassed. His method is invariably critical, but he aims at rising to the highest, most universal aspects of every subject with which he deals. As a master of style he ranks with the greatest European writers. The structure of his sentences is clear, precise, and compact; and he keeps the mind awake by vivid images drawn from nature and from human life, by interesting, sometimes remote, allusions, by rapid strokes of wit, and by unexpected turns of thought, as if he were abandoning his main theme, while he is in reality indirectly advancing it. He has often been called the most critical of poets; it would be equally just to call him the most poetical of critics.

The greatest of Lessing's purely critical writings is *Laocoon*, a fragment, but a fragment containing the germs of much of the best thought of his own and the immediately succeeding generations. It has an enduring value as the first serious and great attempt to distinguish sharply the realms of art and poetry, and to foster both by subjecting each to its own laws. Next in importance stands his *Hamburgische Dramaturgie*, a series of criticisms on plays represented at the Hamburg National Theatre. By these splendid criticisms, which are based in the main on Aristotle's *Poetics*, with many side references to Diderot's theories, he put an end to the abject submission of dramatic writers to French traditions. In his later years he issued the *Wolfenbüttel Fragments*, portions of a theological work by Reimarus, a deistical writer of admirable force and clearness. He thus became involved in a hot controversy with indignant professors and pastors, the noisiest of whom was Pastor Goeze of Hamburg. The tracts issued by Lessing in the course of this controversy are in form among the most perfect of his writings; they are at once learned, keen, and witty. And in the history of Western thought they are of deep significance. His immediate object was to secure for criticism absolute freedom of movement; but he did very much more. He foreshadowed, as a vital element of the coming time, inquiry as to the origin and growth of the Scriptures, the rise of Christianity, and the fundamental character of religion. And he indicated a far higher standpoint than that of the popular philosophers by vindicating the claims of feeling in spiritual life as opposed to those of the bare understanding. In his *Education of the Human Race* he gave systematic shape to the fruitful principle that a religion which is not true absolutely or for all time may be of vast importance by meeting the needs of a portion of the race in special epochs, and that there is in history, notwithstanding apparent reactions, a progressive movement towards higher intellectual and moral ideals. The suggestions thrown out in controversy he developed artistically in one of the greatest of his writings, the fine dramatic poem, *Nathan the Wise*, a work which enshrines all that was noblest in the struggles and the aspirations of his age, and connects the thought of the 18th with that of the 19th century. As a drama, it has serious faults; but it powerfully effects its purpose by revealing, in the enlightened Jew, its hero, the grandeur of a nature which, instead of binding itself in dogmatic fetters, cultivates a spirit of free and disinterested humanity.

Thus in all directions this great writer labored for the intellectual regeneration of his people. If Goethe, Schiller, and Kant found a nation prepared to receive their work, they owed the fact to many causes; but among these the chief were the political activity of Frederick II. and the literary activity of Lessing.

After the Seven Years' War.

VII. The Classical Period.—At the close of the Seven Years' War the conditions of public life were very unfavorable to literature. The country was impoverished, and Frederick the Great and Maria Theresa were almost the only sovereigns who showed the least regard for the welfare of their subjects. But the mind of the nation had been thoroughly aroused from its long slumber. It had been startled into patriotism by Frederick's unsurpassed energy, while the labors of the chief writers had imbued the better part of the middle class with a desire for a more varied and interesting life. As political freedom was still a dream of the future, they turned more and more to books for refreshment and stimulus. Multitudes of young men who in other circumstances would have occupied themselves solely with practical duty became authors, and they urged each other to an activity without parallel in any previous period.

Sturm und Drang movement.

Most of these young writers were deeply influenced by the men of the older generation—Lessing, Wieland, and Klopstock. They were also ardent students of Shakespeare, Ossian, and Dr. Young, poets who were oddly supposed to be on the same level, and to share the same tendencies. Rousseau excited almost as much enthusiasm in Germany as in France, and the criticism of Diderot found many warm admirers. Under these diverse influences a curious movement began which is known as that of "Sturm und Drang" ("Storm and Pressure"). It lasted, from about 1770, for ten or twelve years, and included nearly all the writers who still had fame to win. Their most prominent quality was discontent with the existing world. They detested not only tyranny and superstition but everything which prevented, or seemed to prevent, the free exercise of any powerful impulse. To break down conventionalities appeared to the "Sturm und Drang" poets their true function; but even this did not satisfy them. They longed for some knowledge deeper and more intimate than that attained by science, philosophy, or history, for some emotion intenser than can arise from any known human relation. All these conflicting feelings they expressed in their writings. From slavish submission to French critical laws they were of course completely emancipated. Most of them despised laws of every kind in literature as well as in life, and continually proclaimed that the duty of a man of genius was to write precisely as nature dictated. By "genius" they meant vehement sensations, by "nature" a free use of vigorous epithets.

Herder.

The writer who formed the connecting link between Lessing on the one hand and Goethe and Schiller on the other, and whom the best writers of the "Sturm und Drang" movement regarded as their critical guide, was Johann Gottfried Herder (1744–1803). Herder is sometimes compared with Lessing, but while Lessing has a cosmopolitan touch which makes him intelligible and attractive to all the world, Herder is in the strictest sense a German, and is only slightly studied beyond his own nation. He was less boldly original than his older contemporary, and never attained the clearness, force, and classic beauty of Lessing's style. Nevertheless he is justly ranked among the most distinguished spirits Germany has produced. His mind was receptive in many different directions, and what he absorbed he made his own by independent thought, giving it out in new and suggestive forms. As an original poet, Herder does not rank high; yet genuine poetic impulses are visible in the poem in which he gave shape to the Spanish legends of the Cid. The literature in which he looked for the highest manifestation of thought and feeling was that which appeals to popular sentiment and has its root in popular life. Lessing had already called attention to the songs and ballads of the people; but Herder was the first German who decisively followed the impulse which led in England to the publication of Percy's *Reliques.* In his *Stimmen der Völker* ("Voices of the Peoples") he brought together an admirable collection of the lyrical utterances of many races; and it would be difficult to overrate the service he thus rendered, for he conducted his countrymen to a source of imaginative pleasure and revival in which their literature is exceptionally rich. By far his most important prose work was his *Ideen zur Philosophie der Geschichte der Menschheit* ("Ideas towards the Philosophy of the History of Humanity"), in which, working to some extent on the lines laid down in the brief paragraphs of Lessing's *Education of the Human Race,* he develops the conception of progress, and indicates that we can fully understand any single element of history only by seeing it in the light of human evolution as a whole. This excellent book elevated the aims and enlarged the scope of historic inquiry in Germany; and it still produces a powerful moral effect by its noble spirit of humanity. To the end of his days Herder was animated by a fine enthusiasm for human happiness, and it lights up his pages even when his subject does not lead to its direct expression.

Goethe.

To Herder belonged the high honor of stimulating and directing, at a critical stage, the young genius of Johann Wolfgang Goethe (1749–1832). In naming Goethe we mention the writer who holds in German literature the place held by Shakespeare in the literature of England, and by Dante in that of Italy. He towers high above even the greatest of his contemporaries, predecessors, and successors,—Schiller himself, who is most worthily associated with him, being far inferior in breadth of sympathy and splendor of creative impulse. Goethe, indeed, is one of the few writers who, while marked by strongly national characteristics, belong to the world rather than to a particular country. The special phases of his age have begun to pass away, but his best work has lost none of its freshness; it cannot become old, since it is rooted in elements of human life that eternally endure.

All things co-operated to render worthy of his destiny this favorite child of fortune. During his long life he enjoyed almost uninterrupted physical vigor; he was born into a family of prosperous circumstances, although not so highly placed as to satisfy his ambition; he received the best intellectual training his epoch could afford; in Weimar he was free to adapt the plan of his life to his inclinations; and he appeared at the very time when, by an era of sincere poetic endeavor and unparalleled critical labor, the mind of the nation had been prepared for the boldest efforts of genius. Nature has seldom lavished so many advantages on the greatest of her great men.

The quality in Goethe which immediately arrests attention is the extraordinary range of his activity. Hardly any aspect of human existence was strange to him. He possessed in an unsurpassed degree the faculty of dramatically thinking himself into phases of life to which his personal impulses would not have led him; and he deliberately enlarged his experience by exercising this power at every stage of his career. It was his prevailing conviction that all ideals which fascinate or have fascinated humanity must have a touch of vitality; and none was so remote from him but he sought to penetrate to its meaning. He could be just to Hellenic culture without doing wrong to mediævalism; he appreciated the spirit of Christianity without being indifferent to the faith of the Parsees or the Buddhists; he presented the ascetic aspirations of a "beautiful soul," while setting forth the gaiety of the brightest and most careless tempers; he felt the charm of art at the same time that he carried on profound researches in science; he loved his country, and yet, even when it was overrun by Napoleon's troops, he would not join the patriots in saying a harsh word of France. This absolute universality destroyed enthusiasm for special practical movements; but it gave astonishing variety to his literary achievements. Goethe's was in every respect a thoroughly poetic nature. He could not pass through a profound experience, an image of beauty could not cross his vision, without an accompanying impulse to find for his emotion an adequate sensuous representation. So vast a body of writings as his inevitably includes much that is tedious, but in his happiest moments his genius moved with the ease, the certainty, the calmness of the great forces of nature; he could be as perfect in the lightest stroke of delicate feeling as in the grandest flight of soaring imagination. The world he reflects is the world we actually know; but he is not, therefore, in any narrow sense, a realist. The facts he images are shaped and colored by his thought and feeling; he breathes into them a life by which they are made of universal significance. This combination of realism and idealism is one of the chief secrets of his power. His art aims at producing the most general effects, yet it is kept fresh, vivid, and true by incessant contact with the concrete life of men.

Heine relates that he felt inclined to address Goethe in Greek, so like was the calm dignified old man to an earthly Zeus; and this is probably the image suggested to most minds by his name. But in youth he was full of eager life, restless, and passionate, and his early works bear the impress of turbulent feeling. Of these the first published was *Götz von Berlichingen*, which instantly established his fame as one of the chief writers of the "Sturm und Drang" school. It is almost as formless as their inartistic writings. The language is sometimes excessively rude, and there is no attempt to combine the different scenes into an harmonious picture. Yet it is sharply separated off from the tasteless plays with which it was compared, for everywhere we find traces of immature power. The characters are alive; they act and react upon each other as we should expect men and women to do in a stormy and troubled epoch; and by a few touches of apparently unconscious art we are made to realize the vital change through which the society of the age of the Reformation was passing. *Die Leiden des jungen Werthers* ("The Sufferings of Young Werther") gave Goethe a European reputation. Much of its sentimentalism now excites smiles instead of tears; but with all its faults it has an enduring fascination. It breathes a warm love of nature, of which it presents vivid pictures; it conveys a powerful impression of the mingled force, sweetness, and unreasonableness of early passion; and it expresses with deep pathos that weariness of life which forms one of the moods of poetic youth, and the manifestation of which was a favorite pastime of the less sincere "Sturm und Drang" versifiers. The promise of *Götz* and *Werther* was not sustained by all the works produced in the first part of his career. *Clavigo* is only a fairly good acting play; and *Stella* has even more than the extravagant sentimentalism of *Werther*, with only an occasional touch of its poetry. On the other hand, it was now that Goethe began *Faust;* and the fragment, *Prometheus*, expresses a grand defiance that is the more impressive because of the deep philosophic thought which may be traced in the background. It was, however, in his lyrics that the richly varied life of Goethe's youth most perfectly revealed itself. There are no German lyrics, if we except Heine's, which deserve to be compared with Goethe's; perhaps none in any literature have a more subtle charm. Profiting by the teaching of Herder, he studied the artless beauty of the best songs of the people, to some of which he gave new form, while retaining their primitive simplicity. His own lyrics are at once popular and artistic; he takes as his themes the joys, the longings, the regrets which all men understand, and weds them to melodies of delightful ease and grace. Almost every poem was suggested by some passing emotion of his own; yet his feeling is so purified that his words become the voice rather of humanity than of an individual man. His ballads are not, as a rule, so powerful as his songs, but both have one quality in common —without elaborate descriptions they continually call up by an apparently accidental word or phrase a clear vision of some natural object or scene. He is equally master of himself in rendering nature as a mirror in which we see the reflection of our own experience, or as a power moving on in calm indifference to our hopes and fears.

In 1775 Goethe settled in Weimar, where Wieland already was, and whither he was ultimately followed by Herder and Schiller, so that the little town became the centre of the intellectual life of Germany. After an interval of ten years, during which he published nothing, he paid his famous visit to Italy. Here his genius was kindled anew, and a close study of sculpture and painting suggested to him the necessity of submitting more fully than he had yet done to the permanent laws of art. The fruits of this experience were *Iphigenia*, *Tasso*, and *Egmont*, all of which he took with him to Italy in an unfinished form. The first two of these dramas were accepted as imitations of the antique; but they are so only in the sense that in each the parts are rigidly subordinated to the intention of the whole, that there is an orderly sequence in the development of the action, and that they are marked by elevation and simplicity of style. While incomparably more finished as works of art than any of the greater works he had before produced, they indicated no falling off in energy of imagination. *Iphigenia*, although its subject is Greek, is in tone and motive altogether Christian; and it would be difficult to name a more attractive picture of a modern lady than the pure and high-minded heroine. In *Tasso* Goethe draws in strong and sure outlines the sorrows of a poetic nature which will not sharply discriminate the real from its own ideal world. This dramatic poem is hardly more remarkable for the truth and vividness of its conceptions than for the charm of its versification and the wealth and beauty of its language. *Egmont*, however, has more movement, and touches human experience at deeper points. Most readers agree with Schiller's criticism, that there is too much melodrama in the closing scene, in which Clärchen appears to the hero as the spirit of freedom, and that, notwithstanding the liberties taken with history, Goethe has hardly succeeded in making Egmont the type of an enemy of despotism. But Clärchen is a beautiful study of a mind stirred by love to great resolves; and there is splendid portraiture in the characters of Alva, William of Orange, and the Princess of Parma.

Schiller.

Meanwhile, a new literary force had revealed itself in the life of Germany: Schiller (1759–1805), Goethe's great rival, had begun to divide with him the public attention and interest. The names of these two poets, in virtue of whose labors their period deserves to be called classical, are indissolubly connected, yet they were marked off from each other by profound distinctions. Goethe is often called the poet of culture, and it is true that he never ceased to subject his powers to systematic discipline. He was also one of the keenest critics of modern times. But the charm of his best writings is not dependent on criticism or culture; it springs from the spontaneous movement of a great imaginative faculty. Schiller, on the other hand, while also endowed with imagination, possessed it in a much less degree. His poetry would probably have lived even if he had not had the advantage of a thorough grasp of æsthetic laws; but it would certainly have had no claim to the distinguished place it now holds in European literature. He did not attempt so wide a range as Goethe, and within his scope he was not, like Goethe, a disinterested observer; he flung himself into the midst of the struggles of his time, and fought valiantly as the champion of a side. Fortunately for Germany, his side was always that of a truly chivalrous mind; for Schiller was one of the most unselfish of men, with lofty aspirations for the race, and a generous confidence in its essential goodness. These qualities determined the character of his conceptions. Goethe presents us with idealized pictures of the world; Schiller's creations are not so much pictures of the world as the figures of a realm distinct from actual life. His supreme aim was to express great sentiments and ideas, and as the medium for their utterance he conceived characters which are to be found only in a poet's dreams.

Schiller began his literary career as a youth of two-and-twenty, inspired by revolutionary ardor, detesting every conventionality of society, dreaming of a world in which will and passion should have absolute license. He relieved himself of his vehement emotions in his first three plays, *Die Räuber* ("The Robbers"), *Fiesco*, and *Cabale und Liebe* ("Intrigue and Love"). Genius never beat with more Titanic energy against an unsympathetic world than in these dramas; the impulse of the "Sturm und Drang" period, as it was about to die away, spoke in them its wildest, most passionate word. *Don Carlos*, his next drama, still manifested inability to form an organic whole; it contains scenes which have no bearing on the central action, and there is hardly an attempt to explain deeds by natural and intelligible motives. But we are no longer in the presence of one who merely raises an outcry against the existing world; furious resistance to despotism has become enlightened enthusiasm for freedom, humanity, and progress. Although the part of Marquis Posa is imperfectly worked into the scheme of the play, he is a nobly ideal creation; through him Schiller pours forth his own aspirations for the welfare of mankind. There is admirable art in the momentary elevation caused by his greatness of soul even in the dark and selfish Philip and the restless and wayward Don Carlos.

After he settled in Jena in 1789 as professor of history, Schiller was often in Weimar; but for a time he and Goethe held apart. By and by they began to approach each other, and from about 1794 their acquaintance ripened into fast friendship. The friendship of Goethe and Schiller is one of the most beautiful in the history of literature. It made no essential change in Goethe's modes of thought or expression, but it spurred him to the highest activity of which his genius was capable. His friend, he himself declared, "created for him a second youth, and again made him a poet, which he had almost ceased to be." On the other hand, in contact with Goethe's larger intellectual life, Schiller was raised to new points of view, and he acquired for the first time that mastery of artistic methods which secured for him his highest triumphs. He now became as remarkable for the perfection of his form as for the depth and warmth of his feeling.

The two friends worked harmoniously in connection with Schiller's journal *Die Horen,* and wrote in common the *Xenien,* a number of epigrammatic verses meant to wound their literary enemies. On the whole, it is surprising that comparatively so few of the arrows in this rather large quiver are delicately pointed and feathered. A very different stage of excellence is reached by Schiller's well-known ballads, which were written during the period of his intimacy with Goethe. Nearly all of them are marked by force of conception and by purity and dignity of style. In lyrical poetry he had acquired some distinction before he knew Goethe, but it was in competition with his friend that he achieved his masterpiece, *Das Lied von der Glocke* ("The Song of the Bell"), in which within a small compass he presents an impressive picture of the course of human life, varying his melody with subtle art to suit the changing aspects of his theme. Less artistically perfect than the *Glocke,* other lyrics, such as *Der Genius, Die Ideale, Der Spaziergang,* have the power which belongs to deeper personal emotion. In ease and spontaneity none of Schiller's lyrics equal Goethe's, in which, as Heine says, "the word embraces you while the thought kisses you." But they express in clear and noble language some of the highest feelings excited in a poetic mind by contemplation of human life and destiny.

In his dramatic writings Schiller was influenced by Goethe even more than in his lyrics and ballads. The whole series of tragedies which he now wrote have historic or legendary themes, and he displays remarkable skill in unfolding through the past his greatest ideas respecting the future. At the same time he evokes from it a company of finely ideal figures, whose qualities are revealed by the systematic development of large and carefully conceived schemes. *Wallenstein,* the earliest of the series, consists of two plays, *The Piccolomini* and *Wallenstein's Death,* the former of which is preceded by a number of scenes presenting a vivid picture of Wallenstein's camp. The tragic motive of this great work is somewhat obscure. We are made conscious by many artful touches of the ultimate issue; but Schiller does not render fully intelligible the play of the influences which result in disaster. There is however, high imaginative faculty in his conception of Wallenstein's powerful, dark, and wavering character; and every reader feels the charm of the love passages between Max Piccolomini and Thekla. In *Maria Stuart* Schiller triumphs over an obvious difficulty by admitting the heroine's guilt, while he stirs our pity for her sufferings and our admiration for the spirit of endurance with which they are met. In the *Jungfrau von Orleans,* "The Maid" would have given purer pleasure if she had not been represented as loving one of the English commanders; but this only slightly mars the splendid picture of her patriotic devotion. As a work of art, the *Braut von Messina* is the least successful of the later dramas, for it attempts to combine romantic and classic elements which are irreconcilable; it contains, however, some of the most brilliantly rhetorical passages in the German language. The last of his completed works, and in some respects the best, was *Wilhelm Tell.* Here his love of freedom shaped for itself forms of immortal beauty. At a time when the French emperor threatened the independence of all Europe, men felt the power of the play more keenly than can be done in a calmer period; but it has permanently enriched the life of humanity by its conception of a character dominated by high, ideal passions. Schiller never saw Switzerland, yet in this powerful drama he renders with astonishing vividness the grander effects of Alpine scenery.

Goethe's ballads.

Hermann und Dorothea.

Wilhelm Meister.

During his friendship with Schiller Goethe wrote in competition with him many lyrics and ballads. In works of the latter class, as Goethe himself thought, he was surpassed by his friend. He is incomparably more subtle and suggestive than Schiller; but for this very reason he is less effective. A ballad does not deserve its name if it is not popular; and we hear the voice of the people themselves in Schiller's free, bold, and simply harmonious verses. One of the longer works published by Goethe during this period was *Hermann und Dorothea.* His delicately chosen language and dignified hexameters are not always in keeping with the somewhat prosaic life they are here used to portray; but the poem is the nearest approach that has been made to the successful epic treatment of an ordinary theme. And it rises to a high level of imaginative power in the contrast it suggests between the still life of the humble village, with its little idyll of satisfied love, and the far-off desolation of the revolutionary wars, of which we are reminded by the band of emigrants. The genius of Goethe moves more freely in *Wilhelm Meister,* of which the first part was now published. This work has perhaps given rise to more contradictory criticism than any other book in modern literature. We may safely disregard the opinion of those who find in it all the excellences that can be combined in a prose romance, for it is without plan, and its style is singularly unequal. When Goethe himself admitted that he did not possess the key to its full significance, his warmest admirers may allow that perhaps there is no key to possess. Yet few of his writings present more striking evidence of the fertility of his power. He interests us equally—to recall only a few of the characters—in the gay and wordly Phillina, in the romantic Mariana, and in that most mysterious, lovely, and fascinating of creations, Mignon, whose *Kennst du das Land* is perhaps the noblest of those pathetic poems in which a soul in an uncongenial world calls up a momentary vision of its true home. It is not only in its dramatic conceptions that *Wilhelm Meister* is great; it contains some of Goethe's deepest thoughts on life and literature.

Faust.

After the death of Schiller, Goethe turned his attention more and more to science, his achievements in which have been fully appreciated only since the growth of the doctrine of evolution. Still, it was in his latest period that he completed the most famous and the greatest of his works, *Faust,* a poem which he began in youth and did not finish until nearly his last birthday. The Faust of legend was a vulgar magician. Goethe so conceives the character that it indicates the deepest mysteries of human existence. The second part, in which the problem of the poem is solved, can hardly be regarded as a work of art; it is, or seems to be, confused and dark. And the individual elements of the first part are not completely welded; they form rather a series of poems than a single creation. In these individual elements, however, we find the grandest sweep of imaginative thought yet achieved by the German genius. The episode of Gretchen reflects with perfect art the most alluring and the most sorrowful facts of life; and philosophy and religion in their highest aspects meet in Faust's aspirations and struggles.

Goethe's latest writings.

It might have been supposed that at the age of seventy Goethe had no new imaginative worlds to conquer; yet he then published his *Westöstlicher Divan,* representing, with dramatic sympathy and lyric force almost unabated, the combined mysticism and sensuousness of Oriental life. Ten years before, he had issued *Wahlverwandtschaften* ("Elective Affinities"), a powerful picture of impulses which law cannot control, and in which are concealed the germs of tragic issues. It has, however, less charm than another prose work, *Dichtung und Wahrheit* ("Poetry and Truth"), in which he draws a slightly idealized sketch of his early life. This fascinating book has made the figure of young Goethe as familiar as his chief dramatic characters; and no creations of the fancy are better known than the Frederikas and the Lilis, who had long before occasioned his sweetest lyrics, and the memory of whom in old age gave delicacy and music to his style.

French Revolution.

While Goethe and Schiller were in the midst of their career, Europe was startled by the French Revolution. At first it stirred as much interest in Germany as in England. The aged Klopstock greeted it with odes full of the fiery energy of youth, and for a time Schiller almost fancied that his loftiest hopes were about to be realized. Sympathy, however, was transformed into bitter opposition by the Reign of Terror; and when Germany was trodden under foot by Napoleon, she turned more and more from every kind of French influence. Thus it happened that, although the ideas of the Revolution have indirectly affected the literature of Germany as deeply as that of the rest of Europe, their immediate effect was slight and transitory.

Kant. An event of the highest importance in the intellectual growth of Germany was the publication, in 1781, of Kant's *Kritik der Reinen Vernunft.* It is hard for men of a later time, accustomed to metaphysical speculation, to realize the impression produced by this great book. Its effect in philosophy was not unlike that caused in our own day in science by Mr. Darwin's *Origin of Species.* Everywhere among thoughtful men, at the universities especially, philosophy became the absorbing subject of study; and it was taken up at a point from which its whole past development was for the first time intelligible. Goethe, without neglecting the movement, was perhaps less stirred by it than any other prominent writer; Schiller became one of Kant's most enthusiastic students, and traces of the new system are to be found in many of his later lyrics and dramas. He also applied its principles to æsthetics in several admirable critical writings. By and by, dissatisfied with the gulf left by Kant between mind and matter as "things in themselves," philosophers started in search of some principle which should harmonize all the elements of existence; and thus grew up, one after the other, the systems of Fichte, Schelling, and Hegel. For more than a generation these thinkers excited deeper interest than imaginative writers; the most serious minds were fascinated by speculations which placed in new lights all the greatest questions relating to human thought and action.

Sturm und Drang poets. Of the poets or versifiers who began their career with Goethe, the one who for some time attracted most notice was Klinger (1753–1831), whose play, *Sturm und Drang*, is at least memorable through its title. Other plays of his were *Conradin* and *Medea;* and he also wrote romances, of which the best known were *Faust's Leben, Thaten, und Höllenfahrt* and *Der Weltmann und der Dichter.* His writings are violent and noisy, without a touch of true art; what he mistook for imagination was a power of crude and unmeasured declamation. His later works express the bitterness of a deeply disappointed man. Lenz (1750–92), whose name is usually connected with that of Klinger, did not even make so distant an approach to imagination as his rival; his plays are the wild outgrowths of a mind which has made no sincere observation of life, and has submitted neither to intellectual nor to moral discipline. A man of much greater talent than either was Daniel Schubart (1739–91), the restless, licentious, and unfortunate poet who, for publishing a piece of false news, was confined for ten years in a fortress, where he suffered incredible hardships. In his attempts to portray the horrible he is sometimes extremely grotesque, but his best verses have both music and pathos, and they had the good fortune to exercise some influence on Schiller. He was one of the earliest publicists of Germany, and his hatred of despotism was the real cause of the infamous act which deprived him of freedom. Writers who shared the spirit of "Sturm und Drang," and applied it in new directions, were Lavater and Basedow. Lavater enjoyed the friendship of nearly every distinguished man of his day, yet he was vain and fanatical. His *Physiognomische Fragmente* ("Fragments on Physiognomy") were supposed by thousands of readers to find in the relations of mind and body the materials of a new and mysterious science; but the pretended science was in reality a mixture of commonplace and extravagance. Basedow, although with too passionate a faith in the power of education to effect an immediate transformation of the race, did excellent service by advocating, after Rousseau, a more humane and natural system of mental training than had before prevailed. The same cause was more temperately promoted by Campe, who wrote some admirable books for the young; and the Swiss educational reformer, Pestalozzi, set forth methods of instruction in earnest didactic works which had some effect in nearly every country in Europe.

Hainbund or Göttingen school. The excitement of the "Sturm und Drang" writers was shared by a band of young poets who in other respects displayed a wholly different temper. Most of them were students at Göttingen, where they gathered round Boie, editor of the *Musenalmanach,* a journal he had started in imitation of *Le Mercure de France,* and to which Goethe and many of the best of the younger men of the day contributed. They called themselves the "Hainbund" ("Grove confederation"), because of their dancing one night by moonlight round an oak tree, swearing eternal friendship, and vowing to devote themselves to their native land. The god of their idolatry was Klopstock, whose somewhat fantastic enthusiasm for primitive Germany they fully shared, and whose labors on behalf of virtue they never ceased to celebrate, while they loathed and despised Wieland. Several members of the "Hainbund" afterwards acquired distinction, and all of them were more or less remarkable for the genuinely popular tone of their writings. **Bürger.** By far the greatest of them was Bürger (1748–94), who although he never did full justice to himself, gave evidence of an original and adventurous genius. His *Lenore,* a translation of which was Scott's first published work, is full of weird power, and his sonnets are among the most perfect in German literature. His faculty of meeting the popular taste was possessed by Hölty (1748–76), who, however, delighted in mild and calm expression, while the best of Bürger's poems are full of stir and action. Johann Martin Miller (1750–1814) became known chiefly as the author of the romance *Siegwart,* a rather weak imitation of *Werther.* Some irreverent spirits ventured to laugh at its tedious pathos, but it was welcomed by the majority of the middle class, who took especial delight in the songs it includes. Christian, Count Stolberg, and his brother, Frederick Leopold, were also members of the Göttingen school. Besides imitations of Greek plays, they issued odes, ballads, and songs. Of the two the most powerful was Frederick Leopold (1750–1819), in some of whose briefer pieces there is true feeling for nature. He continually verges, however, on extravagance, and often takes the fatal step from the sublime. **Voss.** A stronger writer was Johann Heinrich Voss (1751–1826), author of a famous idyll, *Louise,* which was received by Schiller as a poem of first-rate importance, and suggested to Goethe the idea of his *Hermann und Dorothea.* Its homeliness of style is perhaps more in keeping with its simple and commonplace theme than the classic grace of Goethe's verses. Voss acquired a better title to fame by an admirable translation of Homer, which did for the *Iliad* in Germany what Pope's translation did in England. Voss's rendering is less polished than Pope's, but incomparably more faithful. **Claudius.** Matthias Claudius (1740–1815), although not a member of the "Hainbund," is usually associated with it because of his general sympathy with its tone. The *Wandsbecker Bote* ("Wandsbeck Messenger"), in which he brought together all his writings, contains much simple poetic feeling, and some of his songs are still popular favorites.

Imitators of Wieland. While these writers attached themselves to Klopstock, others showed traces of Wieland's influence. The most important of this class was Wilhelm Heinse (1749–1803), whose chief work was *Ardinghello,* a prose romance. He shares Wieland's general theory of life, but, instead of expressing it in the calm, ironical style of his master, he is vehement, tumultuous, and enthusiastic. Amid his wild exaggerations he sometimes displays a remarkable power of describing physical beauty. He was an ardent student of art, and was the first German writer who succeeded in reproducing in glowing language the impression produced upon him by pictures and music. Other imitators of Wieland were Aloys Blumauer, who mistook vulgar burlesque for satire; Alxinger, whose *Doolin von Mainz* may be taken to represent a large class of tiresome poems of chivalry; and Von Thümmel, who, with considerably more ability than these writers, spoiled his good qualities by cynical grossness. **Imitators of Goethe and Schiller.** An indefinite number of mediæval plays were written in imitation of Goethe's *Götz,* and robber romances in imitation of Schiller's *Räuber.* Of the latter the earliest and most famous was the *Rinaldo Rinaldini* of Vulpius. Jung Stilling (1740–1817) continued the sentimental tone of *Werther* in a number of curious autobiographic tales, which acquired extraordinary popularity, and threw much light on the inner tendencies of the later pietists. Among imitators of Goethe and Schiller's lyrical poetry the best were Matthison and Salis-Seewis; but they were more successful in reproducing his moral feeling than in rivalling his high art. For many years the stage was in the possession of Iffland (1759–1814) and Kotzebue (1761–1819). The former, who was a distinguished actor, wrote dramas chiefly of domestic interest. They are without genius, but had the merit of almost displacing the foolish mediæval plays of Goethe's imitators. Kotzebue was a most prolific writer; and although he had no imagination, and wrote merely to catch the applause of the moment, his comedies still deserve to be named among the few works of this class which have hitherto been produced in Germany.

Jacobi.

A writer who exercised some influence over the youth of Goethe was Frederick Jacobi (1743–1819). He was the author of two romances, *Alwill* and *Woldemar*, in both of which there is a little of Werther's sentimentalism, although their main purpose is didactic. He also wrote a number of philosophical works. His main principle is that the sources of religion and morality are to be found in intuition; and by a constant reiteration of this doctrine he worked in opposition to Spinoza, to Kant, and to Schelling. There are occasional gleams of philosophical genius in Jacobi, and he is of some interest to English readers because of the attention Sir William Hamilton appears to have devoted to his writings.

Richter.

An author of a very different type, and of far greater eminence, was Jean Paul Richter, usually called Jean Paul (1763–1825). It is difficult to do justice to Jean Paul, for he commits almost every fault of which a writer of romance can be guilty; he is at different times pedantic, extravagant, sentimental, and tedious. He prescribed for himself no limits; everything that occurred to him at the moment of his writing went down exactly as it suggested itself. Yet it is impossible even to look into any of his innumerable books without recognizing his genius. The work which has maintained the strongest hold over the nation is perhaps his charming prose idyll, *Die Flegeljahre* ("The Years of Wild Oats"); but his great romance, *Titan*, and the less ambitious *Siebenkäs*, or "Flower, Fruit, and Thorn Pieces," have also kept their place as works of permanent excellence. The most admirable quality of Richter is his humor. No German writer plays with his subject more delightfully, and he produces his most striking effects in dealing with the simplest, most unpretending relations of life. He is usually very near the sources of pathos when he smiles, and Jean Paul's pathos, at its best, is full of power, awakening the deepest feeling by its obvious sincerity. Sometimes it is associated with lofty imagination, as in the famous dream in which he describes a universe without religion. His feeling for the periodic changes of season in nature is that of a poet in the highest sense, his descriptions of spring being perhaps unsurpassed for their glowing yet tender beauty. To his other excellences we must add the manly spirit which led him to scoff, occasionally without due measure, at every kind of vulgarity and pretence, and at the same time preserved in its original freshness his sympathy with his fellow-men and his passion for their enlightenment and progress.

Romantic school.

The most important literary movement which originated during the lifetime of Goethe was that of the Romantic school, whose leading members at first attached themselves to him, but gradually diverged more and more from his spirit. The rise of the school was in some measure due to the philosophy of Fichte, whose theory of the ego as the principle which freely creates its own world gave new importance to the individual as opposed to law and convention. Schelling still more effectually prepared the way for the Romanticists by his poetic treatment of the relations between the mind and nature; and several of his disciples, especially Steffens, worked in the same direction by dwelling on the possibilities of mystery in human life and in the external world. The aim of the Romantic school was to assert for modern feeling the right of a freer, more varied utterance than can be provided for it by the forms of classic literature. They were not in sympathy with their own time; they found it tame, prosaic, colorless; and to enrich it with new elements they went back to mediævalism, in which, as they conceived it, daily life had not been divorced from poetry. They drew enthusiastic pictures of the Middle Ages, of the charms of chivalry, of the loyalty of each class to the class above it and to society as a whole, of the devout piety which was supposed to regulate the conduct of prince and peasant alike, and which revealed itself in splendid architecture and a gorgeous ritual. With a like purpose the Romanticists pointed to Oriental life, and began the serious study of Sanskrit and Persian poetry. The chief writers whom they opposed to the classical poets both of antiquity and of modern times were Shakespeare and Calderon; but they also brought to light many mediæval authors who had previously been neglected, and stimulated the Germans to a systematic study of the whole of their past literature.

The Romanticists did not strike out a wholly original path, for there were in the writings of Lessing, Goethe, and Schiller—especially of Goethe—elements in full harmony with all that was best in the new tendency. They were guilty of grotesque exaggeration in their descriptions of the superior happiness of mediæval nations and Oriental peoples, and they did much harm by checking the rising appreciation of measure and order in literary form which had been encouraged by the great classical writers. In practical life, too, their labors led to results opposed to the progressive tendencies of the age; for in the case of many adherents of the Romantic school, enthusiasm for the Middle Ages soon ceased to be a mere literary fancy—they strove to reproduce obsolete mediæval ideas. Large numbers of them joined the Catholic Church, and became the most vehement opponents of spiritual and political freedom. Still the Romanticists gave prominence to certain vital principles. That we now feel the charm of what was great and beautiful in the Middle Ages, is in part the result of their teaching; and to some extent we owe to them the recognition of deeper elements in the world than reason can formulate, and the conviction that the thought of each age must create for itself a medium of expression adapted to its special nature.

Novalis.

The writer known as the prophet of the Romantic school was Frederick von Hardenberg, generally called Novalis (1772–1801). In his unfinished romance, *Heinrich von Ofterdingen*, he revealed a mystical and sensitive spirit, penetrated by religious aspiration, and feeling itself ill at ease in the hard rough world. These qualities are still more pathetically expressed in his poems, the best perhaps being those in which he directly utters spiritual emotions.

The brothers Schlegel.

The critical leaders of the school were the brothers August Wilhelm von Schlegel (1767–1845) and Friedrich von Schlegel (1772–1829). It is to be feared that many English readers have derived their impression of the former mainly from Heine's malicious caricature. In reality, although destitute of creative power, he was a man of great intellectual distinction. His translations from Shakespeare are masterly, and his rendering of Calderon has also genuine merit. He did much to promote the scientific study of Sanskrit, and his lectures on dramatic art and literature, and on the theory and history of plastic art, contain many fruitful suggestions. Friedrich von Schlegel, who was a writer of greater depth and versatility than his brother, caused much scandal by his romance, *Lucinde*, in which the school appeared for the moment as a powerfully dissolving force in regard to the most sacred of human relations. His most important work, however, is his *History of Ancient and Modern Literature*. Throughout his exposition he is a propagandist of his special ideas; but the book is of lasting importance as the earliest attempt to present a systematic view of literary development as a whole. The period in which the brothers worked most effectually for their school was between 1796 and 1800, when they lived in Jena, and formed the centre of a brilliant circle which included Fichte, Schelling, Tieck, and Wilhelm von Humboldt. Here they edited the *Athenæum*, in which they chastised feeble and pretentious writers, and awoke general interest in mediæval art and literature, and in the systems of philosophy that harmonized with their special tendency.

Tieck.

The most productive, and for a time the most famous, writer of the Romantic school was Ludwig Tieck (1773–1853). Many of the smaller tales in his *Phantasus* have not yet lost their interest. They are, indeed, as far as possible from representing the real life of mediævalism, but they have a mystic and fairy-like charm which is not the less powerful because it is purely imaginative. In his later novels he took his themes from modern life, and they display a remarkable talent for keen and searching satire. Most of them, however, are already practically forgotten, for Tieck was unable to give form to his ideas, and his imagination was wayward and eccentric.

Wackenroder.

In his lyrical poetry he seldom touches a true note, and his dramas have no high qualities to make up for their utter and deliberate lack of plan. Yet his dramatic criticism, of which he wrote a great deal in Dresden—where he lived for many years, the centre of an adoring body of disciples—is often happy and suggestive; and his completion of Schlegel's translation of Shakespeare is poetic in feeling, and indicates a rare mastery of language and versification. A writer of less importance, but who exercised considerable influence over Tieck at an early period of his career, was W. H. Wackenroder (1772–98), whose *Phantasien über die kunst* ("Fancies concerning Art") was published by Tieck after the writer's early death. Both in this book and in his *Overflowings from the Heart of an Art-loving Friar* he expresses a deep feeling for Christian, especially allegoric, art. He was here in full sympathy with the whole Romantic school, which derived intense delight from the spiritual art of the early mediæval painters, but cared little for the noble beauty of Greek art or of the art of the Renaissance.

Fouqué.

Fate-Tragedy.

Among the authors who wrote in the spirit of the Romantic school, and who were for a long time extremely popular, one of the chief was E. T. A. Hoffmann (1776–1822). His treatment of ghostly and horrible themes is often very grotesque; but he has flashes of vivid narrative which indicate a deep appreciation of some of the more mysterious aspects of human nature. Clemens Brentano (1777–1842) was one of the most ambitious of the Romanticists, and he had originality both of thought and fancy; but he was too confused, too indifferent to form, to produce more than a passing impression. Of far more enduring excellence than anything he himself wrote was *Des Knaben Wunderhorn*, a book of popular lyrics which he collected with his brother-in-law, Achim von Arnim. Arnim (1781–1831) revealed imagination and feeling in his *Kronenwächter* ("Guardians of the Crown"); and his *Countess Dolores* gives evidence of great natural power. His works, however, suffer the penalty which attaches to the total neglect of art. De La Motte Fouqué (1777–1843) does not, in the majority of his writings, rise above the level of his fellows; like them, he usually lacks clearness, precision, and genuinely human interest. But in one little book, *Undine*, he achieved a masterpiece. This charming tale, with its sweetness, pathos, and dream-like beauty, is now above criticism; it has taken its place as one of the select class of creations which appeal to all the world, and do not depend for their popularity on the tendencies of a particular time. Joseph von Eichendorff (1788–1857) is an adherent of the Romantic school only in some of his tales; his lyrics combine its depth of emotion with clear and musical expression, and his best stories are written in a frank and attractive style. Adelbert von Chamisso (1781–1838), although usually classed as to some extent a Romanticist, has none of the dreaminess and mysticism of the school. He became a German both in thought and feeling; but his ordered and vigorous style presents many traces of his French origin. He is now chiefly remembered by *Peter Schlemihl*, a tale of quaint and suggestive humor. The most distinguished dramatist of the Romantic school was Heinrich von Kleist (1776–1811), whose dramas were not represented till after his death, but have since then attracted much attention. Some of his characters are conceived with great vigor, but in his tragic motives he lacks invention, and all his works are more or less marred by morbid sentimentalism. Allied to the Romantic school, although not directly connected with it, were the writers of the so-called fate-tragedies. The originator of this curious class of works was Werner (1768–1823). It would be difficult to imagine a more trivial conception of fate than that which he develops in his *Twenty-Fourth of February*, which represents a series of disasters as occurring at intervals on a particular day in consequence of a father's curse. The notion, however, struck the popular fancy, and for ten years even Kotzebue could not contest the supremacy of the fate-tragedians. The chief followers of Werner were Müllner and Houwald. Franz Grillparzer (1791–1872) began his career with a play—*Die Ahnfrau* ("The Ancestress")—in the style of these popular writers, but in his later tragedies he strove to attain classic force and dignity; and by at least one play, *Sappho*, he achieved a place among the most distinguished German dramatists.

Influence of Romantic school.

Schleiermacher.

Philological writers.

The whole life of Germany was to some extent influenced by the Romantic school. In politics it was represented, among others, by Joseph Görres, who agitated with constantly growing enthusiasm for the revival of mediævalism both in church and state. In philosophy Franz Xaver von Baader followed a like tendency by entering deeply into the spirit of Jacob Boehme's mystical philosophy, and interpreting its principles in accordance with Catholic doctrine. Frederick Schleiermacher (1768–1834) was a thorough Protestant, and his services to serious literature were incomparably higher than those of Baader. He was an admirable dialectician, and did more than any other writer to promote in Germany a sympathetic study of Plato. Yet there is a touch of Romanticism in the vague, shadowy, and mystic language in which he presents the elements of Christian thought and life. The love of the Romantic writers for previous epochs of German history and literature led to the great researches of the brothers Grimm, who founded the scientific study of the German language and of German antiquities. They were followed by many devoted scholars, among whom may be named Beneke, Lachmann, Moritz Haupt, and Franz Pfeiffer. The Oriental studies of the Romanticists also promoted comparative philology, which acquired something of the character it now bears through the labors of the illustrious scholars, Wilhelm von Humboldt and Franz Bopp.

Patriotic writings.

Rückert.

During the calamitous period when Germany was beaten and humbled by Napoleon the Romantic school, by continually recalling the past glories of the nation, contributed largely to the revival of patriotic feeling. A like result was achieved by Fichte, whose addresses to the German people, delivered in Berlin while it was occupied by French soldiers, are models of fervid yet thoughtful and dignified eloquence. In the war of liberation the popular excitement was expressed with great spirit by Theodor Körner (1791–1813) and Ernst Moritz Arndt (1769–1860). Of these two writers Arndt is the most poetic, but few even of his lyrics have much literary value. To judge them fairly we must think ourselves back into the epoch in which the nation spontaneously arose to avenge its wrongs and assert its independence. It was as a writer of patriotic war songs that Frederick Rückert (1789–1866) opened his career. Afterwards he moved over a wide range, distinguishing himself especially as a translator of Oriental poetry. He was master of almost every form of lyrical expression, and had hardly less facility in narrative and didactic verse. As regards the substance of his poetry, he is perhaps chiefly remarkable for the tone of calm resignation which he learned from his Eastern masters. In his preference for Oriental modes of thought he has been followed in recent times by Daumer, Bodenstedt, and other poets, who, however, chiefly aim at contrasting the ascetic ideals of Christianity with a gayer, brighter, scheme of life. The whole movement had its origin, and was virtually exhausted, in Goethe's *Westöstlicher Divan*.

War of liberation.

Uhland.

Swabian school.

Had the hopes of German patriots been realized after the war of liberation, literature might have profited by the growth of an intelligent national spirit. But the reward of the German people for their immense sacrifices was bitter opposition on the part of their Governments to every aspiration for freedom and unity. Arndt himself, who had done so much to kindle patriotic ardor, was dismissed in disgrace from his professorship at Bonn, which he did not regain till 1840, when Frederick William IV. mounted the Prussian throne. And the brothers Grimm with other scholars were ignominiously turned out of Göttingen. The mass of the people lost interest in high thought and endeavor, and nourished itself on weak poetry like the *Urania* of Tiedge, and detestable novels like those of Clauren. Yet even in poetry the period was not destitute of important names. Ludwig Uhland (1787–1862), whose first volume of poems appeared in 1815, ranks with the greatest of modern lyrical writers. He is truly popular and patriotic in tone, yet his songs and ballads have an ease and grace of style which raise him far above any of the Romantic school. Uhland was the founder of the so-called Swabian school of poets, of whom the most cultivated was Gustav Schwab. Other Swabian poets were Justinus

Kerner, who attempted, not unsuccessfully, to combine pathos and humor, and Eduard Mörike, whose poetry is generally of a melancholy tone, relieved, however, by touches which indicate a fine sympathy with nature. The theatre was dominated by Raupach (1784–1852) and Freiherr von Auffenberg (1798–1857), the former reigning in Berlin, the latter in Carlsruhe. Both had talent and knowledge of the stage, but there is neither genius nor art in their plays. Immermann (1796–1840), although not without poetic power, lacked the faculty of controlling his dramatic conceptions. He was more successful in romance—his *Epigonen*, and still more his *Münchhausen*, displaying vivid fancy and a quaintly original humor. Sir Walter Scott, who was deeply influenced by German literature, repaid his obligations by influencing it in turn. One of the best of his imitators was Wilhelm Hauff (1802–1827), who had the merit of nearly putting an end to Clauren's popularity by satirizing his style. Hauff's chief work was *Lichtenstein*, which excited hopes that were too soon extinguished by death. Wilhelm Häring, known as Wilibald Alexis (1798–1876), also began as an imitator of Scott, but he afterwards wrote more original historical romances, the scenes of which he laid in Brandenburg. Johanna Schopenhauer, mother of the philosopher, was considered in her day an attractive writer of romance, but she is now remembered only for the sake of her son. She was surpassed in vigor of thought and style by Caroline Pichler (1769–1843), who wrote several well-known historical novels.

History. Throughout the whole of this period Germany maintained her eminence in classical study, contributions of the highest importance to the knowledge of ancient life being made by Wolf, Hermann, Boeckh, and Otfried Müller. In history she produced several writers of distinction. Spittler (1752–1810) was a worthy successor of Justus Möser in the free and artistic treatment of historical subjects; in youth he was kindly treated by Lessing, whose clear style he appears to have taken as his model. Johannes von Müller (1752–1809), the historian of Switzerland, used to be considered by the Germans an eloquent writer, almost a prose poet, but he is now generally regarded as an affected rhetorician. Raumer, in his chief work, *History of the Hohenstaufen*, gave forth the results of deep research in an animated and vigorous narrative. Schlosser, author of a *History of the Eighteenth Century*, was also an historian who combined purity and strength of style with learning. Niebuhr, in his *Roman History*, pushed his scepticism too far, but he profoundly modified opinion in regard to the tests of historic credibility.

VIII. *The Latest Period.*—With the death of Goethe in 1832 began a new era in German literature, an era not yet closed. The period has been one of intense political excitement. In 1848 the national aspiration for freedom and unity found decisive expression in action; since that time Germany has achieved unity by the sword, while she still slowly feels her way towards freedom. It was inevitable that in such an epoch much of the best energy of the nation should be devoted to politics, but there has also been great literary activity—activity deeply influenced by the practical struggles, hopes, and fears of the time.

Philosophy. Philosophical speculation has been continued without interruption, and in many respects it has been, and still is, the deepest current in the intellectual life of Germany.

School of Hegel. From 1818 till his death in 1831, when he was a professor in Berlin, Hegel dominated the highest thought. His vast system, in which he attempted to explain the ultimate facts of the world and to bind by a chain of deductive reasoning the elements of all knowledge, found enthusiastic adherents among the more ambitious of the younger literary men, and for many years after his death it determined the character of their work. Gradually, however, the school broke up into three distinct divisions, the right, the centre, and the left. Of these the most active were the members of the latter party, who interpreted Hegel's doctrine in a revolutionary sense. Arnold Ruge, one of the most brilliant writers of the school, applied Hegelianism to politics, in which he associated himself with the extreme radicals. David Friedrich Strauss, who also started as a follower of Hegel, in his memorable *Leben Jesu* resolved the narratives of the Gospels into a series of myths, and found the vital element of Christianity in its spiritual teaching. Feuerbach, going still further, warred against all religion, urging that it should be replaced by a sentiment of humanity. While the different sections of Hegelians opposed each other, Schelling developed the later phases of his system; and thought was turned into a new channel by Herbart, whose psychological work has been carried on at a later time by Lotze. Krause also attracted attention by philosophical ideas through which he aimed at solving the practical difficulties of modern life. Ulrici and the younger Fichte have exercised considerable influence as the advocates of a pantheistic doctrine by which they endeavor to reconcile religion and science. None of these names, however, have the importance which attaches to that of Arthur Schopenhauer, who, although his chief book was written in the lifetime of Goethe, did not secure a hearing until long afterwards. At the present time he stirs deeper interest than any other thinker. German philosophers have, as a rule, been utterly indifferent to style, but Schopenhauer's prose is clear, firm, and graceful, and to this fact he owes much of his popularity. He expressed bitter contempt for his philosophical contemporaries, and, going back to Kant, claimed to have corrected and completed his system. His main doctrine is that will is the fundamental principle of existence; but his importance arises less from his abstract teaching than from his descriptions of the misery of human life. History seemed to him but a record of turmoil and wretchedness; and there is high literary genius as well as moral earnestness in his graphic and scornful pictures of the darker aspects of the world. Eduard von Hartmann, the latest original philosopher of Germany, works on essentially the same lines, but seeks to reconcile Schopenhauer not only with Hegel and Schelling but with Leibnitz.

Schopenhauer.

Science. The growth of science has been one of the most powerful factors in the recent intellectual development of Germany, and some of the best books of the period have been works presenting in a popular form the results of scientific labor.

Humboldt. Among these the first place still belongs to the *Cosmos* of Alexander von Humboldt. Its fundamental conceptions are no longer in full accordance with the best thought; but it is made enduringly impressive by the writer's power of handling vast masses of facts, by his poetic feeling for the beauty and the order of nature, and by the purity and nobility of his style. Some of the greatest men of science, such as Liebig, Virchow, and Helmholtz, have also made admirable attempts to render their subjects intelligible and interesting to ordinary readers. Büchner and Vogt have considerable merit as popular scientific authors, but their writings are marred by a polemical tendency which induces them to dogmatize on metaphysical questions beyond their proper range.

Historians. In historical literature Germany has recently produced many eminent writers. The historian who enjoys the widest popularity is Leopold Ranke, who has instructed two generations by communicating in an agreeable style the results of extensive research in many different fields of inquiry. Gervinus acquired a permanent place as an historian by his excellent *History of the Nineteenth Century*. Works of high value have also proceeded from Giesebrecht, who has written on the Holy Roman Empire with enthusiastic appreciation of the great emperors; from Droysen, the diligent historian of Prussia; from Dahlmann, whose labors included German, English, French, and Danish history; from Häusser, whose masterpiece is an elaborate history of Germany since the death of Frederick the Great; from Waitz, the chief authority on the growth of the German constitution; from Sybel, by whose researches much new light has been thrown on the French Revolution; from Mommsen, the vigorous historian of ancient Rome; and from Curtius, whose history of Greece is not more remarkable for its learning than for the clear and attractive arrangement of its materials. Of late years much attention has been devoted to "Culturgeschichte," which describes the life of a people in all its phases, either through the whole past or during a particular epoch. A favorable example of works of this class is Karl Biedermann's *Germany in the Eighteenth Century*.

Recent German literature is extraordinarily rich in histories of the individual elements of intellectual development. In its histories of philosophy it is absolutely supreme. Hegel still ranks as one of the greatest historians of philosophy, although the value of his expositions is lowered by a tendency to find his own doctrine in preceding thinkers. Erdmann, Schwegler, and Ueberweg were among the most important workers in the same department; and with them may be named Kuno Fischer, who writes the history of philosophy with a striking power of sympathetic appreciation and in a fascinating literary style. Less attractive in manner than Fischer, Lange, in his *History of Materialism*, did full justice for the first time to the different phases of materialistic philosophy, and is especially happy in the skill with which he traces the growth of a recognition of law in the phenomena of nature. Since Lessing, æsthetics have always formed a prominent branch of philosophy among the Germans; and they have hardly been less successful as historians of art than as historians of metaphysics. High distinction has been achieved, among other art historians, by Kugler, Vischer, Carrière, and Lübke. Of historians of literature, especially German literature, there is almost a small army. One of the earliest of these was Gervinus, who, although his critical canons are not now in favor, had an unusual faculty for grouping his materials and sharply defining what seemed to him the essential qualities of particular writers and movements. The history of German literature by Vilmar, although written in an eloquent style, is too partial in its judgments to have permanent value. Koberstein is remarkable rather for industry than for insight; but the literary histories of Julian Schmidt and Gottschall are both marked by decisive, often penetrating, critical judgment. One of the best works of this kind for style, thought, and research is Hettner's elaborate *History of Literature in the Eighteenth Century*.

Biographers.

The Germans possess a vast mass of biographical literature, a large proportion of which is rendered almost worthless by inartistic treatment. Luther alone forms the subject of more than one hundred and fifty biographies; yet a satisfactory study of the Reformer has still to be written. In recent times, however, there has been a marked improvement, several biographers having conscientiously striven not only to be thorough in research but to write simply, clearly, and vividly. The first to set a good example was Varnhagen von Ense, whose numerous biographies are masterpieces of well ordered and dignified prose. Germany owes an admirable biography of Ulrich von Hutten to Strauss, who also wrote interesting sketches of several prominent modern authors. Other biographies which deserve mention are Karl Grün's philosophical study of Feuerbach, Rosenkranz's scholar-like life of Diderot, and Justi's life of Winckelmann. The popularity of Mr. Lewes's life of Goethe for a long time deterred German writers from touching a subject he had handled with so much talent; but of late there has been a remarkable revival of interest in Goethe, and Hermann Grimm has ventured to present a fresh study of his intellectual and moral character.

Heinrich Heine.

In imaginative literature the greatest writer of the latest period is Heinrich Heine. No German writer since Goethe and Schiller has excited so much interest throughout Europe, and among the Germans themselves his fame is steadily rising. He professed to care little for what men said of his poetry, yet it is mainly as a lyrical poet that his name lives. His *Buch der Lieder* is one of the most fascinating collections of lyrics in European literature. Although a deadly enemy of the Romantic school, he had moods, especially in youth, in which he shared its dreaminess and mysticism; and these qualities he expressed in some of his best songs, but with perfect grace of style and melody. He struck with equally finished art chords of passion and aspiration beyond the range of even the chief Romanticists, for Heine was in every respect a modern man, penetrated by a love of freedom, and by a high enthusiasm for beauty. Except Goethe, no other German poet achieves his effects by such simple means; with the language of a village maiden he gives shape to feelings and ideas of exquisite refinement and subtlety. His satirical poems are sometimes gross and cynical; but none of them are without touches of humor. In his prose, which deals with a wide range of subjects, he is rather French than German in his love of sparkling epigram and biting wit. Almost every theme, however sacred, gives Heine occasion for mockery, but in the midst of cruel laughter he is often restrained by a pathetic memory, which he expresses with unsurpassed delicacy. This combination of pathos, wit, and humor gives him a unique place in the literature of his country.

Platen.

Platen, who belongs rather to the previous period, was one of the many writers whom Heine bitterly attacked, but he was a poet of considerable power. Like Heine himself, he failed in the drama; and even in his successful writings he is not remarkable for wealth of thought or depth of feeling. His odes and sonnets, however, are in language and metre so artistically finished as to rank among the best classical poems of modern times. Börne was another writer whose fame, although the two men were at one time warm friends, suffered from Heine's satire. He was a manly literary critic, and as a political writer dealt at the despotic Governments of Germany blows which they keenly felt.

Young Germany.

A school of writers known as Young Germany was deeply influenced by Heine, and had the good fortune to be singled out for persecution by the confederate diet. Their object was to effect a complete revolution in the political and social institutions of Germany, and at the same time they became the propagandists of ideas intended to undermine the church. The most important member of the school was Karl Gutzkow, who wrote a number of dramas which maintain their hold of the stage. He was also the author of many romances, of which the chief were *Die Ritter vom Geiste* ("The Knights of the Mind") and *Der Zauberer von Rom* ("The Magician of Rome"). These works are of enormous length, and their polemical tendency has already begun to weaken their interest. But the leading characters are genuine creations, and the incidents are interwoven with great artistic skill. Heinrich Laube, another member of the group, is the author of an historical romance, *The German War*, which represents, in a clear, fresh, and vivid style, the condition of Germany during the Thirty Years' War. He has also enriched the stage with several excellent plays. Less important authors associated with these writers were Gustav Kühne, Theodor Mundt, and Ludolf Wienbarg—the latter universally recognized as a keen and vigorous critic.

Novelists.

The novel has acquired the same important place in Germany as in France and England, and it need scarcely be said that the vast majority of works of this class are forgotten almost as soon as they are issued. One of the most distinguished of recent novelists is Gustav Freytag, whose chief work, *Soll und Haben* ("Debit and Credit"), is a study of commercial life intensely realistic in tendency. Lately he has undertaken a series of romances, *Die Ahnen* ("The Forefathers"), intended to represent in a highly poetic form the different epochs of German history. Important historical romances have been written by Levin Schücking, who is remarkable for his power of vividly conceiving character. The Countess Ida Hahn-Hahn is the writer of a number of novels in an artificial style, affecting to represent good society. Her manner has been cleverly satirized by Fanny Lewald, who is one of the best German novelists, keen and true in observation of life, and artistic in method. Paul Heyse's short tales have firmness of outline, and are at the same time full of delicate grace; as a writer of elaborate romance, he has also achieved success. The humor of Hackländer is generally considered to surpass that of any other recent writer; and among the novelists of simple village life Auerbach easily takes the first place. Frederick Spielhagen has penetrated deeply into the spirit of the age, and in *Problematische Naturen* ("Problematic Natures") and other works reveals its tendencies with cultivated imaginative force. The novels of Fritz Reuter, although written in Platt Deutsch, take high rank; they are fresh in style, and combine keen observation of life with a fine appreciation of comic effect.

Dramatic writers.

Contemporary literature has not, as in England, been divorced from the stage; the best imaginative writers find scope for their energies in work for the theatre. Besides Gutzkow and Laube, Gottschall has been a fertile writer both of tragedy and comedy; Freytag also, and Prutz, are original dramatic authors. The dramas of Christian Grabbe, full of eccentricity, but with a certain wild power, originated a movement resembling to some extent that of the "Sturm und Drang" poets. Its chief representative was Hebbel, a writer endowed with imaginative gifts, but who marred every play by affectation and extravagance. Freiherr von Münch-Bellinghausen, known as Friedrich Halm, author of *Der Fechter von Ravenna* ("The Gladiator of Ravenna"), and Mosenthal, author of *Deborah*, achieved distinction by aiming at something higher than mere stage effect. Paul

Lindau is the author of some refined comedies, and Adolf Wilbrandt has written both comedies and tragedies which meet the taste of Vienna. Charlotte Birch-Pfeiffer and Roderich Benedix were prolific writers of plays with the sort of merit that belongs to an intimate knowledge of the technical necessities of the stage.

Lyrical and narrative poets.

Many recent writers have attempted lyrical and narrative poetry, some of them with sufficient power to maintain worthily the traditions of German literature. From about 1830 onwards, a group of Austrian poets, more or less political in tendency, commanded the respect of all Germans. The chief was Count von Auersperg, who assumed the name of Anastasius Grün. His first important work was *Walks of a Vienna Poet*, published in 1831, but his fame rests chiefly on two volumes of lyrics issued some years later. He had enthusiastic faith in the future, and expresses his hopes in verses full of color, sometimes brilliant and effective. Another Austrian writer, Nicholas Strehlenau, generally called Lenau, gives powerful utterance in several poems to the sorrows of a deeply melancholy nature. Meissner and Hartmann, Bohemian poets, have a considerable reputation, the latter as a writer of great artistic merit, the former as a poet of vivid imagination and free sympathies. Leopold Schefer was for a long time a popular poet, and the genial optimism of his chief book, the *Laienbrevier*, is interesting because of the contrast it presents to the pessimist tone of more recent writers. Before the revolutionary movements of 1848 a number of writers attempted to force poetry into the service of freedom. Of these one of the best known is Herwegh. He advocated liberty with a vehemence that won for him immense popularity, but the interest of his writings is rather historical than literary. Ferdinand Freiligrath was of a more truly poetic temperament. His poems, although without delicacy, have graphic force, and in his earlier writings he displayed a remarkable talent for reproducing the gorgeous colors of tropical landscape. Other poets who have made verse a means of awakening in the popular mind a passion for political justice are Hoffmann von Fallersleben, who has a considerable command of musical expression, and Franz Dingelstedt, a versatile writer who has done good work as a novelist and dramatist. Gottschall, already named as a dramatist and an historian of literature, began as a political poet, but afterwards gave evidence of disinterested imagination in two narrative poems, *Göttin* and *Zeno*. The lyrics of Emmanuel Geibel, some of which are also political, with a conservative tendency, have found favor with nearly all classes; they reveal a gentle and refined spirit, and are written with something of Uhland's grace. Among the most distinguished contemporary writers is Robert Hamerling, whose poetry is remarkable for the boldness of its conceptions and its almost vehement passion.

Form in German literature.

Since the middle of the 18th century Germany has never been without writers of deep thought and vast research; and in her supreme writers—in Lessing, Goethe, Schiller, and Heine—these qualities have been associated with a feeling for artistic finish which has not been surpassed in England or even in France. But the tendency of German authors beneath the highest rank has been to neglect the laws of expression. Thus there is in Germany an extraordinary quantity of literature which, although the result of great labor, and full of ideas, makes intolerable demands on the patience of readers. The lack of measure and precision has in many cases deprived of nearly all value powers of imagination, reason, and industry, which would have made the literary fortune of a Frenchman. This deficiency of style is in some degree explained by the fact that an undue proportion of German literature has hitherto been addressed, not to the public, but to specialists, who naturally concern themselves more with substance than with form. During the present generation there have been symptoms of a remarkable change. Ever since the Germans began to feel that they are one people, and to strive after political unity, an increasing number of scholars and thinkers have displayed an ambition to extend their influence, while several imaginative writers have consciously appealed to the nation as a whole. The inevitable result has been that they have aimed at more methodical arrangement than their predecessors, and have cultivated greater force, simplicity, and directness of speech. Nothing has fostered this wholesome tendency so much as the growing respect of the nation for the great masters of its language, a respect indicated by the new editions of their writings which appear year after year. The higher class of poets, dramatists, and novelists have also profited by the deepening conviction that the function of art is not to battle with practical evils, but to create a world of ideal beauty in which the mind may find refuge from the perplexities of real life.

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(J. SI.)

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GERMERSHEIM, a fortified town in Rhenish Bavaria, the chief town of a circle, is situated at the confluence of the Queich and the Rhine, 8 miles S. W. of Spires. It possesses a Catholic and a Protestant church, a Latin school, and a hospital. The industries include fishing, shipbuilding, brewing, the manufacture of cigars, and the cultivation of vegetables, fruit, flax, and hemp. The number of the garrison in the town is usually about 2500.

Germersheim existed as a Roman stronghold under the name of Vicus Julius. The citadel was rebuilt by the emperor Conrad II., but the town itself was founded in 1276 by the emperor Rudolph I., who granted it the rights of a free imperial city. He died here in 1291. From 1330 to 1622, when it was conquered by Austria, the town formed part of the Palatinate of the Rhine. From 1644 to 1650 it was in the possession of France; but on the conclusion of the peace of Westphalia it was again joined to the Palatinate. In 1674 it was captured and devastated by the French under Turenne, and after the death of the elector Charles in 1685, it was claimed by the French as a dependency of Alsace, on which account followed the Germersheim succession war, which lasted till the peace of Ryswick in 1697. Through the intervention of the pope in 1702, the French, on payment of a large sum, agreed to vacate the town, and in 1715 its fortifications were rebuilt. On the 3d July, 1744, the French were defeated there by the imperial troops, and on the 19th and 22d July, 1793, by the Austrians. In 1835 the beautiful new town was built, and the present extensive fortifications commenced. Population in 1875, including the garrison, 6456.

GERONA, a city of Spain, the chief town of the province of Gerona (one of the four into which Catalonia was divided), is situated about 54 miles N. E. of Barcelona on the railway to Perpignan in France, near the junction of the Ter and the Oña. The older part of the town occupies the steep slope of the hill of the Capuchins, and with its old-fashioned buildings presents a picturesque appearance against a background of loftier heights; while the newer portion stretches down into the plain and beyond the river, which adds to the effect of the scene by a bridge of three arches. The old city walls with their bastions still remain, though in a dilapidated state; and the hill is crowned by what were at one time very strong fortifications. At present Gerona is a comparatively insignificant place, although it is the seat of a bishop, has four parish churches, an *instituto*, a seminary, a public library, and a theatre, numbers about 15,000 inhabitants, and carries on the manufacture of paper and cotton and woollen goods. To the ecclesiologist, however, it offers unusual attractions. The cathedral is one of the grandest specimens of Gothic architecture in Spain, the nave being the widest pointed vault in Christendom, as it measures no less than 73 feet from side to side, while Albi, the next in size, is only 58 feet, and Westminster Abbey is only 38. The old cathedral on the same site was used as a mosque by the Moors, and on their expulsion in 1015 it appears to have been very greatly modified, if not entirely rebuilt. During the 14th century new works were again carried out on an extensive scale; but it was not till the beginning of the 15th that the proposal to erect the present magnificent nave was originated by the master of the works, Gullielmo Boffiy. "The keystone of the last division of the vault," says Mr. Street, "seems to have been placed in the time of Bishop Benito, so late as *circa* 1559," and in 1581 the same bishop laid the first stone of the bell tower. "At the east end of the nave three arches open into the choir and its aisles, which with their many subdivisions give an extraordinary impression of size to the vast vault of the nave, and make it look larger than it really is." The general appearance of the exterior is rather ungainly, but there is a fine approach by a flight of 86 steps to the façade, which rises in tiers and terminates in an oval rose-window. Among the interior decorations the most remarkable is the retablo and baldachin of the 14th century; and among the tombs may be mentioned those of Bishop Berenger (*ob.* 1408), Ramon Berenger (Cap de Estopa), and the Countess Ermesinda (*ob.* 1057). The collegiate church of San Feliu (St. Felix) is mainly of the 14th century, but it was considerably modified in the 16th, and its façade dates from the 18th. It is one of the few Spanish churches that can boast of a genuine spire, and it thus forms a striking feature in the general view of the town. Besides the tomb of Alvarez and the sepulchre of the patron saint, it contains an image of St. Narciso, which, according to the local superstition, had the power of producing swarms of poisonous flies, as was sufficiently proved by the destruction of the French investing the city in 1285 and again in 1684. The Benedictine church of San Pedro de los Gallos is an interesting Romanesque building of early date; and in the same vicinity is a small church worthy of notice as a rare Spanish example of a transverse triapsal plan.

Gerona is the ancient *Gerunda*, a city of the Ausetani. It boasts that it is the place in which St. Paul and St. James first rested when they came to Spain; and it became the see of a bishop about 247. For a considerable period it was in the hands of the Moors, and their emir, Soleiman, was in alliance with Pepin about 759. It was taken by Charlemagne in 785; but the Moors regained and sacked it in 795, and it was not till 1015 that they were finally expelled. At a later date it gave the title of count to the king of Aragon's eldest son. Into the details of its later vicissitudes it is needless to enter; but its historians tell how it has been besieged no fewer than twenty-five times in all, and that only four of the sieges have resulted in its capture. The investment by the French under Marshal Hocquisicourt in 1653, that of 1684 by the French under Marshal Belfond, and the successful enterprise of Marshal Noailles in 1694, are the three great events of the 17th century. Surrendered by the French at the peace of Ryswick, it was again captured by Marshal Noailles in 1706, after a brilliant defence; and in 1717 it held out against the Austrians. But its noblest resistance was yet to be made. In May, 1809, it was besieged by the French, with 35,000 troops, under Verdier, Augereau, and St. Cyr; forty batteries were erected against it, and a heavy bombardment maintained; but under the leadership of Mariano Alvarez it held out till famine and fever compelled a capitulation on 12th December. The French, it is said, had spent 20,000 bombs and 60,000 cannon balls, and their loss was estimated at 15,000 men.

See Juan Gaspar Roig y Jalpi, *Resumen de las Grandezas*, etc., Barcelona, 1678; J. A. Nieto y Samaniego, *Memorias*, Tarragona, 1810; Street, *Gothic Architecture in Spain.*

GERRHA, an ancient city of Arabia Felix, on the west side of what is now the Persian Gulf, described by Strabo as inhabited by Chaldæan exiles from Babylon, who built their houses of salt and repaired them by the application of salt water. Three identifications of the site have been attempted, D'Anville choosing El Katig, Niebuhr preferring Koneit, and Forster suggesting the ruins at the head of the bay behind the islands of Bahrein.

GERS, a department of France, composed of the whole or parts of the five old districts of Gascony, viz., Armagnac, Astarac, Lomagne, Comminges, and Condomois. It is bounded N. by the department of Lot-et-Garonne, E. by Tarn-et-Garonne and Haute-Garonne, S. by Hautes-Pyrénées and Basses-Pyrénées, and W. by Landes. It lies between 43° 17′ and 44° 5′ N. lat., and between 1° 10′ E. and 0° 18′ W. long., being about 72 miles in length from E. to W., and 53 in breadth from N. to S. This department is hilly, particularly in the south, where it is mostly covered with ramifications of the Pyrenees. Some of these in the south rise nearly 1200 feet above the level of the sea, but they rapidly decrease in height towards the north. The principal of them run from N. E., N., and N. W., and are separated by longitudinal valleys of great beauty and fertility, narrow in the south, but opening in the north to a width of 3 or 4 miles. The greater part of the department belongs to the basin of the Garonne, while a small portion in the west is drained by the Adour. The chief affluents of the former are the Save, Gimone, Arratz, Gers, and Baise; and those of the latter, the Arros, Midou, and Douse, the last two uniting and taking the name of Midouse, before joining the Adour. The climate is temperate and salubrious, but very changeable. There is seldom any snow, and there is scarcely any frost. More than half of the department is arable; about one-seventh is occupied by vines, and the rest is meadows, wood, or heath. The soil is not of great fertility, but is tolerably well cultivated, and the grain produced is more than sufficient for home consumption. Wheat, maize, oats, and rye are the principal grain crops. About one-third of the wine produced is used for home consumption, and the remainder is chiefly manufactured into brandy, known by the name of Armagnac. The amount of brandy distilled in the department annually is about 22 million gallons. Horned cattle, sheep, mules, swine, game, and poultry, particularly ducks and geese, are abundant. The minerals and manufactures are unimportant. There are quarries of red and green marble; and gypsum, marl, white clay, and sand for the manufacture of glass are obtained. Gers is divided into the arrondissements of Auch, Lectoure, Mirande, Condom, and Lombez, with 29 cantons and 467 communes. The chief town is Auch. The total area is

2425 square miles, and the population in 1866 was 295,692, and 283,546 in 1876.

GERSON, John (1363–1429), otherwise John Charlier of Gerson, Johannes Gersonus, John de Gersone, J. Jarson, De Jarsone, or Gersen, the famous chancellor of the university of Paris, and the ruling spirit in the œcumenical councils of Pisa and Constance, was born at the village of Gerson, in the bishopric of Rheims and department of Ardennes, on December 14, 1363. We learn a good many details about his family and early upbringing from allusions in some of his devotional tracts. His parents, Arnulph Charlier and Elizabeth de la Chardenière, "a second Monica," belonged to the peasant class, were of eminent piety, and rejoiced to see seven of their twelve children, four daughters and three sons, devoting themselves to a religious life. Young Gerson was sent to Paris to the famous college of Navarre when fourteen years of age. After a five years' course he obtained the degree of licentiate of arts, and then began his theological studies under two very celebrated teachers, Giles Des Champs (Ægidius Campensis) and Peter D'Ailly (Petrus de Alliaco), rector of the college of Navarre, chancellor of the university, and afterwards bishop of Puy, archbishop of Cambray, and cardinal. D'Ailly remained his life-long friend, and in later life the pupil seems to have become the teacher (see pref. to *Liber de Vita Sper. Animæ*). Gerson very soon attracted the notice of the university. He was elected procurator for the French nation in 1383, when barely twenty years of age, and re-elected the year afterwards. In 1384 he took the degree of bachelor of theology. Three years later a still higher honor was bestowed upon him; he was sent along with the chancellor and others to represent the university in a case of appeal taken to the pope. Dr. John Montson had been condemned by the faculty of theology because he had taught that the Virgin Mary, like other ordinary descendants of Adam, was born in original sin; and the Dominicans, who were fierce opponents of the doctrine of the immaculate conception, were expelled the university. Montson appealed to Pope Clement VII. at Avignon, and D'Ailly, Gerson, and the other university delegates, while they personally supported the doctrine of the immaculate conception, were content to rest their case upon the legal rights of the university to test in its own way its theological teachers. Gerson's biographers have compared his journey to Avignon with Luther's visit to Rome. It is certain that from this time onwards he was zealous in his endeavors to spiritualize the universities, to reform the morals of the clergy, and to put an end to the schism which then divided the church. In 1392 Gerson became doctor of theology, and in 1395, when D'Ailly was made bishop of Puy, he was at the early age of thirty-two, elected chancellor of the university of Paris, and made a canon of Notre Dame. This great university was then at the height of its fame, and its chancellor was necessarily a man prominent not only in France but in Europe, sworn to maintain the rights of his university against both king and pope, and entrusted with the conduct and studies of a vast crowd of students attracted from almost every country in Europe. Gerson's writings bear witness to his deep sense of the responsibilities, anxieties, and troubles of his position. He was all his days a man of letters, and an analysis of his writings is his best biography. His work has three periods, in which he was engaged in reforming the university studies, maturing plans for overcoming the schism (a task which after 1404 absorbed all his energies), and in the evening of his life writing books of devotion.

Gerson wished to banish scholastic subtleties from the studies of the university, and at the same time to put some evangelical warmth into them. He was called at this period of his life Dr. Christianissimus; later his devotional works brought him the title Doctor Consolatorius. His plan was to make theology plain and simple by founding it on the philosophical principles of nominalism. His method was a clear exposition of the principles of theology where clearness was possible, with a due recognition of the place of mystery in the Christian system of doctrine. Like the great nominalist William of Occam, he saved himself from rationalism by laying hold on mysticism—the Christian mysticism of the school of St. Victor. He thought that in this way he would equally guard against the folly of the old scholastic and the seductions of such Averroistic pantheism as was preached by heretics like Amalric of Bena. His plans for the reformation of university studies may be learned from his *Tract. de Examinatione Doctrinarum* (*Opp.* i. 7), *Epistolæ de reform. Theol.* (i. 121), *Epistolæ ad Studentes Collegii Navarræ, quid et qualiter studere debeat novus theologiæ auditor, et contra curiositatem studentium* (i. 106), and *Lectiones duæ contra vanam curiositatem in negotio fidei* (i. 86). The study of the Bible and of the fathers was to supersede the idle questions of the schools, and in his *Tract. contra romantiam de rosa* (iii. 297) he warns young men against the evil consequences of mediæval romance-reading. He was oftentimes weary of the chancellorship—it involved him in strife, and in money difficulties; he grew tired of public life, and longed for learned leisure. To obtain it he accepted the deanery of Bruges from the duke of Burgundy, but after a short sojourn he returned to Paris and to the chancellorship.

Gerson's chief work was what he did to destroy the great schism. Gregory XI. had died in 1378, one year after Gerson went to the college of Navarre, and since his death the church had had two popes. To the mediæval mind, imaginatively apprehending great thoughts in picture-representations, two popes meant two churches and a divided Christ. The spiritual unity of the church, which is founded on the spiritual union of all believers to Christ, was unintelligible to it. Gerson and his contemporaries could not disentangle the invisible from the visible, and if daring spirits like Wickliffe and Huss declared that the elect were the true church, the practical consequences which they drew from this showed that they also were unable to escape from the confusion. The schism had practically been brought about by France. The popes had been under French influence so long that it appeared to France a political necessity to have her own pope, and pious Frenchmen felt themselves somewhat responsible for the sins and scandals of the schism. Hence the melancholy piety of Gerson, D'Ailly, and their companions, and the energy with which they strove to bring the schism to an end. During the lifetime of Clement the university of Paris, led by D'Ailly, Gerson, and Nicholas Clamenges, met in deliberation about the state of Christendom, and resolved that the schism could be ended in three ways,—by cession, if both popes renounced the tiara unconditionally, by arbitration, or by a general council. Clement died. The king of France, urged by the university, sent orders that no new pope should be elected. The cardinals first elected, and then opened the letter. In the new elections, however, both at Rome and Avignon, the influence of Paris was so much felt that each of the new popes swore to "cede" if his rival would do so also.

Meanwhile in 1395 the national Assembly of France and the French clergy adopted the programme of the university—cession or a general council. The movement gathered strength. In 1398 most of the cardinals and most of the crowned heads in Europe had given their adhesion to the plan. During this period Gerson's literary activity was untiring, and the throb of public expectancy, of hope and fear, is revealed in his multitude of pamphlets. At first there were hopes of a settlement by way of cession. These come out in *Protest. super statum ecclesiæ* (ii. 1), *Tract. de modo habendi se tempore schismatis*, *De Schismate*, etc. But soon the conduct of the popes made Europe impatient, and the desire for a general council grew strong—see *De Concilio generali unius obedientiæ* (ii. 24). The council was resolved upon. It was to meet at Pisa, and Gerson poured forth tract after tract for its guidance. The most important are—*Trilogus in materia Schismatis* (ii. 83), and *De unitate Ecclesiæ* (ii. 113), in which following D'Ailly (see Tschackert's *Peter v. Ailli*, p. 153), Gerson demonstrates that the ideal unity of the church, based upon Christ, destroyed by the popes, can only be restored by a general council, supreme and legitimate, though unsummoned by a pope. The council met, deposed both anti-popes, and elected Alexander V. Gerson was chosen to address the new pope on the duties of his office. He did so in his *Sermo coram Alexandro Papa in die ascensionis in concilio Pisano* (ii. 131). All hopes of reformation, however, were quenched by the conduct of the new pope. He had been a Franciscan, and loved his order above measure. He issued a bull which laid the parish clergy and the universities at the mercy of the mendicants. The great university of Paris rose in revolt, headed by her chancellor, who wrote a fierce pamphlet—*Censura professorum in theologia circa bullam Alexandri V.* (ii. 442). The pope died soon after, and one of the most profligate men of that time, Pope John XXIII. (Balthasar Cossa), was elected his successor. The council of Pisa had not brought peace; it had only added a third pope. D'Ailly despaired of general councils (see his *De difficultate reformationis in concilio universali*), but Gerson struggled on. Another matter too had roused him. The feuds between the houses of Orleans and Burgundy had long distracted France. The duke of Orleans had been foully and treacherously murdered by the followers of the duke of Burgundy, and a theologian, John Petit, had publicly and unambiguously justified the murder. His eight verities, as he called them—his apologies for the murder—had been, mainly through the influence of Gerson, condemned by the university of Paris, and by the archbishop and grand inquisitor, and his book had been publicly burned before the cathedral of Notre Dame. Gerson wished a council to confirm this sentence. His literary labors were as untiring as ever. He maintained in a series of tracts that a general council could depose a pope; he drew up indictments against the reigning pontiffs, reiterated the charges against John Petit, and exposed the sin of schism—in short, he did all he could to direct the public mind towards the evils in the church and the way to heal them. His efforts were powerfully seconded by the emperor Sigismund, and the result was the council of Constance. This council, unlike its predecessor at Pisa, was summoned by a pope—Pope John XXIII. Sigismund was present, resolutely determined to unite and reform the church, and guided by Cardinals D'Ailly and Zarabella, and above all by Gerson. Gerson indeed practically ruled the council up to the election of a new pope. It was he that dictated the form of submission and cession made by John XXIII., and directed the process against Huss. Many of Gerson's biographers have found it difficult to reconcile his proceedings against Huss with his own opinions upon the supremacy of the pope; but the difficulty has arisen partly from misunderstanding Gerson's position, partly from supposing him to be the author of a famous tract—*De modis uniendi ac reformandi ecclesiam in concilio universali*. All Gerson's high-sounding phrases about the supremacy of a council were meant to apply to some time of emergency. He was essentially a trimmer, and can scarcely be called a reformer. He never wrote the bold tract of Abbot Andrew of Randolph (*cf.* Schwabe, *Johannes Gerson*, pp. 483–491), and he hated Huss with all the hatred the trimmer has of the reformer. The council of Constance, which revealed the eminence of Gerson, became in the end the cause of his downfall. He was the prosecutor in the case of John Petit, and the council, overawed by the duke of Burgundy, would not affirm the censure of the university and archbishop of Paris. Petit's justification of murder was declared to be only a moral and philosophical opinion, not of faith. The utmost length the council would go was to condemn one proposition, and even this censure was annulled by the new pope, Martin V., on a formal pretext. Gerson dared not return to France, where, in the disturbed state of the kingdom, the duke of Burgundy was in power. He lay hid for a time in Germany, and then returned to France, to Lyons, where his brother was prior of the Celestines. It is said that he taught a school of boys and girls in Lyons, and that the only fee he exacted was to make the children promise to repeat the prayer, "Lord, have mercy on thy poor servant Gerson." His later years were spent in writing books of mystical devotion and hymns. He died at Lyons on July 12, 1429. Tradition declares that during his sojourn there he translated or adapted from the Latin a work upon eternal consolation, which afterwards became very famous under the title of *The Imitation of Christ*, and was attributed to Thomas à Kempis. Recent researches, however, have proved beyond a doubt that the famous *Imitatio Christi* was really written by Thomas, and not by John Gerson or the Abbot Gersen.

The literature on Gerson is very abundant. See Dupin, *Gersoniana*, including *Vita Gersoni*, prefixed to the edition of Gerson's works in 5 vols. fol., from which quotations have here been made; Charles Schmidt, *Essai sur Jean Gerson, Chancelier de l'Université de Paris*, Strasburg, 1839; Schwabe, *Johannes Gerson*, Würzburg, 1859. On the relations between Gerson and D'Ailly, see Paul Tschackert, *Peter von Aillie*, Gotha, 1877. On the authorship of the *Imitatio Christi*, see the editions of Dibden, Genæ, and Kettlewell. On Gerson's public life, see also histories of the councils of Pisa and Constance, especially Herm. v. der Hardt, *Con. Constantiensis libri IV.*, 1695–9.

(T. M. L.)

GERSONIDES, or Ben Gerson, Levi, a distinguished Jewish philosopher and commentator, was born at Bagnolo in Languedoc, towards the close of the 13th century, probably in 1288. As in the case of the other Jewish writers on philosophy during the Middle Ages, extremely little is known of his life. His family had been distinguished for piety and exegetical skill, but though he was known in the Jewish community by commentaries on certain books of the Bible, he never seems to have accepted any Rabbinical post. Possibly the freedom of his opinions, which drew on him the suspicion of infidelity, may have put obstacles in the way of his preferment. He is known to have been at Avignon and Orange during his life, and is believed to have died at Perpignan in 1370. Part of his writings consist of commentaries on the portions of Aristotle then known, or rather of commentaries on the commentaries of Averroes. Some of these are printed in the early Latin editions of Aristotle's works. His most important treatise, that by which he has a place in the history of philosophy, is entitled *Milhamoth Adonai* (The Wars of God), and is said to have occupied twelve years in composition. A portion of it, containing an elaborate survey of astronomy as known to the Arabs, was translated into Latin in 1342 at the request of Clement VI. The *Milhamoth* is throughout modelled after the plan of the great work of Jewish philosophy, the *Morê Nebuchîm* of Moses Maimonides, and may be regarded as an elaborate criticism from the more philosophical point of view (mainly Averroistic) of orthodoxy as presented in that work. The six books pass in review (1) the doctrine of the soul, in which Gersonides defends the theory of impersonal reason as mediating between God and man, and explains the formation of the higher reason (or acquired intellect, as it was called) in humanity,—his view being thoroughly realist and resembling that of Ibn Gebirol (see Avicebron); (2) prophecy; (3) and (4) God's knowledge of facts and providence, in which is advanced the curious theory that God does not know individual facts, and that, while there is general providence for all, special providence only extends to those whose reason has been enlightened; (5) celestial substances, treating of the strange spiritual hierarchy which the Jewish philosophers of the Middle Ages accepted from the Neo-Platonists and the Pseudo-Dionysius, and also giving, along with astronomical details, much of astrological theory; (6) creation and miracles, in respect to which Gerson deviates widely from the orthodox position of Maimonides.

A careful analysis of the *Milhamoth* is given in Rabbi Isidore Weil's *Philosophie Religieuse de Lévi-Ben-Gerson*, Paris, 1868. See also Munk, *Mélanges de Phil. Juive et Arabe*; and Joel, *Religions-philosophie d. L. Ben-Gerson*, 1862. The *Milhamoth* was published in 1560 at Riva di Trento, and has been republished at Leipsic, 1866.

GERSTÄCKER, Friedrich (1816–1872), who enjoyed a most extensive popularity as a novelist and a writer of travels both at home and abroad, was born at Hamburg on 10th May, 1816. Having lost his father at the age of nine, he was placed under the guardianship of an uncle at Brunswick, who sent him to a house of business at Cassel as clerk. He soon got tired, however, of the monotonous commercial routine, and selected the more active life of a farmer, in which capacity he spent the years from 1835 to 1837 in Saxony. But the uneventful agricultural life was unable to repress in him the innate roving instinct which, according to his own statement, had received a strong impulse in his eighth year by the perusal of *Robinson Crusoe*. The word "America" had from that time exercised on him an irresistible charm, and so he went in 1837 from Bremen to New York. He travelled on foot over all parts of the United States, working as he went for his bare subsistence, and then settled for some time in Arkansas, where he led the life of a roving sportsman. Only now and then he visited inhabited places to see civilized society, and to earn some means by whatever work he could obtain. Thus he went in 1842 to Point Coupée in Louisiana, where he undertook the management of a hotel. This time, however, he did not return with the acquired means to the backwoods, but repaired to his German home to see his mother and other relatives, after having led an adventurous life for six years and a half. On his return to Germany he found himself, to his great surprise, known as an author, on a limited scale at least. His mother had shown his diary, which he regularly sent home, and which contained descriptions of his adventures in the New World, to the editor of the *Rosen*, who readily published them in his periodical. The travelling sketches having found great favor with the German public, Gerstäcker issued them, in 1844, in a collected form, under the title of *Streif- und Jagdzüge durch die Vereinigten Staaten Nordamerikas*. His next literary labors consisted of translations from the English, during the performance of which it occurred to him that he might himself become an original author, since he was able to delineate original characters, to relate remarkable occurrences, and to describe romantic scenery from his own experience, whilst others were obliged to draw upon their imagination only in producing works of fiction. Accordingly Gerstäcker issued, in 1845, his first novel, *Die Regulatoren in Arkansas*, and henceforth the stream of his productiveness flowed on uninterruptedly. In 1849 he again repaired to America, being this time provided with a grant from the then "German Government," and acting at the same time as correspondent to the *Augsburger Allgem. Zeitung*. After having made very extensive travels both in America, Polynesia, and Australia, he returned in 1852 to Leipsic. In 1860 his innate restlessness drove him to South America, chiefly with a view of inspecting the German colonies there. After having traversed nearly all the principal South American countries he returned to Germany, but for a short time only, for in 1862 he accompanied the Duke Ernest of Coburg-Gotha to Egypt and Abyssinia. This was his last great journey, after the return from which he lived first near Gotha and then at Brunswick, where he died on May 31, 1872.

Gerstäcker was greatly esteemed and liked as a man, on account of his genial temper and straightforward character, and as an author he enjoyed an almost unprecedented popularity at home and was very favorably known abroad. The charm of his productions consists in the natural freshness of his descriptions, nearly all of which have an exotic background, and in the originality of his characters, the most prominent of which are drawn from real life. He did not possess any high literary power, and probably never touched up what he had once written; his writings lack therefore on the whole that artistic finish which forms one of the principal elements of a good writer. This defect, however, impresses even on his works of fiction the stamp of probability, nay of truthfulness. His writings nowhere betray that intention of producing an effect which so often destroys the illusion of the reader in elaborately worked out productions. He generally writes in a homely, ungarnished manner, just as a traveller would relate his adventures amidst a circle of friends. His writings, therefore, nearly always rivet the attention of the reader from beginning to end. The works of Gerstäcker have, besides, the merit that they formed a wholesome counterpoise against the too idealistic tendency of the literature of Germany, against the lax and realistic school of France, and against the morbid sensationalism which prevailed in England. A number of his works have been translated into several modern languages, but mostly into English; their descriptions of exciting adventures on land and sea affording, with their sturdy humor, congenial reading to the English-speaking community in the Old and New World. His best works, from a literary point of view, are, besides the above-mentioned *Regulatoren*, his *Fluszpiraten des Mississippi*, his South Sea novel *Tahiti*, his Australian romance *Die beiden Sträflinge*, his *Matrosenleben* and *Blau Wasser*. His collected works have been issued in a cheap and handy edition published at Jena.

GERVAIS, Paul (1816–1879), an eminent palæontologist, was born September 26, 1816, at Paris, where he obtained the diplomas of doctor of science and of medicine, and in 1835, as assistant to De Blainville in the laboratory of comparative anatomy at the Museum of Natural History, commenced palæontological research. In 1841 he obtained the chair of zoology and comparative anatomy at the Faculty of Sciences in Montpellier, of which he was in 1856 appointed dean. In 1848–52 appeared his important work *Zoologie et Paléontologie Françaises*, supplementary to the palæontological publications of G. Cuvier and De Blainville; of this a second and greatly improved edition was issued in 1859. In 1865 he accepted the professorship of zoology at the Sorbonne, vacant through the death of Gratiolet; this post he left in 1868 for the chair of comparative anatomy at the Paris Museum of Natural History, the anatomical collections of which he greatly enriched by his exertions. He was elected a member of the Academy of Sciences at Paris, in the place of Coste, January 26, 1874. Gervais was remarkable for the disinterestedness with which he devoted himself to the cause of science. He died February 10, 1879, in the sixty-third year of his age.

Besides his *Zoologie et Paléontologie Françaises*, Gervais wrote:—The "Zoologie" for Laplace's *Voyage autour du Monde*, 1833, etc. (with F. Eydoux); *Hist. naturelle des insectes aptères*, 1837, etc. (with Walkenaer); *Le jardin des plantes*, 1842, etc. (with P. Bernard); *Atlas de Zoologie*, 1844; *Zoologie de la France*, 1847 (with Aicard and others); *Hist. naturelle des mammifères*, 1853, etc.; part of Thiollière's *Description des poissons fossiles*, 1854, etc.; *Théorie du squelette humain*, 1856; *Zoologie médicale*, 1859 (with Van Beneden); *De la métamorphose des organes et des générations alternantes*, 1860; *Un million de faits*, 1861 (with Aicard, Desportes, and others); *De l'ancienneté de l'homme*, 1865; *Zoologie*, 1866, in the series *Éléments des sciences naturelles*; *Recherches sur l'ancienneté de l'homme et la période quaternaire*, 19 pl., 1867; *Zool. et paléontologie générales*, 1867; *Éléments de zoologie*, 1868 and 1869; *Ostéographie des Cétacés*, 1869, etc. (with Van Beneden); *Notions élémentaires d'histoire naturelle*, 1869 and 1872 (with Marchand and Raulin). His scientific papers are exceedingly numerous. See E. Blanchard, "Nécrologie," *Revue Scientifique*, Feb. 15, 1879, p. 783; S. Meunier, *La Nature*, March 15, 1879, p. 225.

GERVAISE of Canterbury, born about 1150, was one of the monks of the priory of Christ Church, Canterbury, and witnessed the burning of the cathedral in 1174. His earliest known literary effort was a *Tractatus de Combustione et Reparatione Dorobornensis Ecclesiæ*, being an account of that conflagration and of the subsequent process of rebuilding, written probably about 1184. This was followed about 1194 by *Imaginationes de discordiis inter monachos Cantuarienses et Archiepiscopum Baldewinum*, a detailed relation of clerical disputes which had occurred during the episcopate of Baldwin from 1185 to 1190. Gervaise's *Chronica de tempore regum Angliæ, Stephani, Henrici II., et Ricardi I.*, brings the history down to the death of the last named (1199); but his *Vitæ Dorobornensium Archiepiscoporum* closes with that of Reginald Fitz-Joceline (1191). These works, which are all of them characterized by laboriousness and trustworthiness, are reprinted in Twysden's *Historiæ Anglicanæ Scriptores* (vol. x.). In the library of Corpus Christi College, Cambridge, there is an unpublished MS., also by Gervaise, containing a work entitled *Mappa Mundi*, and also an English chronicle from the fabulous ages to the death of Richard. The year of the death of Gervaise is not recorded, but the fact that he does not appear to have accomplished any part of his promised chronicle of the reign of John may fairly be taken to imply that he did not live long after 1200. See Wright, *Biographia Britannica* (1846).

GERVASE, or Gervaise, of Tilbury (*Gervasius Tilburiensis*), an English Latin writer of the 13th century, was probably born at Tilbury in Essex. He is frequently said to have been a nephew of Henry II. of England; but if this was the case, it is strange that in speaking of Henry to Otto IV. he makes no allusion to this relationship, but simply calls him "my master the illustrious king of the English, Henry II., your uncle *vestri avunculi*." The truth probably is that the statement owes its origin to some careless copyist or reader either taking *vestri* for *nostri* in this passage, or, as M. Petit Radel suggests, the contraction *vri* for *mei*. Gervase was present at the peace of Venice in 1177, was professor of canon law some years later at Bologna, and afterwards entered the service of William II. of Sicily. Having obtained the favor of Otto IV., who had close intercourse with England, he was by him appointed about 1200, chancellor and marshal of the kingdom of Arles. He subsequently received the provostship of the nunnery at Ebsdorf, and died about 1235. His best known, if not his only important work, is the *Otia Imperialia*, which he composed about 1212 for the entertainment of his imperial patron. The first two books are a sort of geographical and historical compendium, and the third is devoted to all kinds of curious facts and beliefs. The history begins at the beginning with the creation of the world, but it only comes down to the author's own days, as he confesses he had not the gift of prophecy. It is a fairly learned but on the whole very dry digest of the ordinary narratives handed on from chronicler to chronicler, relieved at times with curious disquisitions, or passages from the writer's own experience. It is mainly the third book which justifies Mr. Wright's assertion that Gervase was "one of the most amusing writers of the period," for in it he collects a great many popular myths and legends about such matters as the magnet, asbestos, the sirens of the British sea, the veronica, the horn of St. Simon, and so on.

The *Otia* was printed by Leibnitz in vol. i. of *Scriptores rerum Brunsvicensium*, and corrections from MSS. appeared in vol. ii. A portion of the second book had already been printed by J. J. Maderus as *Gervasii Tilb. de Imperio Romanorum*, Helmstadt, 1673; and Liebricht has since made selections from the non-historical portions, Hanover, 1856. The *Dialogus de Scaccario*, now recognized as the work of Nigel bishop of Ely, was long attributed to Gervase; and he had consequently the credit also of the *Tricolumnus* (now lost) claimed by the author of the dialogue. It is needless to mention the works assigned to him by Bale; but we have his own authority for the statement that he wrote a *Liber Facetiarum*, or book of anecdotes, for Henry II. See Petit Radel in *Hist. Litt. de la France*, vol. xvii.

GERVINUS, Georg Gottfried (1805–1871), one of the most eminent literary and political historians of Germany, was born on May 20, 1805, at Darmstadt. His well-to-do parents, belonging to the middle classes, had him educated at the gymnasium of the town, where he studied with great success. At the age of fourteen they chose for him a commercial career, but Gervinus continued his classical studies privately, and made himself fully acquainted with the polite literature of Germany and other countries. He also cultivated his literary and musical tastes by frequenting the theatre of the Hessian capital, which was then in an excellent condition. In 1825 he relinquished the uncongenial commercial life, and repaired, after a brief preparation, to the university of Giessen to study philology. The short interruption in his school education helped to develop in him, in an eminent degree, his social qualities, and taught him to employ methodically and usefully every hour of his life. In 1826 he went to Heidelberg, where he attended the lectures of the great historian Schlosser, who became henceforth his guide and his model. From 1828 to 1830 he held a mastership in a private institution at Frankfort-on-the-Main, issuing at the same time, in conjunction with Morstadt and Hertlein, a comprehensive edition of Thucydides, and writing an essay on Bloomfield's English translation of the Greek historian. In 1830 he returned to Heidelberg, and wrote among other essays one on Probert's *Ancient Laws of Cambria.* The year 1832 he spent in Italy as travelling tutor to a young Englishman, and on his return to Heidelberg he wrote several historical treatises, which he issued in 1833, in a collected form, as the first volume of his *Historische Schriften.* This publication procured him the appointment of professor extraordinarius; and the first volume of his *Geschichte der poetischen Nationalliteratur der Deutschen* brought him, through the special recommendation of the historian Dahlmann, the appointment to a regular professorship of history and literature at Göttingen. He settled there at Easter, 1836, and married a wealthy young lady, who proved a true "companion to his intellect." In the following year he wrote his *Grundzüge der Historik,* which is perhaps the most thoughtful of his philosophico-historical productions. The same year brought his expulsion from Göttingen in consequence of his manly protest, in conjunction with six of his colleagues, against the unscrupulous violation of the constitution by Ernest Augustus, king of Hanover and duke of Cumberland. After applying himself to his literary and artistic studies at Heidelberg, Darmstadt, and Rome, he returned once more to Heidelberg, where he continued, among other works, his history of German literature, and was appointed in 1844 honorary professor. He zealously took up in the following year the cause of the German Catholics, hoping it would lead to a union of all the Christian confessions, and to the establishment of a national church. He also came forward in 1846 as a patriotic champion of the Schleswig-Holsteiners, and when, in 1847, King Frederick William IV. promulgated the royal decree for summoning the so-called "United Diet" (Vereinigte Landtag), Gervinus hoped that this event would form the basis of the constitutional development of the largest German state; and, thinking that the hour of publicistic activity had arrived, he founded, in common with some other patriotic scholars, the *Deutsche Zeitung,* which certainly was one of the best-written political journals ever published in Germany. His appearance in the political arena secured his election as deputy for the Prussian province of Saxony to the National Assembly sitting in 1848 at Frankfort. The weight of his name and his journalistic activity were of considerable advantage to the liberals in that short-lived parliament; but when he saw that all their endeavors were frustrated by the indecision of the king of Prussia, who declined accepting the imperial crown of Germany, he retired in gloomy disappointment from all active political life. So embittered was he against the royal house of Hohenzollern that neither the formation of the North German Confederation in 1866, which in former years he would have hailed with the greatest satisfaction, nor the glorious establishment in 1870 of a united German empire, could reconcile him to a dynasty one sickly scion of which had foiled the national aspirations of Germany. Gervinus now took refuge among his literary and historical studies, more especially devoting himself to the study of Shakespeare, the result of which was his great work *Shakespeare* (1849, 1850), in four volumes. He also revised his *magnum opus,* the *History of German Literature,* for a fourth edition (1853), and began at the same time to plan his *History of the 19th Century,* which was to be a continuation of the *History of the 18th Century* by his guide and teacher, Schlosser. He heralded that voluminous work by a programme or manifesto entitled *Einleitung in die Geschichte des neunzehnten Jahrhunderts,* which was issued in 1853, and made a great stir in the literary and political world, chiefly owing to the circumstance that the Government of Baden imprudently instituted a prosecution against the author for high treason. Gervinus had prophesied in his famous pamphlet the final victory of democracy, and based his prediction on the theory that all the great revolutionary outbreaks follow each other in a kind of geometrical progression,—to wit, 1820, 1830, and 1848. Hence he concluded that the next great revolutionary shock would take place about 1888–1890, and that it would insure the final victory to democracy, just as the same decade brought in former centuries freedom and independence to the Americans, the French, the English, and the inhabitants of the Netherlands. Arraigned before a tribunal, he defended himself with a great display of ability and manly courage, but was nevertheless condemned to an imprisonment of two months, and all the copies of the "seditious publication" were to be destroyed. Fortunately for Germany, this disgrace was spared her, the verdict having been rescinded by a higher tribunal. This occurrence, which would have aroused a more elastic temper to greater political activity, had the contrary effect upon the sensitive mind of Gervinus. He buried himself still more among his books, and even forbore to deliver lectures. With unwearied energy he now devoted himself to his above-mentioned great historical work, *Geschichte des neunzehnten Jahrhunderts seit den Wiener Verträgen,* which he issued in eight volumes, the first in 1855 and the last in 1866. In the midst of his historical studies he found relief in his devotion to the works of his favorite musician Handel. He founded, and liberally supported, the Handel Society in Germany, whose object it was to restore the compositions of the great master in an authentic form, and to issue German versions of the texts suitable to the compositions. The result of his Handel studies was his critical and æsthetical work *Händel und Shakespeare, zur Æsthetik der Tonkunst* (1868), in which he drew an ingenious parallel between his favorite poet and his favorite composer, showing that their intellectual affinity was based on the Teutonic origin common to both, on the same healthiness of their mental capacities, on their analogous intellectual development, and even on a similarity of their inclinations and fates. This philosophical treatise fell flat on the German public, who could not forgive the author for having extolled Handel above the great national masters, Haydn, Mozart, and Beethoven. The ill-success of that publication, and the indifference with which the latter volumes of his *History of the 19th Century* were received by his countrymen, together with the feeling of disappointment that the unity of Germany had been brought about in another fashion and by other means than he wished to see employed, combined to embitter in the highest degree the writer and the politician, but it could not sour in him his kindly and humane disposition, nor did it in the least affect his sociable temper, and he cultivated refined society to the last. He died rather suddenly, on the 18th of March, 1871.

The works which will, above all others, insure to Gervinus a lasting fame, are his *Geschichte der Deutschen Dichtung* and his work on *Shakespeare.* The former, a fifth edition of which was edited (1871–74) by the eminent literary historian and philologist, Professor Karl Bartsch of Heidelberg, was the first comprehensive history of German poetry in a connected form, and was executed with a literary skill, a profound erudition, and a lofty enthusiasm for the subject, which imprinted upon it the stamp of a national work of permanent value. The author represented the literary activity of Germany in its successive stages as it grew out of her political life, thus making political history the foil and basis of literary history. His judgment was sincere and independent, and although his criticism often assumed a censorious and pedantic tone against the most prominent poets of Germany, the German people, without allowing themselves to be misguided in their judgment regarding the merits of Goethe, Schiller, Jean Paul, etc., gratefully accepted his work as a national homage to that subject of which they have most reason to be proud. The object of Gervinus in writing his literary history was, besides, a patriotic one. He endeavored to show that Germany, having already attained great eminence in literature, should henceforth exclusively devote herself to political activity, and surpass other nations also in this respect. He had a no less patriotic object in view in writing his commentary on *Shakespeare,* which has been made popular in England by an excellent translation. This work is not so much a philological or æsthetical commentary as a treatise pointing out the ethical or moral precepts which may be deduced from his productions, and this circumstance makes it of considerable value and interest also to English readers. Gervinus, who considered Shakespeare the intellectual property of Germany, in the same way as he considered Handel the artistic property of England, wished above all to inculcate on his countrymen the teachings of healthy practical activity to be found in the works of the English dramatist. The object for which he wrote, viz., the moral improvement of his readers from a practical point of view, seemed to him the easier to be accomplished through the productions of Shakespeare, because the poet was descended from a kindred race, and the fructifying seeds of his thoughts and sentiments, falling upon a congenial soil, would be sure to take root there kindly. As a political historian, Gervinus was the antipode of Ranke. Following the principles of F. C. Schlosser, he slighted all documentary history. He had such a deep distrust of all state papers and diplomatic documents that he considered them as most untrustworthy sources for any historical record. He confined himself, therefore, chiefly to taking into account the political events and their results just as they lay on the surface; and, not consulting the state archives for the secret springs which set them in motion, he based his historical narratives almost entirely on his subjective judgment. Many brilliant passages will be found in his general *History of the 19th Century*, such as the accounts of the South American and Greek revolutions, and of the July revolution in 1830; and his *Historische Schriften* also contain a number of valuable treatises and essays, which may be said to have paved the way to a new era in the art of writing history. Gervinus entertained a kindly feeling towards England, which he called the land of political mastery; and though he was, what is both the bane and the glory of so many Germans, rather a cosmopolitan, he nevertheless remained a German patriot to the core. He was, besides, distinguished by a rare nobleness and manliness of character, and considering that he was a powerful factor in the literary and political progress of modern times, we may fully agree with Ranke's opinion "that he will never be forgotten." (C. A. B.)

GESENIUS, Friedrich Heinrich Wilhelm (1786–1842), Orientalist and biblical critic, was born at Nordhausen, Hanover, on the 3d of February, 1786. From the gymnasium of his native town he passed in 1803 as a student of philosophy and theology to the university of Helmstadt, where Henke was his most influential teacher; but the latter part of his undergraduate course was taken at Göttingen, where Eichhorn and T. C. Tychsen were then at the height of their popularity. In 1806, shortly after graduation, he became "repetent" and "privat-docent" in that university; and, as he was fond of afterwards relating, had Neander for his first pupil in Hebrew. In 1809, on the recommendation of Johann von Müller, he was appointed to a mastership in the gymnasium of Heiligenstadt, Westphalia, whence, in the following year, he was transferred to the university of Halle, where, from being professor extraordinarius in theology, he was in a very short time promoted to an ordinary chair (1811). Many offers were subsequently made to him of high preferment elsewhere, but he clung to Halle for the remainder of his life, and taught with great regularity for upwards of thirty years, the only interruptions indeed being that of 1813–14, occasioned by the war of liberation, during which the university was closed, and those occasioned by two prolonged literary tours, first in 1820 to France and England in the society of his colleague Thilo for the examination of rare Oriental manuscripts, and afterwards in 1835 to England and Holland in connection with his Phœnician studies. At a very early period he became the most popular teacher of Hebrew and of Old Tesament introduction and exegesis in Germany; and during his later years the annual number of students attending his lectures on these and kindred subjects, such as church history and Biblical archæology, amounted to nearly 500. Of his pupils many have risen to great eminence in the departments he specially cultivated; among these the names of Von Bohlen, Hoffmann, Hupfeld, Rödiger, Tuch, Vatke, and Benfey may be mentioned. In 1827 Gesenius was made a consistorialrath; but, unless account be taken of the violent attacks to which he, along with his friend and colleague Wegscheider, was in 1830 subjected by Hengstenberg and his party in the *Evangelische Kirchenzeitung*, there are few noteworthy occurrences to be recorded in his biography. His death took place at Halle, October 23, 1842. It would be difficult to overestimate the services rendered by Gesenius to Semitic philology. To him belongs in a large measure the credit of having freed it from the trammels of theological and religious prepossession by which it had previously been hampered, and of inaugurating the strictly scientific method which has since been so fruitful in valuable results. Nor can it be doubted that as an exegete he has exercised a powerful, and on the whole a beneficial, influence on the tendencies of modern theological investigation.

Of his very numerous works the earliest, published in 1810, entitled *Versuch über die Maltesische Sprache*, was a successful refutation of the widely current opinion that the modern Maltese was of Punic origin. In the same year appeared the first volume of the *Hebräisches u. Chaldäisches Handwörterbuch*, completed in 1812 (8th ed., 1878; English translation by Tregelles, 1846–52). The *Hebräische Grammatik*, published in 1813 (22d ed., by Kautzsch, 1878), was followed in 1815 by the *Geschichte der Hebräischen Sprache* (now very rare), and in 1817 by the *Ausführliches Lehrgebäude der Hebräischen Sprache.* The first volume of his well-known commentary on Isaiah (*Der Prophet Jesaja*), with a translation, appeared in 1821; but the work was not completed until 1829. The *Thesaurus philologico-criticus Linguæ Hebraicæ et Chaldaicæ V. T.*, begun in 1829, he did not live to complete; the latter part of the third volume is edited by Rödiger (1858). The other works of Gesenius are *De Pentateuchi Samaritani Origine, Indole, et Auctoritate* (1815), supplemented in 1822 and 1824 by the treatise *De Samaritanorum theologia*, and by an edition of *Carmina Samaritana*; *Paläographische Studien über Phönizische u. Punische Schrift* (1835), a pioneering work which he followed up in 1837 by his collection of Phœnician monuments (*Scripturæ linguæque Phœniciæ monumenta quotquot supersunt*); an Aramaic lexicon (1834–39); and a treatise on the Himyaritic language written in conjunction with Rödiger in 1841. Gesenius also contributed extensively to Ersch and Gruber's *Encyclopädie*, and enriched the German translation of Burckhardt's *Travels in Syria and the Holy Land* with valuable geographical notes. For many years he also edited the Halle *Allgemeine Literaturzeitung.* A well executed sketch of his life was published in 1843 (*Gesenius: eine Erinnerung für seine Freunde*).

GESNER, Johann Matthias (1691–1761), a distinguished German classical scholar, was born at Roth, near Ansbach, 9th April, 1691. He studied at the university of Jena, and in 1714 published a work on the *Philopatris* ascribed to Lucian. In 1715 he became librarian and conrector at Weimar, in 1729 rector of the gymnasium at Ansbach, and in 1730 rector of the Thomas school at Leipsic, where he had for colleagues Joh. A. Ernesti and Joh. Sebastian Bach. On the foundation of the university of Göttingen he became professor of rhetoric and subsequently librarian also. He died at Göttingen 3d August, 1761. His special merit as a classicist is the attention he devoted to the explanation and illustration of the subject matter of the classical authors.

His principal works are editions of the *Scriptores de re rustica*, of Quintilian, Claudian, Pliny the younger, Horace, and the Orphic poems; *Primæ lineæ isagoges in eruditionem universam*; an edition of Faber's *Thesaurus eruditionis scholasticæ*, afterwards continued under the title *Novus linguæ et eruditionis Romanæ thesaurus*; *Opuscula varii argumenti*; and *Thesaurus epistolarum Gesneri.* See Ernesti, *Opuscula oratoria*, 1762; and *Göttinger Professoren*, Gotha, 1872.

GESNER, or Gessner, Konrad (1516–1565), a very famous naturalist and author, surnamed the German Pliny and literarum miraculum on account of his vast erudition, was born of poor parents at Zürich, 26th March, 1516. He received the first elements of education from Chaplain Frick, his maternal uncle; and it was while gathering plants in his relative's garden that he became imbued with that enthusiastic love of science which remained with him through life. In 1513 he went to Strasburg, then to Bourges, and in 1534 to Paris, studying at all those places with characteristic passionate zeal. In 1535 we find him again at Zürich, where he married somewhat imprudently, for he was very poor, and had no immediate prospect of bettering his condition. His whole day was occupied in teaching, but at least the night was his own, and too great a portion of the time that others give to rest was occupied by Gesner in adding to his already great stock of erudition. In 1537 he was appointed professor of Greek at Lausanne, and in 1541 professor of physics and natural history at Zürich. But in neither of these offices was he well paid, and during those years he wrote a large number of books, partly to support himself, partly from the interest he felt in their subjects. He wrote several works on ancient medicine and on botany, and a treatise on milk (in which he described the rural economy of Switzerland), translated into Latin a Greek logical manual and some works on the moral interpretation of Homer, carefully edited a new edition of *Johannis Stobæi Sententiæ* (Zürich, 1543) and an expurgated edition of Martial (1544), prepared a new edition of the Latin dictionary of Ambrosius Calepinus (Basel, 1544), and wrote besides some lesser dissertations and translations. All this, however, was only mere side work, for in 1545 he issued at Zürich the first part of his justly renowned *Bibliotheca Universalis*, a catalogue of all the works in Latin, Greek, and Hebrew, extant and not extant, published or as yet unpublished. Under each important name there was given a vast mass of bibliographical information and criticism, original and selected. Three years later the second part of this stupendous work appeared, likewise at Zürich, under the title of *Pandectarum sive partitionum universalium Conradi Gesneri Tigurini Libri XXI.* Only nineteen of these books then appeared; the twenty-first, which was a theological encyclopædia, was published in 1549, but the twentieth, which was to contain the medical writings, and which he intended should represent the quintessence of the labors of a lifetime, was never finished and never published.

The next few years were spent in writing small treatises, and in the preparation of another *magnum opus*, a zoological work entitled *Historia Animalium*, which was published in six books (the last of these unfinished) at Zürich between 1551 and 1587. To prepare himself for the worthy execution of this undertaking he read 250 authors, travelled over nearly all Europe, received hints from hosts of learned friends, and did not disdain the information which he obtained from hunters and shepherds. He also made himself a proficient artist, in order that he might by drawings assist his labors. This work contained the names of all known animals in the ancient and modern languages, a description of each as to every important particular, and a mass of interesting literary information, embracing facts and legends regarding them. After this he again occupied himself with lesser writings for some years. He devoted some attention to philology, aided in the preparation of a German-Latin dictionary, and pointed out the force and undreamt-of beauty that lay in that then vulgar and half-developed tongue. But again these and other publications were only secondary labors, for he had a third great work in preparation. He had for some time given great attention to botany, and he now proposed to publish a work on that science corresponding to his great work on zoology. He had made a large collection of materials towards this when his health, never very good, completely gave way. A few hours before his death he desired to be carried into his museum, and there he spent the last moments of life. He died 13th December, 1565, not having completed his fiftieth year.

Gesner's intense devotion to science, and his almost incredible powers of acquisition, are seen from the recital of the facts of his biography, and from a mere catalogue of his labors. It deserves to be added that his life was singularly pure and blameless, that his love of knowledge was as disinterested as it was engrossing, that he was always ready and glad to acknowledge any help he received. When obliged to engage in controversy, he did so in a dignified and courteous manner. His medical writings show him to have been far above the silly prejudices of his day. A cheerful and amiable piety was a prominent feature in his character—a character chastened, not soured, by the trials of a hard lifetime.

After Gesner's death his unpublished writings went through a career of vicissitudes not unlike that of their author. A part of them, edited by Professor Schmiedel, was published at Nuremberg in 1753. Other parts followed, but the work was never completed. Lives of Gesner have been written by J. Simmler (Zürich, 1566) and J. Hanhart (Winterthur, 1824). See also Lebert's *Gesner als Arzt* (Zürich, 1854), and Gesner's autobiography in his *Bibliotheca Universalis* (1st ed., p. 180).

GESSNER, Salomon (1730–1788), Swiss painter and poet, and once a very favorite and widely-read author, was born at Zürich 1st April, 1730. With the exception of some time spent in Berlin, and a visit to Hamburg undertaken in order to see Hagedorn, he passed the whole of his life in his native town, where he carried on the business of a bookseller. He died 2d March, 1788. The first of his writings that attracted attention was his *Lied eines Schweizers an sein bewaffnetes Mädchen* (1751). Then followed *Daphnis* (1754), *Idyllen* (1756), *Inkel and Yariko* (1756), a version of a story already worked out by Gellert and Bodmer, and *Der Tod Abels* (1758), "a sort of idyllic prose pastoral." It is somewhat difficult for us now to understand the reason of Gessner's universal popularity, unless it was the taste of the period for the conventional pastoral. His writings are marked, it is true, by sweetness and melody, but the sweetness soon becomes insipidity, and the melody monotony. He represents in most of his works the existence of shepherds in a golden or rather tinsel age, and nothing more unreal could possibly be imagined. His men and women are inane and lifeless representations. They are all alike, and all equally uninteresting. They never give utterance to any powerful, genuine, human sentiments. Their talk is but meaningless platitude. As a painter Gessner represented "still country scenes, rocks, springs and waterfalls, shepherds and shepherdesses"—in short, the conventional classical landscape. His son, Konrad Gessner (1764–1826), was also a painter of some reputation.

Collected editions of Gessner's works were repeatedly published (2 vols. 1777–78, finally 2 vols. 1841, both at Zürich). They were translated into French (3 vols., Paris, 1786–93), and versions of the *Idyllen* appeared in English, Dutch, Portuguese, Spanish, Swedish, and Bohemian. Gessner's life was written by Hottinger (Zürich, 1796); see also his *Briefwechsel mit seinem Sohn* (Bern and Zürich, 1801).

GESTA ROMANORUM, a Latin collection of anecdotes and tales, probably compiled about the end of the 13th century or the beginning of the 14th, which still possesses a twofold literary interest, first as one of the most popular books of its time, and secondly as the source, directly or indirectly, of much which has since become current under the stamp of genius. Of its authorship nothing certain is known; and there is little but gratuitous conjecture to associate it either with the name of Helinandus or with that of Petrus Berchorius (Pierre Bercheure). It is even a matter of debate whether it took its rise in England, Germany, or France; while Mr. Douce was disposed to give the credit of it to the Germans, Herr Œsterley is inclined to recognize the priority of the English. The work at least was evidently intended as a manual for preachers, and was probably written by one who himself belonged to the clerical profession. The name, *Deeds of the Romans*, is only partially appropriate to the collection in its present form, since, besides the titles from Greek and Latin history and legend, it comprises fragments of very various origin, Oriental and European. The unifying element of the book is its moral purpose; everything is made serviceable for reproof and doctrine, the powerful chemistry of the allegorical method extracting the sunshine of Christian truth from the cucumbers of the most worldly and wicked circumstance. The style is barbarous, and the narrative ability of the compiler seems to vary with his source; but he has managed to bring together a considerable variety of excellent material. He gives us, for example, the germ of the romance of "Guy of Warwick," the story of "Darius and his Three Sons," versified by Occleve, part of Chaucer's "Man of Lawes' Tale," a tale of the emperor Theodosius, the same in its main features as that of *Lear*, the story of the "Three Black Crows," the "Hermit and the Angel," so well known from Parnell's version, and a story identical with the *Fridolin* of Schiller. Owing to the loose structure of the book, it was easy for a transcriber to insert any additional story into his own copy, and consequently the MSS. of the *Gesta Romanorum* exhibit considerable variety. Œsterley, who has bestowed the fullest investigation on the subject, recognizes an English group of MSS. (written always in Latin), a German group (sometimes in Latin and sometimes in German), and a group which is represented by the vulgate or common printed text. The earliest editions are supposed to be those of Ketelaer and De Lecompt at Utrecht, of Arnold Ter Hoenen at Cologne, and of Ulrich Zell at Cologne; but the exact date is in all three cases uncertain.

An English translation, probably based directly on the MS. Harl. 5369, was published by Wynkyn de Worde about 1510–1515, the only copy of which now known to exist is preserved in the library of St. John's College, Cambridge. In 1577 Richard Robinson published a revised edition of Wynkyn de Worde, and the book proved highly popular. Between 1648 and 1703 at least eight impressions were issued. In 1703 appeared the first vol. of a translation by B. P., probably Bartholomew Pratt, "from the Latin edition of 1514." A translation by the Rev. C. Swan, first published in 2 vols. in 1824, forms part of Bohn's Antiquarian Library, and was re-edited by Wynnard Hooper in 1877. The German translation was first printed at Augsburg, 1489. A French version, under the title of *Le Violier des histoires romaines moralisëz*, appeared in the early part of the 16th century, and went through a number of editions; it has been reprinted by G. Brunet (Paris, 1858). Critical editions of the Latin text have been produced by A. Keller (Stuttgart, 1842), and Œsterley (Berlin, 1872). See also Warton, "On the Gesta Romanorum," dissertation iii., prefixed to the *History of English Poetry;* Douce, *Illustrations of Shake-*

speare, vol. ii.; Frederick Madden, Introduction to the Roxburghe Club edition of *The Old English Versions of the Gesta Romanorum*, 1838.

GETA, Publius Septimus Antoninus (189–212), younger son of the Roman emperor Severus, was born at Milan, 189 A.D. Between him and his brother Caracalla there existed from their early years a keen rivalry and antipathy. On the death of their father in 211 they were, in accordance with his instructions, proclaimed joint emperors; and after the failure of a proposed treaty by which Caracalla was to retain Europe and western Africa, and Geta Asia and Egypt, Caracalla, on the pretence of a desire for reconciliation, arranged a meeting with his brother in his mother's apartments, and by means of assassins murdered him in her presence (212). His name was obliterated from all public inscriptions; all coins bearing his effigy were to be destroyed; and the use of his name, either in conversation or in writing, was forbidden under pain of death.

GETHSEMANE. See Jerusalem.

GEULINCX, Arnold (1625–1669), one of the most distinguished of the earlier Cartesians, was born at Antwerp in 1625. Few details are known with regard to his life, and his more important works are extremely rare. He studied philosophy and medicine at the university of Louvain, and took there the degree of doctor. For twelve years he continued at the same university as lecturer, and was noted as one of the most successful teachers. For what reason he left is quite uncertain, but he seems to have been obliged to fly from Louvain and to take refuge in Leyden, where he appears to have been in the utmost distress. Only the generous assistance of a friend, by name Heidanus, prevented his death from absolute want of means. At Leyden he entered the Protestant Church, having been previously a Catholic, and it has been supposed that his flight from Louvain was due to doubts excited there as to his orthodoxy. This, however, is merely conjecture. In 1663, through his friend Heidanus, he obtained leave to lecture at Leyden, and devoted himself with the utmost zeal to his new duties. He died in 1669. His most important works were published posthumously. During his lifetime there seem to have been made public only the theses which he defended on graduating at Louvain (*Saturnalia, seu quæstiones quodlibiticæ in utramque partem disputatæ*, 2d ed. 1665). The *Metaphysica vera*, 1691, and the *Γνῶθισεαυτόν, sive Ethica, post tristia auctoris fata*, 1696 (first part, 1665), are the works by which he is known in the history of philosophy. In addition to these were published *Physica vera*, *Logica restituta*, and *Annotata in Principia Philosophiæ R. Cartesii.* Geulincx takes up principally the doctrine, left in an obscure and unsatisfactory state by Descartes, of the relation between soul and body. Extension and thought, the essences of spiritual and corporeal natures, are absolutely distinct, and cannot act upon one another. External facts are not the causes of mental states, nor are mental states the causes of physical facts. So far as the physical universe is concerned, we are merely spectators. The influence we seem by will to exercise over bodies is only apparent; volition and action only accompany one another. I cannot be the author of any state of which I am unconscious, for my very nature is consciousness; but I am not conscious of the mechanism by which bodily motion is produced, hence I am not the author of bodily motion. Body and mind are like two clocks which act together, because at each instant they are adjusted by God. A physical occurrence is but the occasion on which God excites in me a corresponding mental state. Geulincx is thus definitely the originator of the theory called Occasionalism. But the principles on which that theory was founded compelled a further advance. God, who is the cause of the concomitance of bodily and mental facts, is in truth the sole cause in the universe. No fact contains in itself the ground of any other; the existence of the facts is due to God, their sequence and co-existence are also due to him. He is the ground of all that is. My desires or volitions and my thoughts are thus the desires, volitions, or thoughts of God. Apart from God, the finite being has no reality. Geulincx is thus the precursor of Spinoza, and, like Spinoza, he gave out his final results under the title of Ethics. Descartes had left untouched, or nearly so, the difficult problem of the relation between the universal element or thought and the particular desires or inclinations. All these are regarded by Geulincx as modes of the divine thought and action, and accordingly the end of human endeavor is the end of divine will, or the realization of reason. The love of right reason is the supreme virtue, whence flow the cardinal virtues diligence, obedience, justice, and humility. Liberty is obedience to reason; *nemo servit qui rationi servit.*

Geulincx has not directly touched the problem which evidently must have caused the greatest difficulty to the Cartesians—how we perceive extended reality—though he plainly indicates the opinion that we do not perceive it, but have the idea of it from God. He thus carried out to their extreme consequences the irreconcilable elements in the Cartesian metaphysics, and his works have the peculiar value attaching to the vigorous development of a one-sided principle. The abrupt contradictions to which such development leads of necessity compels revision of the principle itself.

See Damiron, *Phil. en France au 17me siècle*, 1846; Bouillier, *His. de la Phil. Cartesienne*, i. ch. 14: Erdmann, *Versuch einer Gesch. d. neu. Phil.*, i., *b.*, sec. 2; Ritter, *Gesch. d. Phil.*, xi. pp. 97–169 (Ritter's account of Geulincx is the fullest in any history of philosophy); K. Fischer, *Gesch. d. neu. Phil.*, i. 2, 11–27.

GEX, a town of France, the chief town of an arrondissement in the department of Ain, is beautifully situated, 2000 feet above sea level, at the base of the Jura chain on the Journant, 3 miles from the Swiss frontier, and 10 miles N. W. of Geneva. It has tanneries, saw-mills, and corn-mills, and a considerable trade in cheese and wine. The town gives its name to the old *Pays de Gex*, situated between the Alps and the Jura, which was successively under the protection of the Swiss, the Genevese, and the counts of Savoy, until in 1602 it came into the possession of France, retaining, however, until the Revolution, its old independent jurisdiction, with Gex as its chief town. The population of the town in 1876 was 1469.

GEYSERS, Geisers, or Geisirs, are fountains of a peculiar construction, in virtue of which they shoot up into the air, at more or less regular intervals of time, a column of heated water and steam or of mud. Those of Iceland have been known at least from the time of Saxo Grammaticus, who briefly mentions them in his *Danorum regum historiæ;* but no satisfactory explanation of the phenomena was advanced till near the middle of the present century, when Bunsen brought his scientific knowledge and power of investigation to bear on the subject. Sir George Mackenzie, in his *Travels in Iceland*, 1811, had written as follows:—"Let us suppose a cavity C (fig. 1), communicating with the pipe PQ, filled with boiling water to the height AB, and that the steam above this line is confined so that it sustains the water to the height P. If we suppose a sudden addition of heat to be applied under the cavity C, a quantity of steam will be produced which, owing to the great pressure, will be evolved in starts causing the noises like discharges of artillery, and the shaking of the ground." He admitted that even to his own mind this could be only a partial explanation of the facts of the case, and that he was unable to account for the frequent and periodical production of the necessary heat; but he has the credit of hitting on what is certainly the proximate cause—the sudden evolution of steam. By Bunsen's theory the whole difficulty is solved, as is beautifully demonstrated by the artificial geyser designed by Professor J. H. J. Müller of Freiburg (fig. 2). If the tube *ab* be filled with water and heated at two points, first at *a* and then at *b*, the following succession of changes is produced. The water at *a* beginning to boil, the superincumbent column is consequently raised, and the stratum of water which was on the point of boiling at *b* being raised to *d* is there subjected to a diminished pressure; a sudden evolution of steam accordingly takes place at *d*, and the superincumbent water is violently ejected. Received in the basin *c*, the air-cooled water sinks back into the tube, and the temperature of the whole column is consequently lowered; but the under strata of water are naturally those which are least affected by the cooling process; the boiling

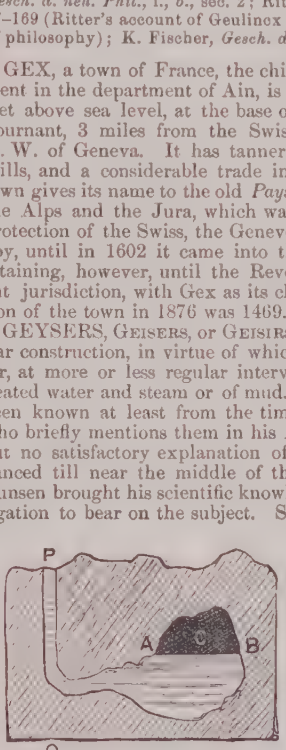

Fig. 1.

begins again at A, and the same succession of events is the result (see R. Bunsen, "Physikalische Beobachtungen über die hauptsächlichsten Gisire Islands," in *Poggendorf's Annalen der Physik und Chemie*, vol. lxxii., 1847; and J. Müller, "Ueber Bunsen's Geysertheorie," *ibid*, vol. lxxix., 1850). The principal difference between the artificial and the natural geyser-tube is that in the latter the effect is not necessarily produced by two distinct sources of heat like the two fires of the experimental apparatus, but by the continual influx of heat from the bottom of the shaft, and the differences between the boiling points of the different parts of the column owing to the different pressures of the superincumbent mass. This may be thus illustrated:—AB is the column of water; on the right side the figures represent approximately the boiling points (Fahr.) calculated according to the ordinary laws, and the figures on the left the actual temperature of the same places. Both gradually increase as we descend, but the relation between the two is very different at different heights. At the top the water is still 39° from its boiling point, and even at the bottom it is 19°; but at D the deficiency is only 4°. If, then, the stratum at D be suddenly lifted as high as C, it will be 2° above the boiling point there, and will consequently expend those 2° in the formation of steam.

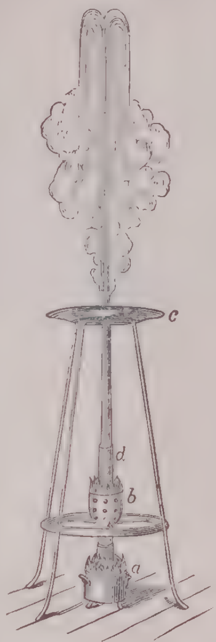

FIG. 2.

Observed.	A	Calculated.
186°		225°
230°		241°
	C	249°
251°		255°
	D	
255°		266°
259°		278°
	B	

Any hot spring capable of depositing siliceous material by the evaporation of its water may in course of time transform itself into a geyser, a tube being gradually built up as the level of the basin is raised. And every geyser continuing to deposit siliceous material is preparing its own destruction; for as soon as the tube becomes deep enough to contain a column of water sufficiently heavy to prevent the lower strata attaining their boiling points, the whole mechanism is deranged. In geyser districts it is easy to find thermal springs busy with the construction of the tube; warm pools, or *laugs*, as the Icelanders call them, on the top of siliceous mounds, with the mouth of the shaft still open in the middle; and dry basins from which the water has receded with their shafts now choked with rubbish.

Geysers exist at the present time in many volcanic regions, as in the Eastern Archipelago, Japan and South America; but the three localities where they attain their highest development are Iceland, New Zealand, and Wyoming in the United States. The very name by which we call them indicates the historical priority of the Iceland group. It is an old Icelandic word—*geysir*, equivalent to gusher or rager—from the verb *geysa*, itself a derivative of *gjosa*, to gush. In native usage it is the proper name of the Great Geyser, and not an appellative—the general term *hver*, a hot spring, making the nearest approach to the European sense of the word (see Cleasby and Vigfusson, *Icelandic English Dictionary*, s. v.).

The Iceland geysers are situated about 50 miles N.W. of Hecla, in a broad valley of alluvial formation, at the foot of a range of hills from 300 to 400 feet in height. Within a circuit of about two miles, upwards of one hundred hot springs may be counted, varying greatly both in character and dimensions. The Great Geyser in its calm periods appears as a circular pool 72 feet in diameter and 4 feet in depth, occupying a basin on the summit of a mound of siliceous concretion; and in the centre of the basin is a shaft, about 9 feet in diameter and 70 feet in depth, lined with the same siliceous material. The clear sea-green water flows over the eastern rim of the basin in little runnels. On the surface it has a temperature of from 76° to 89° Cent., or from 168° to 188° Fahr. Within the shaft there is of course a continual shifting both of the average temperature of the column and of the relative temperatures of the several strata. The results of the observations of Bunsen and Descloizeaux in 1874 were as follows (*cf. Poggendorff's Annalen*, loc. cit., and *Comptes Rendus*, vol. xxiii.):—About three hours after a great eruption on July 6th, the temperature 6 metres from the bottom of the shaft was 121·6° C.; at 9·50 metres, 121·1°; at 16·30 metres, 109° (?); and at 19·70 metres, 95° (?). About nine hours after a great eruption on July 6th, at about 0·3 metres from the bottom, it was 123°; at 4·8 metres it was 122·7°; at 9·6 metres, 113°; at 14·4 metres, 85·8°; at 19·2 metres, 82·6°. On the 7th, there having been no eruption since the previous forenoon, the temperature at the bottom was 127·5°; at 5 metres from the bottom, 123; at 9 metres, 120·4°; at 14·75 metres, 106·4°; and at 19 metres, 55°. About three hours after a small eruption, which took place at forty minutes past three o'clock in the afternoon of the 7th, the temperature at the bottom was 126·5°; at 6·85 metres up it was 121·8°; at 14·75 metres, 110°; and at 19 metres, 55°. Thus, continues Bunsen, it is evident that the temperature of the column diminishes from the bottom upwards; that, leaving out of view small irregularities, the temperature in all parts of the column is found to be steadily on the increase in proportion to the time that has elapsed since the previous eruption; that even a few minutes before the great eruption the temperature at no point of the water column reached the boiling point corresponding to the atmospheric pressure at that part; and finally, that the temperature about half-way up the shaft made the nearest approach to the appropriate boiling point, and that this approach was closer in proportion as an eruption was at hand. Observations made by Mr. Robert Walker in August, 1874, remarkably confirm those of Professor Bunsen (see *Proceedings of Roy. Soc. of Edinburgh*, vol. viii. p. 514). The Great Geyser has varied very much in the nature and frequency of its eruptions since it began to be observed. In 1809 and 1810, *e. g.*, according to Hooker and Mackenzie, its columns were 100 or 90 feet high, and rose at intervals of 30 hours, while, according to Henderson, in 1815, the intervals were of 6 hours, and the altitude from 80 to 150 feet.

About 100 paces from the Great Geyser is the *Strokkr* or churn, which was first described by Stanlay in 1789. The shaft in this case is about 44 feet deep, and, instead of being cylindrical, is funnel-shaped, having a width of about 8 feet at the mouth, but contracting to about 10 inches near the centre. By casting stones or turf into the shaft so as to stopper the narrow neck, eruptions can be accelerated, and they often exceed in magnitude those of the Great Geyser itself.[1] During quiescence the column of water fills only the lower part of the shaft, its surface usually lying from 9 to 12 feet below the level of the soil. Unlike that of the Great Geyser, it is always in ebullition, and its temperature is subject to comparatively slight differences On the 8th of July, 1847, Bunsen found the temperature at the bottom 112·9° C.; at 3 metres from the bottom, 111·4°; and at 6 metres, 108°; the whole depth of water was on that occasion 10·15 metres. On the 6th, at 2·90 metres from the bottom, it was 114·2°; and at 6·20 metres, 109·3°. On the 10th, at 0·35 metres from the bottom, the reading gave 113·9°; at 4·65 metres, 113·7°; and at 8·85 metres, 99·9°.

The great geyser-district of New Zealand is situated in the south of the province of Auckland, in or near the upper basin of the Waikato river to the N. E. of Lake Taupo. In many respects the scene presented in various parts of the districts is far more striking and beautiful than anything of the same kind to be found in Iceland, but this is due not so much to the grandeur of the geysers proper as to the bewildering profusion of boiling springs, steam-jets, and mud-volcanoes, and to the fantastic effects produced on the rocks by the siliceous deposits and by the action of the boiling water. At Whakarewarewa, near Lake Loto Rua, there is a group of eight geysers, one of which, the Waikate, throws the column to a height of 30 or 35 feet (see Hochstetter, *New Zealand*, 1867). But it is in the Yellowstone Park, in the north-west corner of Wyoming, that the various phenomena of the geysers can be observed on the most portentous scale. The geysers themselves are to be counted by hundreds, and the dimensions and activity of several of them render those of Iceland and New Zealand almost insignificant in comparison. The principal groups are situated along the course of that tributary of the Upper Madison, which bears the name of Fire Hole River. Many of the individual geysers have very distinctive characteristics in the form and color of the mound, in the style of the eruption, and in the shape of the column. The "Giantess," as observed by Langford (1870) and Dunraven (1874), lifts the main column to a height of only 50 or 60 feet, but shoots a thin spire to no less than 250 feet. The "Castle" varies in height from 10 or 15 to 250 feet; and on the occasions of greatest effort the noise is appalling, and shakes the ground like an earthquake. Strong distinct pulsations, says Lord Dunraven, occurred at a maximum rate of seventy per minute, having a general tendency to increase gradually in vigor and rapidity until the greatest development of strength was attained, and then sinking again by degrees. The jets grew stronger and stronger at every pulsation for ten or twelve strokes, until the effort would culminate in three impulses of unusual power. The total display lasted about an hour. "Old Faithful" owes its name to the regularity of its action. Its eruptions, which raise the water to a height of 100 or 150 feet, last for about five minutes, and recur every three-quarters of an hour. The "Beehive" sometimes attains a height of 219 feet; and the water, instead of falling back into the basin, is dissipated in spray and vapor. Very various accounts are given of the "Giant." Hayden saw it playing for an hour and twenty minutes, and reaching a height of 140 feet, and Lieutenant Doane says it continued in action for three hours and a half, and had a maximum of 200 feet; but at the earl of Dunraven's visit the eruption lasted only a few minutes. For further details see Dunraven's *Great Divide* (1874), and the *Reports* of Professor Hayden.

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[1] According to Professor Tyndall (see *Royal Institution Notices*, 1853, and *Heat as a Mode of Motion*, 1863), this effect of the stopper is simply due to the fact that it is an impediment to the normally gradual ascent of the heated aqueous strata, and that it is an impediment which at last is suddenly removed.

GEZER (גֶּזֶר), a royal Canaanite city on the boundary of Ephraim in the maritime plain (Josh. xvi. 3–10). It was allotted to the Levites, but its original inhabitants were not driven out until the time of Solomon, when the Egyptians took the city, which was given to Solomon's wife (1 Kings ix. 16). Under the form Gazera it is mentioned as being in the neighborhood of Emmaus-Nicopolis ('Amwâs) and Jamnia (Yebnah) (1 Macc. iv. 15). Throughout the history of the Maccabean wars Gazera plays the part of an important frontier post. It was first taken from the Greeks by Simon the Asmonean (1 Macc. xiv. 7). Josephus also mentions that the city was "naturally strong" (*Antiq.*, viii. 6, 1). The position of Gezer is defined by Jerome (*Onomasticon*, s. v.) as 4 Roman miles north (contra septentrionem) of Nicopolis ('Amwâs) This points to the ruined site called *Tell Jezer*, near the village of Abu Shûsheh, about 4 miles northwest of 'Amwâs. The site is naturally very strong, the town standing on an isolated hill, commanding the western road to Jerusalem, just where it begins to enter the mountains of Judah. The name Gezer (from a root signifying "insulated") was no doubt derived from the position of the place. The ruins include rock-cut tombs, wine-presses, caves, and quarries, with foundations of a citadel on the hill top. A very fine spring ('Ain Yerdeh) exists on the east, and in 1874 a curious discovery was made on the hill side near the spring. The words Tahum Gezer, "boundary of Gezer," were found cut in Hebrew letters on the live rock in two places, and in each case the Greek name Alkios occurred with them. The genuineness of this curious inscription has not been disputed.

GFRÖRER, August Friedrich (1803–1861), historian, was born at Calw, Würtemberg, on the 5th of March, 1803, and at the close of his preliminary studies at the seminary of Blaubeuren, entered the university of Tübingen in 1821 as a student of evangelical theology. After passing his final examinations in 1825, he spent a year in Switzerland, during part of which time he acted as companion and secretary to Bonstetten; the year 1827 was spent chiefly in Rome. Returning to Würtemberg in 1828, he first undertook the duties of repetent or theological tutor in Tübingen, and afterwards accepted a curacy in Stuttgart; but having in 1830 received an appointment in the royal public library at Stuttgart, he thenceforth gave himself exclusively to literature and historical science. His first work on Philo (*Philo u. die jüdisch-alexandrinische Theosophie*, 1831) was rapidly followed by an elaborate biography, in two volumes, of Gustavus Adolphus (*Gustav Adolf, König von Schweden*, 1835–1837), and by a critical history of primitive Christianity (*Kritische Geschichte des Urchristenthums*, 1838), in three volumes, consisting of three parts, entitled respectively "The Century of Salvation," (*Jahrhundert des Heils*), "Sacred Legend," (*Die heilige Sage*), and "Truth" (*Die Wahrheit*). In both of the last-named works Gfrörer had manifested opinions unfavorable to Protestantism, which, however, were not openly avowed until fully developed in his church history (*Allgemeine Kirchengeschichte bis Beginn des 14ten Jahrhunderts*, 1841–1846). In the autumn of 1846 he was appointed to the chair of history in the university of Freiburg, where he continued to teach until his death, which took place at Carlsbad on the 10th of July, 1861. In 1848 he sat as a representative in the Frankfort parliament, where he supported the "High German" party, and in 1853 he publicly went over to the Church of Rome, influenced, however, in this, it is said, more by regard for what he conceived to be its political value, than by any purely religious consideration. Among his later works the most important is the *Geschichte der ost- u. westfränkischen Karolinger* (1858); but those on the pseudo-Isidorian Decretals (*Untersuchung über Alter, Ursprung, u. Werth der Decretalen des falschen Isidorus*, 1848), on the primitive history of mankind (*Urgeschichte des menschlichen Geschlechts*, 1855), on Hildebrand (*Papst Gregor VII. u. sein Zeitalter*, 1859–61), on the history of the 18th century (*Geschichte des 18ten Jahrhunderts*, 1862–73), on German popular rights (*Zur Geschichte deutscher Volksrechte*, 1866), and on Byzantine history (*Byzantinische Geschichte*, 1872–74), are also works of real value. The fruit of much original research, they convey a great quantity of fresh information, and are unusually rich in suggestion; their chief fault may be said to lie in an excess of ingenuity, which leads their author to imagine combinations which never existed, and to invent the most recondite causes for historical occurrences, the explanation of which is rather to be sought in the region of the obvious.

GHÁTS, or Ghauts (literally "the Landing Stairs" from the sea, or "Passes"), two ranges of mountains extending along the eastern and western shores of the Indian peninsula. The *Eastern Gháts* run in fragmentary spurs and ranges down the Madras coast. They commence in the Orissa district of Balasor, pass southwards through Cuttack and Purí, enter the Madras presidency in Ganjám, and sweep southwards through the districts of Vizagapatam, Godávari, Nellore, Chengalpat, South Arcot, Trichinopoli, and Tinnevelly. They run at a distance of from 50 to 150 miles from the coast, except in Ganjám and Vizagapatam, where in places they almost abut on the Bay of Bengal. Their geological formation is granite, with gneiss and mica slate, with clay slate, hornblende, and primitive limestone overlying. The average elevation is about 1500 feet, but several hills in Ganjám are between 4000 and 5000 feet. The *Western Gháts* start from the north of the Tápti valley, and run south through Khándesh, Násik, Tanna, Satara, Ratnagiri, Kanara, and Malabar, and the states of Cochin and Travancore, meeting the Eastern Gháts at an angle near Cape Comorin. The range of the Western Gháts extends uninterruptedly, with the exception of a gap or valley 20 miles across known as the Palghát gap. The length of the range is 800 miles from the Tápti to the Palghát gap, and south of this about 200 miles to the extreme south of the peninsula. In many parts there is only a narrow low strip of coast between the hills and the shore; at one point they rise in magnificent precipices and headlands out of the ocean. The average elevation is 3000 feet, precipitous on the western side facing the sea, but with a more gradual slope on the east to the plains below. The highest peaks in the northern section are Mahábaleswar, where is the summer capital of the Government of Bombay, 4700 feet; Purandhar, 4472; and Sinhgarh, 4162 feet. South of Mahábaleswar the elevation diminishes to about 1000 feet above sea-level. Further south the elevation again increases, and attains its maximum towards Coorg, where the highest peaks vary from 5500 to 7000 feet, and where the main range joins the interior Nilgiri hills. South of the Palghát gap, the peaks of the Western Gháts rise as high as 7000 feet. The geological formation is trap in the northern and laterite in southern section.

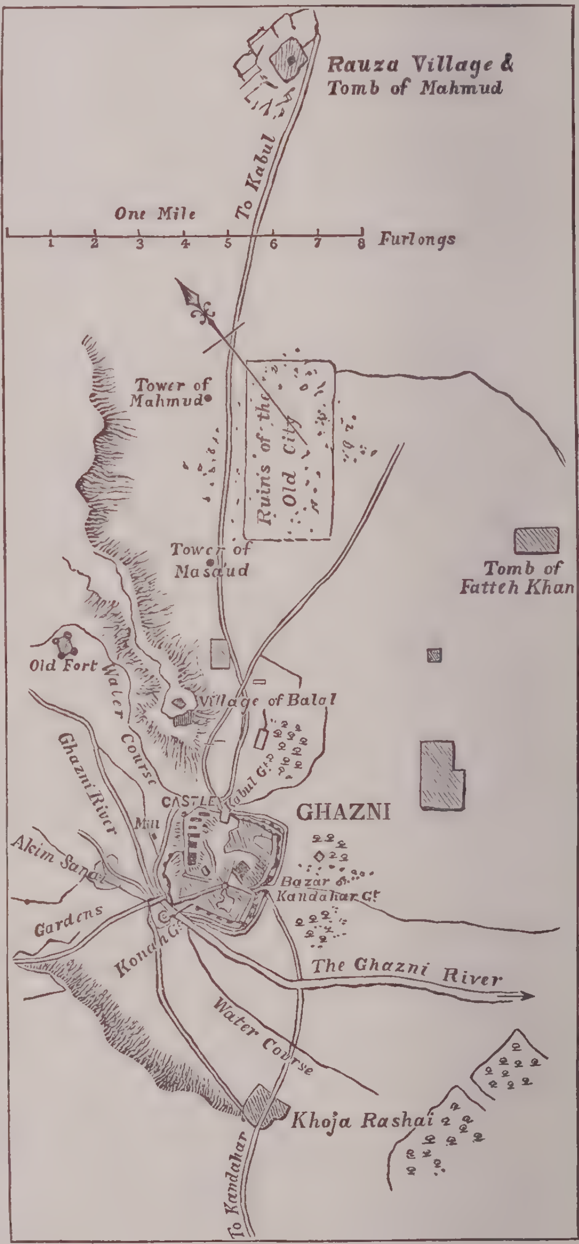
GHÁZIÁBÁD, a town in Meerut district, North-Western Provinces of India, distant 12 miles from Delhi and 28 miles from Meerut, in 28° 39′ 55″ N. lat., 77° 28′ 10″ E. long. The town was founded in 1740 by Ghází-ud-dín, brother of Nawab Salábat Jang, ruler of the Deccan, and takes its name from its founder. It has considerably risen in importance of late years, from having been selected as the point of junction of the East Indian, and the Sind, Punjab, and Delhi railways. A branch into Delhi city diverges from Gháziábád. Population (1872) 7365.

GHÁZIPUR, a district of British India, in the lieutenant-governorship of the North-Western Provinces, and included in the Benares division. It is bounded on the N. by Azimgarh and Sáran, E. by Sáran, S. by Sháhábád, and W. by Benares and Jaunpur. Gházípur forms part of the great alluvial plain of the Ganges, which divides it into two unequal portions. The northern subdivision lies between the Gumti and the Gográ, whose confluences with the main stream mark its eastern and western limits respectively. The southern tract is a much smaller strip of country, enclosed between the Karamnása and the great river itself. No hill or natural eminence is to be found in the district. A few lakes are scattered here and there, formed where the rivers have deserted their ancient channels. The largest is that of Suráha, once a northern bend of the Ganges, but now an almost isolated sheet of water, 5 miles long by about 4 broad.

Gházípur is a closely cultivated district, and out of a total area of 2168 square miles 1546 are actually under cultivation. The harvests are the same as those common to the whole of the plain districts of the North-Western Provinces. The census of 1872 returned a total population in Gházípur district of 1,345,570 souls (males 696,572, females 648,829), dwelling in 3725 villages or townships, and inhabiting 285,007 houses. The Hindus numbered 1,221,810, or 90·7 per cent., and Mahometans, 123,455. Of the three higher Hindu castes there were—Bráhmans, 123,012; Rájputs, 295,355; and Baniyás, 49,538. The lower castes are represented by the Ahírs, 171,216; Chámárs, 122,075; Káyasths, 22,480; and Kurmís, 18,136. Amongst the Mussulmans, the Shaikhs numbered 26,940; Sayyids, 4525; Mughals, 570; and Patháns, 18,452. The district is rich, and in the eastern parts the soil is extremely fertile, so that the cultivators are, on the whole, in easy circumstances. Sixteen towns contain a population exceeding 5000, viz., Gházípur, 38,853; Mahatwar Khás, 8975; Shiupur Diar, 9279; Gahmar, 9050; Sherpur, 7958; Riotipur, 9323; Bára, 5424; Chit, 5821; Narhi, 5527; Bansdih, 7319; Rioti, 7700; Maniar, 5285; Ballia, 8521; Bairia, 5589; Sonbarsa, 7162; and Rasra, 7261. The chief imports into the district are English piece goods and thread, cotton, salt, spices, and grain; the principal exports, country cloth, sugar, fuller's earth, oil seeds, and hides. The headquarters of the Government opium manufacture is at Gházípur town. Carbonate of soda is manufactured from the *reh* or saline efflorescence of the barren *usar* plains, and largely exported. Saltpetre is also largely prepared from the same source. The great trade route is the Ganges, but good roads connect all the principal centres with each other. The East Indian Railway runs for 24 miles through the district, with stations at Zamániah, Dildarnagar, and Gahmar. The total amount of imperial, local, and municipal revenue of the district in 1876 was £200,000. Gházípur is said to be one of the hottest and dampest districts in the North-Western Provinces. In 1869 the annual mean temperature was 80° Fahr., the lowest monthly mean being 61° Fahr., in January, and the highest, 98°, in May. The average total rainfall for eleven years from 1860 to 1871 was 40·1 inches, the maximum being 50·5 inches, in 1861, and the minimum 21·5 inches, in 1868.

GHÁZIPUR TOWN, the capital of the district, stands on the low alluvial northern bank of the Ganges, in 35° 23′ 36″ N. lat. and 83° 35′ 13″ E. long., covering an area of 416 acres, and with a population in 1872 of 38,853. There is considerable trade in sugar, tobacco, long cloth, and rose water. It is the headquarters of the Government opium department, where all the opium from the North-Western Provinces is collected and manufactured under a monopoly. A metalled road runs from Gházípur to Zamániah station on the East Indian Railway, 13½ miles. Lord Cornwallis, the governor-general of India, died at Gházípur in 1805, and a monument and marble statue are erected over his grave.

GHAZNI (called in European books often Ghaznah, Gazna, Ghizni, or Ghuznee, in the Oriental histories more generally Ghaznín), a famous city in Afghanistan, the seat of an extensive empire under two different mediæval dynasties, and again of prominent interest in the modern history of British India. Ghazni stands on the high tableland of central Afghanistan, in 68° 20′ E. long., 33° 34′ N. lat., at a height of 7726 feet above the sea, and on the direct road between Kandahar and Cabul, 233 miles by road N. E. from the first, and 85 miles S. W. from the second. It also stands at the head of the Gomal route from the Indus, one much followed by trade.



Sketch of Ghazni and its Environs.

Ghazni, as it now exists, is a place in decay, and probably does not contain more than 4000 inhabitants. It stands at the base of the terminal spur of a ridge of hills, an offshoot from the Gul-Koh, which forms the watershed between the Arghandáb and Tarnak rivers (see AFGHANISTAN). The castle stands at the northern angle of the town next the hills, and is about 150 feet above the plain. The town walls stand on an elevation, partly artificial, and form an irregular square, close on a mile in circuit (including the castle), the walls being partly of stone or brick laid in mud, and partly of clay built in courses. They are flanked by numerous towers. There is also a loopholed fausse-braye wall, and a ditch which can be filled (partially at least) from the Ghazni river, which flows close to the west of the town. There are three gates. The town consists of dirty and very irregular streets of houses several stories high, but with two straighter streets of more pretension, crossing near the middle of the town. New fortifications had been erected previous to 1857, but their present state is not known. In 1839 they were of no real power to resist artillery of moderate calibre, though imposing in aspect and highly picturesque, judging from the views given by Sir Keith Jackson and others. Of the strategical importance of Ghazni there can hardly be a question. The view to the south is extensive, and the plain in the direction of Kandahar stretches to the horizon. It is bare except in the vicinity of the river, where villages and gardens are tolerably numerous. Abundant crops of wheat and barley are grown, as well as of madder, besides minor products. The climate is notoriously cold,—snow lying two or three feet deep for about three months, and tradition speaks of the city as having been more than once overwhelmed by snow-drift. Fuel is scarce, consisting chiefly of prickly shrubs. In summer the heat is not like that of Kandahar or Cabul, but the radiation from the bare heights renders the nights oppressive, and constant dust-storms occur. It is evident that the present restricted walls cannot have contained the vaunted city of Mahmúd. Probably the existing site formed the citadel only of his city. The remarks of Ibn Batuta (c. 1332) already suggest the present state of things, viz., a small town occupied, a large space of ruin; for a considerable area to the N. E. is covered with ruins, or rather with a vast extent of shapeless mounds, which are pointed out as Old Ghazni. The only remains retaining architectural character are two remarkable towers, rising to the height of about 140 feet, and some 400 yards apart from each other. They are similar, but whether identical, in design, is not clearly recorded. They belong, on a smaller and far less elaborate scale, to the same class as the Kutb Minar at Delhi. Views of one of the minarets will be found in Fergusson's *Indian Architecture*, in Vigne's *Visit to Ghazni, Cabul, etc.*, in Atkinson's *Sketches in Afghanistan*, and other works. Arabic inscriptions in Cufic characters show the most northerly to have been the work of Mahmúd himself, the other that of his son Masa'úd. On the Cabul road, a mile beyond the Minaret of Mahmúd, is a village called Rauzah ("the Garden," a term often applied to garden-mausoleums). Here, in a poor garden, stands the tomb of the famous conqueror himself. It is a prism of white marble standing on a plinth of the same, and bearing a Cufic inscription praying the mercy of God on the most noble Amír, the great king, the Lord of church and state, Abul Kásim Mahmúd, son of Sabuktigín. The tomb stands in a rude chamber, covered with a dome of clay, and hung with old shawls, ostrich eggs, tiger-skins, and so forth. The village stands among luxuriant gardens and orchards, watered by a copious aqueduct. Sultan Baber celebrates the excellence of the grapes of Rauzah.

The famous "Gates of Somnath" (so-styled) were attached to the building covering Mahmúd's tomb until their removal to India, under Lord Ellenborough's orders, on the evacuation of the country in 1842. The governor-general's intention, as announced in a famous prose pæan addressed to the Hindu princes, was to have carried them solemnly through Upper and Central India to Guzerat, and there to have restored them to the (long-desecrated) temple. Calmer reflection prevailed, and the gates were consigned to the arsenal at Agra, where they now remain. These gates (11 feet in height, 9½ in width) are ascertained to be of Himalayan cedar (deodar), and are richly carved in geometric Saracenic patterns, so that there is no likelihood of any real connection with Somnath. But tradition did ascribe to them such a connection. And when Sháh Shúja in 1831 treated with Maháraja Ranjit Singh for aid to recover the throne of Cabul, one of Ranjit's stipulations was the restoration of the gates to Somnath, a circumstance which probably suggested the notion to the eccentric governor-general. A still more remarkable fact (stated in a report by Capt. Claude Wade, dated 21st Nov., 1831) is that the sháh reminded the maharája of a prophecy that foreboded the downfall of the Sikh dominion on the removal of the Ghazni gates. The gates were removed to India in the end of 1842; and the Sikh kingdom practically collapsed with the death of Sher Singh in September, 1843. Another relic of Sultan Mahmúd is the *Band-i-Sultán*, a great dam on the Ghazni river, some 12 miles above the city. Baber describes it as 80 or 100 feet in height, probably along the slope, and about 600 feet long. It had lain ruined in his time since its destruction by Alá-uddin Jahánsoz, but Baber sent money to restore it. Vigne calls it only 25 feet in height. He found it much out of repair. It supplies irrigation to the plain west of Ghazni.

There are many holy shrines about Ghazni surrounded by orchards and vineyards. Baber speaks of them, and tells how he detected and put a stop to the imposture of a pretended miracle at one of them. These sanctuaries make Ghazni a place of Moslem pilgrimage, and it is said that at Constantinople much respect is paid to those who have worshipped at the tomb of the great Ghází. To test the genuineness of the boast, professed pilgrims are called on to describe the chief *notabilia* of the place, and are expected to name all those detailed in certain current Persian verses.

The city is not mentioned by any narrator of Alexander's expedition, nor by any ancient author so as to admit of positive recognition. But it is very possibly the *Gazaca* which Ptolemy places among the *Paropamisadæ*, and this may not be inconsistent with Sir H. Rawlinson's identification of it with *Gazos*, an Indian city spoken of by two obscure Greek poets as an impregnable place of war. The name is probably connected with the Persian and Sanskrit *ganj* and *ganja*, a treasury (whence the Greek and Latin *Gaza*). We seem to have positive evidence of the existence of the city before the Mahometan times (644) in the travels of the Chinese pilgrim, Hwen Thsang, who speaks of *Ho-si-na* (*i. e.*, probably *Ghazna*), as one of the capitals of *Tsaukuta* or Arachosia, a place of great strength. In early Mahometan times the country adjoining Ghazni was called *Zábul*. When the Mahometans first invaded that region Ghazni was a wealthy entrepôt of the Indian trade. Of the extent of this trade some idea is given by Ibn Haukal, who states that at Cabul, then a mart of the same trade, there was sold yearly indigo to the value of two million dínárs (£1,000,000). The enterprise of Islám underwent several ebbs and flows over this region. The provinces on the Helmand and about Ghazni were invaded as early as the caliphate of Moáwia (662–680). The arms of Ya'kúb Leis swept over Cabul and Arachosia (Al-Rukhaj) about 871, and the people of the latter country were forcibly converted. Though the Hindu dynasty of Cabul held a part of the valley of Cabul river till the time of Mahmúd, it is probably to the period just mentioned that we must refer the permanent Mahometan occupation of Ghazni. Indeed, the building of the fort and city is ascribed by a Mahometan historian to 'Amrú Leis, the brother and successor of Ya'kúb (d. 901), though the facts already stated discredit this. In the latter part of the 9th century the family of the Samání, sprung from Samarkand, reigned in splendor at Bokhara. Alptigín, originally a Turkish slave, and high in the service of the dynasty, about the middle of the 10th century, losing the favor of the court, wrested Ghazni from its chief (who is styled Abú Bakr Lawík, wáli of Ghazni), and established himself there. His government was recognized from Bokhara, and held till his death. In 977 another Turk slave, Sabuktigín, who had married the daughter of his master Alptigín, obtained rule in Ghazni. He made himself lord of nearly all the present territory of Afghanistan and of the Punjab. In 997 Mahmúd, son of Sabuktigín, succeeded to the government, and with his name Ghazni and the Ghaznevid dynasty have become perpetually associated. Issuing forth year after year from that capital, Mahmúd carried fully seventeen expeditions of devastation through northern India and Guzerat, as well as others to the north and west. From the borders of Kurdistan to Samarkand, from the Caspian to the Ganges, his authority was acknowledged. The wealth brought back to Ghazni was enormous, and contemporary historians give glowing descriptions of the magnificence of the capital, as well as of the conqueror's munificent support of literature. Mahmúd died in 1030, and some fourteen kings of his house came after him; but though there was some revival of importance under Ibrahim (1059–1099), the empire never reached anything like the same splendor and power. It was overshadowed by the Seljuks of Persia, and by the rising rivalry of GHUR (*q. v.*), the hostility of which it had repeatedly provoked. Bahram Sháh (1118–1152) put to death Kutbuddín, one of the princes of Ghúr, called king of the Jibál or Hill country, who had withdrawn to Ghazni. This prince's brother, Saifuddín Súri, came to take vengeance, and drove out Bahram. But the latter recapturing the place (1149) paraded Saifuddín and his vizier ignominiously about the city, and then hanged them on the bridge. Alá-uddín of Ghúr, younger brother of the two slain princes, then gathered a great host, and came against Bahram, who met him on the Helmand. The Ghúri prince, after repeated victories, stormed Ghazni, and gave it over to fire and sword. The dead kings of the house of Mahmúd, except the conqueror himself and two others, were torn from their graves and burnt, whilst the bodies of the princes of Ghúr were solemnly disinterred and carried to the distant tombs of their ancestors. It seems certain that Ghazni never recovered the splendor that perished then (1152). Alá-uddín, who from this deed became known in history as *Jahánsoz* (*Brûlemonde*), returned to Ghúr, and Bahram reoccupied Ghazni; he died in 1157. In the time of his son Khusru Sháh, Ghazni was taken by the Turkish tribes called Ghuzz (generally believed to have been what are now called Turkomans). The king fled to Lahore, and the dynasty ended with his son. In 1173 the Ghuzz were expelled by Ghiyássuddín Sultan of Ghúr (nephew of Alá-uddín Jahánsoz), who made Ghazni over to his brother Muízuddin. This famous prince, whom the later historians call, it is not clear why, *Shaháb-uddín* Ghúrí, shortly afterwards (1174–5) invaded India, taking Multán and Uchh. This was the first of many successive inroads on western and northern India, in one of which Lahore was wrested from Khusrú Malik, the last of Mahmúd's house, who died a captive in the hills of Ghúr. In 1192 Prithvi Rái or Pithora (as the Moslem writers call him) the Chohán king of Ajmir, being defeated and slain near Thanesar, the whole country from the Himálaya to Ajmir became subject to the Ghúrí king of Ghazni. On the death of his brother Ghiyássuddín, with whose power he had been constantly associated, and of whose conquests he had been the chief instrument, Muízuddin became sole sovereign over Ghúr and Ghazni, and the latter place was then again for a brief period the seat of an empire nearly as extensive as that of Mahmúd the son of Sabuktigín. Muízuddin crossed the Indus once more to put down a rebellion of the Khokars in the Punjab, and on his way back was murdered by a band of them, or, as some say, by one of the *Muláhidah* or Assassins. The slave lieutenants of Muízuddin carried on the conquest of India, and as the rapidly succeeding events broke their dependence on any master, they established at Delhi that monarchy of which, after it had endured through many dynasties, and had culminated with the Moghul house of Baber, the shadow perished in 1857. The death of Muízuddin was followed by struggle and anarchy, ending for a time in the annexation of Ghazni to the empire of Khwarazm by Mahommed Sháh, who conferred it on his famous son, Jaláluddin, and Ghazni became the headquarters of the latter. After Jenghiz Khan had extinguished the power of his family in Turkestan, Jaláluddin defeated the army sent against him by the Mongol at Parwán, north of Cabul. Jenghiz then advanced and drove Jaláluddin across the Indus, after which he sent Okkodai his son to besiege Ghazni. Henceforward Ghazni is much less prominent in Asiatic history. It continued subject to the Mongols, sometimes to the house of Hulákú in Persia, and sometimes to that of Chaghatai in Turkestan. In 1326, after a battle between Amir Husain, the viceroy of the former house in Khorasan, and Tarmashirín, the reigning khan of Chaghatai, the former entered Ghazni and once more subjected it to devastation, and this time the tomb of Mahmúd to desecration. The statement in a recent book on Afghanistan, that a new Ghori dynasty reigned at *Ghazni* from 1336 to 1383, is erroneous.

Ibn Batuta (*c.* 1332) says the greater part of the city was in ruins, and only a small part continued to be a town. Timur seems never to have visited Ghazni, but we find him in 1401 bestowing the government of Cabul, Kandahar, and Ghazni on Pír Mahommed, the son of his son Jahángír. In the end of the century it was still in the hands of a descendant of Timur, Ulugh Beg Mirza, who was king of Cabul and Ghazni. The illustrious nephew of this prince, Baber, got peaceful possession of both cities in 1504, and has left notes on both in his own inimitable Memoirs. His account of Ghazni indicates how far it had now fallen. "It is," he says, "but a poor mean place, and I have always wondered how its princes, who possessed also Hindustan and Khorasan, could have chosen such a wretched country for the seat of their government, in preference to Khorasan." He commends the fruit of its gardens, which still contribute largely to the markets of Cabul. Ghazni remained in the hands of Baber's descendants, reigning at Delhi and Agra, till the invasion of Nadir Shah (1738), and became after Nadir's death a part of the new kingdom of the Afghans under Ahmed Sháh Durráni. We know of but two modern travellers who have recorded visits to the place previous to the war of 1839. George Forster passed as a disguised traveller with a kafila in 1783. "Its slender existence," he says, "is now maintained by some Hindu families, who support a small traffic, and supply the wants of the few Mahometan residents." Mr. Vigne visited it in 1836, having reached it from Multan with a caravan of Loháni merchants, travelling by the Gomal pass. The historical name of Ghazni was brought back from the dead, as it were, by the news of its capture by the British army under Sir John Keane, 23d July, 1839. The siege artillery had been left behind at Kandahar; escalade was judged impracticable; but the project of the commanding engineer, Captain George Thomson, for blowing in the Cabul gate with powder in bags, was adopted, and carried out successfully, at the cost of 182 killed and wounded. Two years and a half later, the Afghan outbreak against the British occupation found Ghazni garrisoned by a Bengal regiment of sepoys, but neither repaired nor provisioned. They held out under great hardships from 16th December, 1841, to 6th March, 1842, when they surrendered. In the autumn of the same year General Nott, advancing from Kandahar upon Cabul, reoccupied Ghazni, destroyed the defences of the castle and part of the town, and carried away the famous gates. Since then Ghazni has not been entered by any Englishman; for when Colonel Lumsden's mission passed this way in 1857 they were not allowed to approach the place.

See Elliot, *Hist. of India*, ed. by Dowson; *Tabakáti-i-Násiri*, translated by Major Raverty in the *Bibliotheca Indica*; E. Thomas, in *J. R. As. Soc.*, vols. ix. and xvii.; Forster's *Journey*; Vigne's *Visit to Ghuzni*, etc.; Masson's *Travels*; Reports of Lumsden's Mission in 1857; *Journal of the As. Soc. of Bengal*, vol. xii.; *Autobiography of Baber*, by Leyden and Erskine; Cunningham's *Hist. of the Sikhs*, etc. (H. Y.)

GHEE (Sanskrit, *Ghrita*), a kind of clarified butter made in the East. The best is prepared from butter of the milk of cows, the less esteemed from that of buffaloes. The butter is melted over a slow fire, and set aside to cool; the thick, opaque, whitish, and more fluid portion, or ghee, representing the greater bulk of the butter, is then removed. The less liquid residue, mixed with groundnut oil, is sold as an inferior kind of ghee. It may be obtained also, according to the *Indian Domestic Economy and Receipt Book*, p. 16, 6th ed., 1865, by boiling butter over a clear fire, skimming it the while, and, when all the water has evaporated, straining through a cloth. Ghee which is rancid or tainted, as is often that of the Indian bazaars, is said to be rendered sweet by boiling with leaves of the *Moringa pterygosperma* or horse-radish tree. In India ghee is one of the commonest articles of diet, and indeed enters into the composition of everything eaten by the Brahmans. It is also extensively used in Indian religious ceremonies, being offered as a sacrifice to idols, which are at times bathed in it. Sanskrit treatises on therapeutics describe ghee as cooling, emollient, and stomachic, as capable of increasing the mental powers, and of improving the voice and personal appearance, and as useful in eye-diseases, tympanitis, painful dyspepsia, wounds, ulcers, and other affections. Old ghee is in special repute among the Hindus as a medicinal agent, and its efficacy as an external application is believed by them to increase with its age. Ghee more than 10 years old, the *purána ghrita* of Sanskrit materia medicas, has a strong odor, and the color of lac. Some specimens which have been much longer preserved—and "clarified butter a hundred years old is often heard of"—have an earthy look, and are quite dry and hard, and nearly inodorous. Medicated ghee (Sanskrit, *ghrita páka*) is made by warming ordinary ghee to remove contained water, melting, after the addition of a little turmeric juice, in a metal pan at a gentle heat, and then boiling with the prepared drugs till all moisture is expelled, and straining through a cloth.

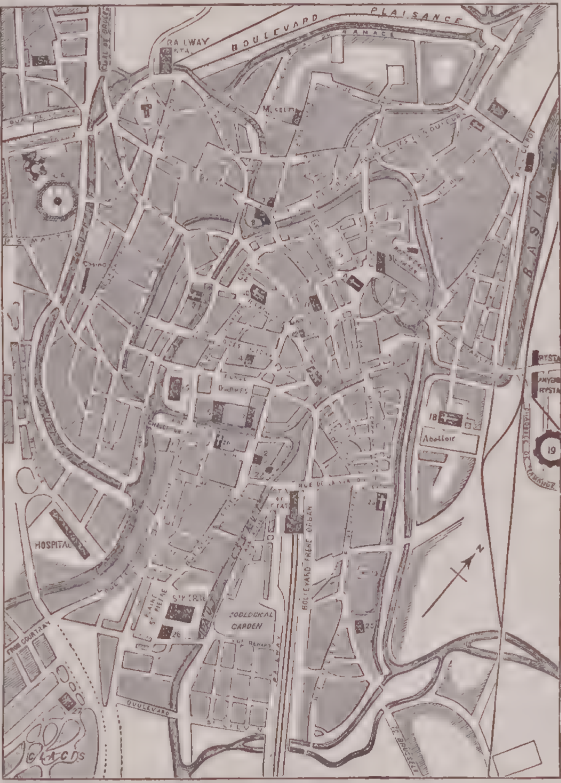
See Udoy Chand Dut, *The Materia Medica of the Hindus, compiled from Sanskrit Medical Works*, Calcutta, 1877, and, on the uses of ghee in culinary operations, the above quoted *Receipt Book*, and *The Indian Cookery Book*, Calcutta (1869?).

GHEEL, or Geel, a town of Belgium, in the province of Antwerp, about 25 miles E. of Antwerp, on the railway between Herenthals and Moll, with a population, according to the census of 1876, of 10,265. Situated in the midst of that half barren stretch of moorland which is known as the Campine or Kampenland, it would have been of little importance, in spite of its manufactures of cloth, leather, wooden shoes, and wax-lights, had it not for long centuries been the seat of a unique method of dealing with the insane. A local legend, tracing the origin of the town back to a chapel of St. Martin erected in the 7th century, goes on to tell how an Irish princess, fearing the fate that long afterwards befell Beatrice Cenci, sought refuge in this remote asylum, but was pursued by her relentless father and put to death, along with a priest Gerrebert, the companion of her flight. The tomb of the victims was soon discovered to have a healing virtue for minds diseased; the sainted Dymphna became the patroness of the insane, and a large and beautiful church in her honor was erected on the site of St. Martin's chapel. Commenced in the 12th century, it was finished in 1340, and consecrated by the bishop of Cambray; and the pilgrimages to the tomb were sanctioned by a brief of Eugenius IV. In 1538 Jean de Mérode, within whose domains the church was situated, instituted a vicariate of nine priests and a director, and in 1562 Henri de Mérode transformed the vicariate into a regular chapter of nine canons and a dean. The church still remains to bear witness to the importance formerly attached to the shrine; and though the tomb of St. Dymphna has long been a cenotaph, a few stray enthusiasts still pass beneath it in hopeful imitation of the thousands in bygone years, whose knees have worn deep furrows in the pavement as they made their ninefold transits on nine successive days. As food and lodging had to be provided for the patients who were brought to the saint, the inhabitants of Gheel grew accustomed to the treatment of the various kinds of mental alienation, and gradually discovered that forcible measures were much less frequently necessary, and danger less likely to result from free intercourse with the insane, than was generally believed throughout Europe. When M. Pontecoulant was appointed by Napoleon prefect of the Revolution department of the Dyle, his attention was called to the success of the domestic régime in force at Gheel, in contrast to the sad condition of affairs in the asylum at Brussels, and he caused the patients to be removed from the capital to the little country town. His example was freely followed by the authorities of different districts, and Gheel received full official recognition. Investigations undertaken about 1850 by M. Ducpétiaux, inspector-general of benevolent establishments in Belgium, resulted in the reform of such abuses as had crept into the system; and the relations of the patient and his protectors were placed on a strict legal footing by the law of 1st May, 1851. Further ameliorations have been introduced in 1852, 1857, 1858, etc. The whole management of the system is under the supervision of officially appointed physicians, and the advantages of a regular establishment are thus combined with those of domestic comfort, social freedom, and activity. Permission to receive patients is granted not only to the town residents, but also to the villagers of the vicinity.

Among the numerous works and papers descriptive of Gheel and its régime, the following may be mentioned:—Gazot, *Hist. ecclésiastique des Pays Bas*, 1614; Biffi, "Memorie originali," in *Gazetta Medica Italiana*, 2d Oct., 1854; Brown, in *Asylum Journal*, 1858; Bucknill, *Ibid.*, 1858, 1859; Bulckens, *Rapport*, etc., Brussels, 1857; papers by Auguste Droste, in *Allg. Zeitsch. für Psychiatrie*, 1853, *Corr. Blätter der Deutschen Ges. für Psychiatrie*, 1856, *Hygea*, 1857, and *Deutsche Klinik*, 1858; Esquirol, *Mal. mentales*, vol. ii.; Jules Duval, *Gheel, ou Une colonie d'aliénés*, Paris, 1860; Ruedy, *Gheel, Beitrag zur Gesch. der prakt. Psychiatrie*, Berlin, 1875.

GHENT, in Low Latin *Ganda* or *Gandavum*, in French *Gand*, in Flemish *Gend*, in German *Gent*, a city of Belgium, at the head of the province of East Flanders, is situated about 30 miles to the west of Antwerp on the Scheldt and the Lys. The two streams branch out to such an extent as to partition the town into 26 islands, which are connected by about 270 bridges, 42 being of stone, and 28 of the others being wooden structures of considerable size. In general Ghent is well built, and, though the older portion has narrow and gloomy lanes, it occupies as a whole a larger area than most European towns in proportion to the population and the number of houses. A striking and pleasing feature is the number of promenades, the most noteworthy being the Coupure or "Cutting," so called from the branch of the Bruges canal constructed in 1758. Gardens, orchards, and corn-fields are enclosed within the ancient boundaries of the walls, which extended nearly 8 miles in circumference. An excellent view of the city and its environs is obtained from the belfry of the grand old watch-tower erected by the men of Ghent between 1183 and 1339, from whose summit the voice of the famous bell Roland called the burghers together for fire or fray. The present spire of cast iron dates from 1854, but it is still surmounted by the golden dragon brought to Ghent from the church of St. Sophia in Constantinople, not long after the conquest of that city by the crusaders. Roland was removed by Charles V., and its place is now supplied by a chime of 44 bells.

Almost all the houses of the wealthier classes of Ghent are constructed after the Italian fashion, with wide portes-cochères, spacious courtyards, and lofty staircases; but along the quays and in the older streets there are still numerous specimens of the quainter and grander architecture of the 16th and 17th centuries. The industrial classes live for the most part in long monotonous rows of poor-looking houses. Among the public squares the most noteworthy are the Friday Market (*Marché du Vendredi*), where in former days the counts of Flanders were inaugurated and the trades unions used to assemble; the *Kauter* (the word in Flemish means field), which became the Place d'Armes in 1812, and is the favorite rendezvous of the fashionable world; the Plaine de St. Pierre, especially used for military reviews; the Corn Market, which is one of the busiest spots in the town; and the Place Sainte Pharailde, which contains the façade of the fish-market and the gate of the Counts' Castle, and is annually the scene of the so-called Fair of the Little Presents (*Presentjesmarkt*). The Plaine des Recollets, which takes its name from the convent of the Reformed Franciscans (1225–1796), was in 1836 chosen as the site of the new court-house. Near the Friday Market is an enormous cannon, 18 feet long, 10 feet in girth, and nearly 3 feet wide at the mouth, formed in the same fashion as "Mons Meg" in Edinburgh Castle, and surnamed *Dulle Griete*, or "Mad Meg or Margaret."



Plan of Ghent.

1. Great Béguinage.
2. Church of St. Sauveur.
3. Library and Royal Athenæum.
4. Church of St. Jacques.
5. Statue of Artevelde.
6. Cannon (Dulle Griete).
7. Counts' Castle.
8. Fish Market.
9. Church of St. Michel.
10. Church of St. Nicholas.
11. Hôtel de Ville.
12. Watch Tower (Belfry).
13. Cathedral of St. Bavon.
14. University.
15. Court-House.
16. Theatre.
17. Baths.
18. Abbey St. Bavon.
19. Béguinage.
20. Church of Ste. Barbe.
21. Theatre.
22. Gas-Works.
23. Church of St. Anne.
24. Little Béguinage.
25, 26, 27. Barracks.

The cathedral of St. Bavon (Flem. *Baefs*) ranks as one of the most splendid of the churches of Belgium. Though the original foundation dates from the 9th or 10th century, the crypt and choir of the actual edifice have no higher antiquity than the 13th century, and the other parts were not completed till the 16th. The roof of the nave has been erected since the destructive fire of 1822. Originally dedicated to St. John, the church received its present name only in 1540, when Charles V. made it the seat of the collegiate chapter of the abbey of St. Bavon; and it was not till 1559 that it was constituted a cathedral at the request of Philip II. of Spain. In its exterior St. Bavon's is rather heavy in style, but it is surmounted by a fine octagonal tower, which, before the destruction of the spire by lightning in 1603, had a height of 360 feet, and still reaches 270 feet. The interior is remarkable for the richness and variety of its decorations. The choir and transepts are lined with black marble, and the balustrades are of white or variegated marble. A statue of St. Bavon in his ducal robes adorns the high altar, and in front are four tall copper candlesticks which belonged to Charles I., and bear the royal arms of England. Beneath the windows of the choir are affixed the arms of the knights of the golden fleece, whose last chapter was held by Philip II. in St. Bavon's in 1559. The chapels are twenty-four in number; their gates are of brass, and almost every available spot has its painting or statue. The eleventh is known as the Chapel of the Lamb, as it contains the central and principal portion of the famous Adoration of the Lamb painted by John Van Eyck in 1432. Hubert Van Eyck, his brother and compeer, and Margaret, his sister, lie buried in the crypt. The church of St. Nicholas —an early Gothic structure, with a great tower of the 15th century and a modern portico—has the credit of being the oldest in the town; and St. Michael's, dating from about 1450, but frequently restored, is memorable as the scene of the worship of reason during the French Revolution. Previous to the Revolution there existed in Ghent a large number of convents and monasteries (thirty-seven establishments of this class, with 1122 inmates, are recorded in 1781); and one of its most famous institutions at the present day is the Béguinage of St. Elizabeth, a community of about 600 or 700 nuns, who inhabit a separate quarter of the town, consisting of little brick-built cottages arranged in streets and squares within a common wall.

Among the secular buildings of Ghent one of the finest is the Hôtel de Ville, its northern façade being an exceptionally rich example of flamboyant Gothic of the 15th century, and its eastern façade presenting a curious contrast, with its rows of Doric, Ionic, and Corinthian columns after the style of the Italian Renaissance. The court-house or palais de justice is a heavy but imposing structure in the Romanesque manner, erected between 1835 and 1843 by the architect Roelandt at the common expense of the state, the province, and the town. The minor apartments of the lower floor have been all more or less sacrificed to the great Hall of the Lost Footsteps, which is 240 feet long and 70 feet wide. About the same time the same architect was entrusted with the designs for the casino, a building adapted for the flower-shows of the Botanical Society and the concerts of the choral union of St. Cecilia. The so-called Government house, which is partly occupied by the provincial administration and partly by the governor as his residence, was assigned by Charles V. to the provost of St. Bavon, became in 1581 the property of William of Orange (the Silent), at a later date served as episcopal palace, and in the time of Napoleon was the prefecture. The present episcopal palace was built in 1845 as an appendage to the cathedral.

With benevolent institutions of various kinds Ghent is abundantly supplied. A lunatic asylum, the Hospital of the Byloque, founded as early as 1225, a maternity hospital dating from 1827, a blind asylum (1854) due to the beneficent bequests of L. Van Caneghem, a deaf and dumb institution (1822), and an *atelier de charité*, or establishment for giving work to the unemployed, which has been in operation since 1817, are worthy of special mention. It would be less of a paradox than might be supposed if the great penitentiary (Rasphuis, or Maison de Force) had been included in the list; for it is remarkable, not only for the sumptuous style of its buildings, but for the philanthropic character of its administration. It was erected between 1772 and 1825 at a cost of 2,150,000 francs, and can accommodate 2600 prisoners.

The spacious university buildings were erected between 1819 and 1826, at the expense of the city, under the auspices of William I., king of Holland. They were designed by Roelandt in the Greek style, and one of the principal features is a portico after the model of the Pantheon at Rome. The university library, containing upwards of 100,000 volumes, and reckoned one of the most valuable in Belgium, was formerly the property of the town. Along with the royal athenæum or high school, it occupies the old abbey of Baudeloo, founded by Baldwin of Constantinople in 1199. The abbey gardens were transformed in 1797 into a botanical garden, which now ranks as one of the finest in Europe. A royal academy for the encouragement of art, founded in 1751 by Charles Marissal, and a musical conservatory originated by the communal council in 1835, are both flourishing institutions; and the technical school with about 800 pupils is one of the very best in Belgium. The Natural History Society, dating from 1851, has established a zoological garden.

Though Ghent has no longer the industrial pre-eminence that it enjoyed in the 14th and 15th centuries, it is still the principal seat of the cotton and leather manufactures of Belgium. Flax-spinning, calico-printing, and sugar-refining are also extensively carried on, and there are engineering works, chemical works, iron-foundries, soap-works, paper-mills, and breweries. No fewer than sixty considerable firms, trading with Germany, France, Italy, and Russia, are engaged in commercial floriculture; and, as a consequence, the flower-shows of Ghent, as they were perhaps the earliest, are still among the finest exhibitions of the kind in Europe. The trade of the town, which deals mainly with the products and raw materials of the industries, is fostered by a good railway system and numerous canals. There is direct communication with the sea by a grand canal, which, however, unfortunately for the Belgians, enters the sea at Terneuse in Dutch territory. The harbor, completed in 1828, is capable of accommodating 400 vessels, and vessels drawing 17 feet of water can unload under the walls of the town. At Sas van Gend, 15 miles north of the city, on the frontier of Holland, there are sluices by which the district can be laid under water.

In 1812 Ghent had no more than 55,161 inhabitants; by 1856 they had increased to 109,668, and by 1869 to 121,469. The census of 1876 gave 127,653. Among the celebrities born in the city are Henry Goethals, distinctively Henry of Ghent, a famous theologian and member of the Sorbonne (d. 1295); Philippe Mouskes, the chronicler; P. Vanderberghe or Montanus, the geographer; Daniel Heinsius; Jacques van Zevecote, one of the principal Flemish poets; Lauren Delvaux, a sculptor; C. L. Dierickx, the local historian; and J. Guislain, the lunacy physician.

The investigations of local antiquaries leave it still doubtful whether Ghent had a Roman origin, as Petrarch supposed (*Gandavum Cæsare conditore superbum*). That there was a military fortress on the spot in the 7th century, is proved by Baudemont's life of St. Amand, the first missionary of Christianity in the district (*Acta Sanctorum*, vol. i.). Of the two monasteries founded by the saint in honor of St. Peter, the one near the Antwerp gate was richly endowed by St. Bavon, and his name became attached, not only to the building, but to the part of the city. About the year 1000 Baldwin Ironarm, first count of Flanders, took possession of Ghent, and a few years after he erected the Gravensteen or Counts' Castle. Trade and manufactures, especially of linen and woollen, were encouraged by Baldwin and his successors, and by the close of the 12th century the men of Ghent were able to purchase commercial and political privileges, and to establish a form of municipal government. They established a court of justice, elected sheriffs, joined the association of the Hanse Towns, and obtained the free navigation of the Rhine from the emperor Frederick I. By the charter of 1192 they obtained the right of fortifying their city, and the first circumvallation carried out between that date and 1214 had a development of 6560 feet. By the end of the 13th century Ghent was a greater city than Paris. In the 14th, under the leadership of the famous Jacob van Artevelde and his son Philip (1332–1382), it raised frequent insurrections against the counts of Flanders, and took a prominent part in the political movements of the Low Countries. In 1385 it was obliged to submit to the duke of Burgundy, but its rights and privileges were left uninjured. At the commencement of the 15th century it had upwards of 40,000 men employed in the woollen manufactures alone, and was able to place in the field from 18,000 to 20,000 men-of-arms. When in 1452 the duke of Burgundy, Philip the Good, imposed a tax on salt and grain, it rose in rebellion, but after a few years' conflict the defeat at Gaveren left it at the duke's mercy. The independence of the burghers was far from being crushed. They showed themselves as turbulent as ever under Mary of Burgundy, who made the city her principal residence; and when she made certain unpopular concessions to Louis XI., they took the law into their hands, and on April 3, 1477, put to death in her presence the two councillors Hugonet and Himber-Court, whom she had intrusted with the mission. After her marriage at Ghent (August 17) with Maximilian of Austria, matters were more peaceful. On Mary's death in 1482 the discontent of the people again broke out. In 1488 they restored their ancient form of government, and held out against the emperor Frederick, who led an army against them in person, but at length in 1492 they came to terms. In 1500 Charles V. was born in the palace at Ghent, the site of which is now occupied by the street called the Cour des Princes. His reign was a critical one for the city, for though it had a population of 175,000, it was but a drop in the bucket of his vast dominions, and he treated it with but little consideration. When in 1536 his sister Maria, at that time in command of the Netherlands, demanded the extraordinary subsidy of 1,200,000 gold florins from Flanders, the citizens refused to contribute, and in 1539 they took arms in self-defence. Charles himself appeared on the scene in 1540, forced them to submission, deprived them of their privileges, executed 26 of the principal leaders of the revolt, confiscated the public buildings, and erected a citadel at a total expense of 411,334 livres, the greater part of which had to be defrayed by Ghent itself. Even this did not crush the spirit of the city. It was by the pacification of Ghent, signed in the town-hall Nov. 8, 1578, that Holland and Zeeland, and the southern states of the Netherlands, formed an alliance against the Spanish supremacy, and three days after the Spanish garrison capitulated to the citizens. In 1584, however, the duke of Parma captured the town for Philip, and the citadel, which had been almost completely demolished, was restored. The attempts of the French in 1641 and 1642 to get possession of Ghent were frustrated by laying the country under water; but in 1678, though in the mean while the fortifications had been considerably extended, the feeble garrison under Don Francisco de Pardo was unable to defend the place against Marshals Humières, Luxembourg, Schomberg, and Vauban. Ghent continued in French hands till the peace of Nimwegen. It played an important part in the war of the Spanish succession, being captured in 1706 by Marlborough, recovered in 1708 by the French Marquis de Grimaldi, and again captured by Marlborough in 1709. In the war of the Austrian succession, Louis XV. made his entry into the city on 25th July, 1745, and remained in possession till the treaty of Aix-la-Chapelle in 1748. By order of Joseph II. in 1781, the citadel and fortifications were dismantled, and the grounds on which they were built were sold. Under the régime of the French Revolution the city was made the chief town of the department of the Scheldt. By the peace of Paris (1814) it passed with Belgium to Holland; but it took an active part in the movement for the separation of the two kingdoms, and after the separation was accomplished (1830) continued to be the headquarters of the agitation of the Orange party. On the recommendation of the duke of Wellington, who visited the town in 1821 to give his opinion on the plans, a new citadel was erected according to the designs of M. Gey van Pittius (1822–1830).

See Jean de Thielrode, *Chronique de St. Bavon*; Sanderus, *Verheerlykt Vlaenderen*; De Jonghe, *Gendtsche Geschiedenissen*, 1746; Dierickx, *Topographie de l'ancienne ville de Gand* (Ghent, 1808), *Mémoires sur la ville de Gand* (Ghent, 1814–15, 5 vols.), *Mém. sur les lois, etc., des Gantois* (Ghent, 1817–18), *Mém. sur le Droit public de la ville de Gand* (Ghent, 1819), and *Het Gentsch Charterboeckje* (Ghent, 1826); Gachard, *Relations des troubles de Gand sous Charles Quint* (Brussels, 1854–5, 3 vols.); P. C. Van der Meersch, *Memorienboek der Stad Ghent* (Ghent, 1853); and "Mémoire sur la ville de Gand considérée comme place de guerre," in *Mémoires Couronnés de l'acad. royale de Belgique*, tom. xxv., 1851–53 (Brussels, 1854); C. L. Gyselynck, *Guide de la ville de Gand précédé d'une notice historique* (Ghent, n. d.).

GHENT, JODOCUS, OR JUSTUS, OF (1465–75). The public records of the city of Ghent have been diligently searched, but in vain, for a clue to the history of Justus or Jodocus, whom Vasari and Guicciardini called Giusto da Guanto. Flemish annalists of the 16th century have enlarged upon the scanty statements of Vasari, and described Jodocus as a pupil of Hubert Van Eyck. But there is no source to which this fable can be traced. The registers of St. Luke's guild at Ghent comprise six masters of the name of Joos or Jodocus who practised at Ghent in the 15th century. But none of the works of these masters have been preserved, and it is impossible to compare their style with that of Giusto. It was between 1465 and 1474 that this artist executed the Communion of the Apostles which Vasari has described, and modern critics now see to the best advantage in the museum of Urbino. It was painted for the brotherhood of Corpus Christi at the bidding of Frederick of Montefeltro, who was introduced into the picture as the companion of Caterino Zeno, a Persian envoy at that time on a mission to the court of Urbino. From this curious production it may be seen that Giusto, far from being a pupil of Hubert Van Eyck, was merely a disciple of a later and less gifted master, who took to Italy some of the peculiarities of his native schools, and forthwith commingled them with those of his adopted country. As a composer and draughtsman Giusto compares unfavorably with the better known painters of Flanders; though his portraits are good, his ideal figures are not remarkable for elevation of type or for subtlety of character and expression. His work is technically on a level with that of Gerard of St. John, whose pictures are preserved in the Belvedere at Vienna. Vespasian, a Florentine bookseller who contributed much to form the antiquarian taste of Frederick of Montefeltro, states that this duke sent to the Netherlands for a capable artist to paint a series of "ancient worthies" for a library recently erected in the palace of Urbino. It has been conjectured that the author of these "worthies," which are still in existence at the Louvre and in the Barberini palace at Rome, was Giusto. Yet there are notable divergences between these pictures and the Communion of the Apostles. Still, it is not beyond the range of probability that Giusto should have been able, after a certain time, to temper his Flemish style by studying the masterpieces of Santi and Melozzo, and so to acquire the mixed manner of the Flemings and Italians which these portraits of worthies display. Such an assimilation, if it really took place, might justify the Flemings in the indulgence of a certain pride, considering that Raphael not only admired these worthies, but copied them in the sketch book which is now the ornament of the Venetian Academy. There is no ground for presuming that Giusto da Guanto is identical with Justus d'Allamagna, who painted the Annunciation (1451) in the cloisters of Santa Maria di Castello at Genoa. The drawing and coloring of this wall painting show that Justus d'Allamagna was as surely a native of South Germany as his homonym at Urbino was a born Netherlander.

GHERARDESCA, UGOLINO DELLA (*c.* 1220–1289), count of Donoratico and head of the Gherardeschi, one of the leading Ghibelline houses of Pisa, began to take part in public affairs about the time when the dissensions which had arisen about the partition of Sardinia had resulted in sending over the entire clan of the Pisan Visconti to the Guelphs. For having given his sister in marriage to one of these—Giovanni Visconti of Gallura—he was banished from Pisa by his own party, who seem to have had good reason otherwise for suspecting his loyalty; but he was permitted to return in terms of the peace of 1267. Notwithstanding the ambiguous character of his politics, he soon succeeded in gaining a high place in the public service of his native city; and in the battle of Meloria (6th August, 1284), which terminated the long war with Genoa, he was one of the three Pisan admirals. It was by his cowardly or traitorous flight at a critical moment, it is said, that the contest was decided in favor of the Genoese; but, be this as it may, whether by means of his treachery, or in spite of it, he almost immediately afterwards (October, 1284) was nominated by the citizens who remained to the twofold office of capitano and podestá for one year; and some months afterwards (February, 1285) this term was extended to ten years. In this capacity of virtual dictator he, by the banishment of ten leading Ghibelline citizens of Pisa, secured peace with the Florentines; he also endeavored to propitiate the Genoese by the offer of Castro in Sardinia, and the Lucchese by the actual surrender of Ripafratta and Viarreggio, but unsuccessfully. Meanwhile, though thoroughly alienated from the Ghibellines, he had not succeeded in gaining the confidence of the Guelphs; and in 1287 he was by them compelled to associate with himself in the government Nino Visconti, a nephew by the marriage already referred to, who had now reached manhood. But this arrangement was rendered nugatory by the disagreements of the two colleagues, and Ugolino found it necessary to resign his office in December of the same year. In his unscrupulous ambition after personal ascendency he now turned for support to the party he had so long deserted, and entered into an alliance with the Gualandi, Sismondi, Lanfranchi, and other uncompromising Ghibellines, who looked upon the archbishop Ruggiero degli Ubaldini as their head. But this unnatural combination soon terminated in an open rupture, the immediate occasion of which was the violence of Ugolino, who, on some sudden provocation, had killed a nephew of the archbishop. In August, 1288, he was beset in the Palazzo del Popolo by the Ghibellines, and, after fire had been set to the building, taken prisoner, along with his sons Gaddo and Ugoccione, and his grandsons Nino (surnamed Brigatto) and Anselmuccio. (Some accounts mention a third grandson, named Henry.) After having been confined for twenty days in the Palazzo del Comune, they were removed to the Gualandi's Tower, Alle Sette Vie, afterwards called the Torre della Fame. Here they were kept till March, 1289, when, by order of the archbishop, the door was locked and the keys thrown into the Arno. Nine days afterwards the tower was re-entered and the bodies removed to the church of San Francisco.

The story of Ugolino, though it is to be met with in other contemporary writers (see Villani, vii. cc. 120, 127), owes all its fame to Dante, who has placed him above Ruggiero on the inner margin of the second division (Antenora) of the ninth and lowest circle of his Inferno. Dante's powerful narrative, which includes "thirty lines unequalled by any other thirty in the whole dominions of poetry" (Landor), has been paraphrased, or rather almost translated, by Chaucer, in the *Monk's Tale,* and has also been reproduced in modern times by Shelley. It ought to be observed, however, with reference to Ugolino's alleged treachery, that the baser explanation of his conduct at Meloria is not to be met with in any document earlier than the 16th century; while with regard to the accusation of having sold the fortresses of Pisa to the Lucchese and Florentines, Dante, though evidently himself believing it, does not say more than that he "was alleged" (aveva voce) to have done so. Ruggiero's share in the murder of Gherardesca has sometimes been doubted, but on very inadequate grounds. Only in one respect can the poet be fairly accused of having absolutely departed from strict historical accuracy, namely, with regard to the age of the sons and grandsons, who, though represented by him as children, appear to have been all of them grown up. The narrative of Villani has already been referred to; references to other sources may be found in Sismondi and in the annotated editions of Dante, particularly in that of "Philalethes" (the late king of Saxony).

GHERIAH, a town and fortress of British India, in the presidency of Bombay, about 170 miles south of Bombay, otherwise called Viziadrug. See VIZIADRUG.

GHIBELLINES. See GUELPHS.

GHIBERTI, LORENZO (1378–1455), whose name alone is worthy to rank with that of Donatello amongst the grand Italian sculptors of the Renaissance, was born at Florence in the year 1378. He learned the trade of a goldsmith under his father Ugoccione, commonly called Cione, and his stepfather Bartoluccio; but the goldsmith's art at that time included all varieties of plastic arts, and required from those who devoted themselves to its higher branches a general and profound knowledge of design and coloring. In the early stage of his artistic career Ghiberti was best known as a painter in fresco, and when his native city Florence was visited by the plague, he repaired to Rimini, where he executed a highly prized fresco in the palace of the sovereign Pandolfo Malatesta. He was recalled from Rimini to his native city by the urgent entreaties of his stepfather Bartoluccio, who informed him that a competition was to be opened for designs of a second bronze gate in the baptistery, and that he would do wisely to return to Florence and take part in this great artistic contest. The subject for the artists was prescribed,—the sacrifice of Isaac; and the competitors were required to observe in their work a certain conformity to the first bronze gate of the baptistery, executed by Andrea Pisano about 100 years previously. Of the six designs presented by different Italian artists, those of Donatello, Brunelleschi, and Ghiberti were pronounced the best, and of the three Brunelleschi's and Ghiberti's superior to the third, and of such equal merit that the thirty-four judges with whom the decision was left entrusted the execution of the work to the joint labor of the two friends. Brunelleschi, however, withdrew entirely from the contest,—according to one account, from his cordial admiration of Ghiberti's genius, according to another, from his unwillingness to share so great an undertaking with any fellow-laborer. The first of his two bronze gates for the baptistery occupied Ghiberti twenty years, and when completed was justly regarded as the greatest work of its kind since the most glorious days of Grecian art. Ghiberti brought to his task a deep religious feeling and the striving after a high poetical ideal which are not to be found in the works of Donatello, though in power of characterization the second sculptor often stands above the first. Like Donatello, he seized every opportunity of studying the remains of ancient art; but he sought and found purer models for imitation than Donatello, through his excavations and studies in Rome, had been able to secure. The council of Florence, which met during the most active period of Ghiberti's artistic career, not only secured him the patronage of the pontiff, who took part in the council, but enabled him, through the important connections which he then formed with the Greek prelates and magnates assembled in Florence, to obtain from many quarters of the Byzantine empire the precious memorials of old Greek art, which he studied with untiring zeal. The unbounded admiration called forth by Ghiberti's first bronze gate led to his receiving from the chiefs of the Florentine guilds the order for the second, of which the subjects were likewise taken from the Old Testament. The Florentines gazed with especial pride on these magnificent creations, which must still have shone with all the brightness of their original gilding when, a century later, Michel Angelo pronounced them worthy to be the gates of paradise.[1] Next to the gates of the baptistery Ghiberti's chief works still in existence are his three statues of St. John the Baptist, St. Matthew, and St. Stephen, executed for the church of San Michele, among which three works, from the ideal character of the entire figure and the peculiar felicity of expression, the palm is generally awarded to the St. Stephen. In the bas-relief of the coffin of St. Zenobio, in the Florence cathedral, Ghiberti put forth much of his peculiar talent, and though he did not, as is commonly stated, execute entirely the painted glass windows in that edifice, he furnished several of the designs, and did the same service for a painted glass window in the church of San Michele. He died at the age of 77.

We are better acquainted with Ghiberti's theories of art than with those of most of his contemporaries, for he left behind him a commentary, in which, besides his notices of art, he gives much insight into his own personal character and views. Every page attests the religious spirit in which he lived and worked. Not only does he aim at faithfully reflecting in his creations Christian truths; he regards the old Greek statues with a kindred feeling, as setting forth the highest intellectual and moral attributes of human nature. He appears to have cared as little for money as Donatello, and expressly thanks heaven that he had not been cursed with a sordid and mercenary spirit, but had ever loved and labored at art for art's own sake.

Benvenuto Cellini's criticism on Ghiberti that in his creations of plastic art he was more successful in small than in large figures, and that he always exhibited in his works the peculiar excellences of the goldsmith's quite as much as those of the sculptor's art, is after all no valid censure, for it merely affirms that Ghiberti faithfully complied with the peculiar conditions of the task imposed upon him. More frequent have been the discussions of late years as to the part played by perspective in his representations of natural scenery. These have acquired a fresh importance since the discovery of the data, from which it now appears that Fabio Uccelli, commonly regarded as the first great master of perspective, worked for several years in the studio or workshop of Ghiberti, and it becomes difficult to determine to what extent Uccelli's successful innovations in perspective were due to Ghiberti's teaching.

Cicognaro's criticism on Ghiberti, in his *History of Sculpture,* has supplied the chief materials for the illustrative text of Lasinio's series of engravings of the three bronze gates of the baptistery. They consist of 42 plates in folio, and were published at Florence by Bardi in 1821. Still more vivid representations are the reproductions on a very large scale by the photographic establishment of Alinari. In the Florence edition of Vasari's *Lives* there is given at full length Ghiberti's commentary on art. Both Mr. Perkins, in his *History of Tuscan Sculpture,* and Mr. Rio, in his *Art Chrétien,* have treated Ghiberti's works with much fulness, and in a spirit of sound appreciation. But the most recent contributions to what may be termed the Ghiberti literature are the chapter expressly devoted to the history of the competition for the baptistery gates in Semple's *Donatello* (Vienna, 1875), and the articles by Adolf Rosemberg in Dohme's *Kunst und Künstler des Mittelalters* (Leipsic, 1877).

GHILAN, or GILAN, a province of Persia, lying along the S. W. shore of the Caspian, separated from the Russian district of Talish by the Astara and bounded W. by Azerbijan, S. by Irak Adjemi, and S. E. by Mazanderan. It is about 150 miles in length, with a breadth varying from 15 to 50 miles; and its area is estimated at from 4500 to 5000 square miles. The greater portion of the province is a lowland region shut in by the mountains of the Elburz range; and though the Kyzyl Usen, which has its sources in the mountains of Kurdistan, is the only river of any size, the country is abundantly watered, and vast stretches of swamp are found in various directions. This is mainly

[1] Through long exposure to the dusty atmosphere of the town they have of late years begun to lose considerably in delicacy of outline; and it is much to be feared that, unless measures are speedily taken for their preservation, they will at no distant period suffer a still more marked deterioration.

due to the character of the climate, which is distinguished by a very heavy precipitation both in winter and summer. Vegetation is almost tropically luxuriant, and the forests are as dense as an Indian jungle. Oaks, maples, ash trees, *planeras*, lime trees, and *parrottias*, are among the prevailing types. The chestnut-leaved oak attains colossal proportions, and a height at times of 130 or 140 feet; and the box tree comes to rare perfection, and forms an important source of wealth. Vines and pomegranates, walnuts, plums, pears, and apples grow wild; and oranges, lemons, peaches, and other fruits are easily cultivated, though sometimes a severe winter proves fatal to the trees. The olive succeeds well in the valley of the Sefudrood, but the oil is extracted in a very primitive manner. Rice is largely cultivated, and forms the principal food of the inhabitants, except in the west, where its place is partially taken by wheat, a cereal indeed to which the Ghilanese farmer is more and more directing his attention. Cotton and sugar are both grown in small quantities, and the character of the climate gives reason to hope that tea plantations may be rendered profitable in some districts. Hitherto the most successful occupation has been silk growing; but frequent failures in the crop have disheartened, if they have not ruined, many of the silk-masters. The quantity produced in 1866 was valued at £743,300, while the average between 1870 and 1875 was only about £270,000. In quality the silk does not rank very high, the greater portion being the produce of Japanese seed. Animal life is nearly as well represented in Ghilan as vegetable life. Tigers, wild boars, deer, and a considerable variety of snakes are found in the jungles; pheasants are a common form of game; aquatic birds of various kinds—pelicans, storks, heron, gulls, ducks, etc., swarm along the coast; and the fisheries in the Caspian are highly productive. The ordinary cattle, a small humped species like that of India, form an article of export; sheep and goats are not so plentiful, but they furnish very fine wool; and the horses are a hardy race, greatly prized in other parts of Persia, and especially in the capital. Wild horses are to be met with in the forests. Trade and commerce are in a very undeveloped state,—and no wonder when, with one trifling exception, there is no carriageable road in the province, and merchandise has to be transported on the backs of horses, mules, or camels. A striking instance of the primitive state of matters is furnished by Mr. Mounsey, who tells how the machinery ordered by the Shah from Europe for his new mint was allowed to go to ruin in the sand at Enzelli, because it was found impossible to provide for its conveyance. The port of Enzelli, though it boasts of a lighthouse and three small forts, is little more than a natural harbor, and in rough weather it is not accessible to the mail steamers, which in the ordinary course call once a week.

The administration of the province is nearly as primitive as its system of roads, and consists of nothing but machinery for the collection of the taxes, which yield about £63,000 to the royal revenue. The capital is Resht, and the administrative districts are Resht, Lahijan, Fomen, Gesku, Talishan, Sheft, Rustemabad, Rudbar, Menjech, Lengerood, Siah Kuh, and Dilman. Every able-bodied man is enrolled in a sort of frontier guard in the district of Talishan, but no regular police is maintained throughout the province. The population is of very various composition; but the main stock, including the Tats and the Gileki, is of Iranian origin. The Gilek is strongly built, but lank, and his complexion is a sort of olive or copper color; the Tat, on the other hand, has a tendency to corpulence, and his complexion is swarthy. According to different estimates, the inhabitants of the province number 150,000, 200,000, or 275,000; but it is more than usually difficult to ascertain the truth of the case, as they are for the most part scattered through the country in small hamlets. Ghilan is part of the ancient district of Hyrcania. The name is usually explained as equivalent to Mud-land; but Spiegel objects to this derivation, and says the true form of the word is Gelan, which has received no interpretation. There is nothing very distinctive about the history of the province; but its position, its climate, and its soil should secure it a flourishing future were its political condition improved.

See Melgunoff, *The Southern Shore of the Caspian* (in Russian); Mounsey, *Journey through the Caucasus*, etc., 1872; Tietze, *Zeitschrift der Ges. für Erdkunde*, Vienna, 1875; and Consular Reports.

GHIRLANDAJO, Domenico del (1449–1494), an illustrious Florentine painter. His full name is given as Domenico di Tommaso Curradi di Doffo Bigordi; it appears therefore that his father's surname was Curradi, and his grandfather's Bigordi. The painter is generally termed Domenico Bigordi, but some authors give him, and apparently with reason, the paternal surname Curradi. Ghirlandajo (garland-maker) was only a nickname, coming to Domenico from the employment of his father (or else of his earliest instructor), who was renowned for fashioning the metallic garlands worn by Florentine damsels; he was not, however, as some have said, the inventor of them. Tommaso was by vocation a jeweller on the Ponte Vecchio, or perhaps a broker. Domenico, the eldest of eight children, was at first apprenticed to a jeweller or goldsmith, probably enough his own father; in his shop he was continually making portraits of the passers-by, and it was thought expedient to place him with Alessio Baldovinetti to study painting and mosaic. His youthful years were, however, entirely undistinguished, and at the age of thirty-one he had not a fixed abode of his own. This is remarkable, as immediately afterwards, from 1480 onwards to his death at a comparatively early age in 1494, he became the most proficient painter of his time, incessantly employed, and condensing into that brief period of fourteen years fully as large an amount of excellent work as any other artist that could be named; indeed, we should properly say eleven years, for nothing of his is known of a later date than 1491.

In 1480 Ghirlandajo painted a St. Jerome and other frescoes in the church of Ognissanti, Florence, and a life-sized Last Supper in its refectory, noticeable for individual action and expression. From 1481–1485 he was employed upon frescoes in the Sala dell' Orologio in the Palazzo Vecchio; he painted the apotheosis of St. Zenobius, a work beyond the size of life, with much architectural framework, figures of Roman heroes, and other detail, striking in perspective and structural propriety. While still occupied here, he was summoned to Rome by Pope Sixtus IV. to paint in the Sixtine Chapel; he went thither not earlier than 1482. In the Sixtine he executed, probably before 1484, a fresco which has few rivals in that series, Christ calling Peter and Andrew to their Apostleship,—a work which, though somewhat deficient in color, has greatness of method and much excellence of finish. The landscape background, in especial, is very superior to anything to be found in the works, which had no doubt been zealously studied by Ghirlandajo, of Masaccio and Masolino in the Brancacci Chapel. He also did some other works in Rome, now perished. Before 1485 he had likewise produced his frescoes in the chapel of S. Fina, in the Tuscan town of S. Gemignano, remarkable for grandeur and grace,—two pictures of Fina, dying and dead, with some accessory work. Sebastian Mainardi assisted him in these productions in Rome and in S. Gemignano; and Ghirlandajo was so well pleased with his co-operation that he gave him his sister in marriage.

He now returned to Florence, and undertook in the church of the Trinita, and afterwards in S. Maria Novella, the works which have set the seal on his celebrity. The frescoes in the Sassetti Chapel of S. Trinita are six subjects from the life of St. Francis, along with some classical accessories, dated 1485. Three of the principal incidents are St. Francis obtaining from Pope Honorius the approval of the Rules of his Order; his Death and Obsequies; and the Resuscitation, by the interposition of the beatified saint, of a child of the Spini family, who had been killed by falling out of a window. In the first work is a portrait of Lorenzo de' Medici; and in the third the painter's own likeness, which he introduced also into one of the pictures in S. Maria Novella, and in the Adoration of the Magi in the hospital of the Innocenti. The altar-piece of the Sassetti Chapel, the Adoration of the Shepherds, is now in the Florentine Academy. Immediately after disposing of this commission, Ghirlandajo was asked to renew the frescoes in the choir of S. Maria Novella. This choir formed the chapel of the Ricci family, but the Tornabuoni and Tornaquinci families, then much more opulent than the Ricci, undertook the cost of the restoration, under conditions, as to preserving the arms of the Ricci, which gave rise in the end to some amusing incidents of litigation. The frescoes, in the execution of which Domenico had many assistants, are in four courses along the three walls,—the leading subjects being the Lives of the Madonna and of the Baptist.

Besides their general richness and dignity of art, these works are particularly interesting as containing many historical portraits—a method of treatment in which Ghirlandajo was pre-eminently skilled. There are no less than twenty-one portraits of the Tornabuoni and Tornaquinci families; in the subject of the Angel appearing to Zacharias, those of Poliziano, Marsilio, Ficino, and others; in the Salutation of Anna and Elizabeth, the beautiful Ginevra de' Benci; in the Expulsion of Joachim from the Temple, Mainardi and Baldovinetti (or the latter figure may perhaps be Ghirlandajo's father). The Ricci chapel was re-opened and completed in 1490; the altar-piece, now removed from the chapel, was probably executed with the assistance of Domenico's brothers, David and Benedetto, painters of ordinary calibre; the painted window was from Domenico's own design. Other distinguished works from his hand are an altar-piece in tempera of the Virgin adored by Sts. Zenobius, Justus, and others, painted for the church of St. Justus, but now in the Uffizi gallery, a remarkable masterpiece; Christ in glory with Romuald and other Saints, in the Badia of Volterra: the Adoration of the Magi, in the church of the Innocenti (already mentioned), perhaps his finest panel-picture, 1488; and the Visitation, in the Louvre, bearing the latest ascertained date, 1491, of all his works. Ghirlandajo did not often attempt the nude; one of his pictures of this character, Vulcan and his Assistants forging Thunderbolts, was painted for Lo Spedaletto, but (like several others specified by Vasari) it exists no longer. The picture attributed to him in the London National Gallery is dubious; it may perhaps have come from the atelier of Verrocchio. The mosaics which he produced date before 1491; one, of especial celebrity, is the Annunciation, on a portal of the cathedral of Florence.

In general artistic attainment Ghirlandajo may fairly be regarded as exceeding all his precursors or competitors; though the names of a few, particularly Giotto, Masaccio, Lippo Lippi, and Botticelli, stand higher for originating power. His scheme of composition is grand and decorous; his chiaroscuro excellent, and especially his perspectives, which he would design on a very elaborate scale by the eye alone; his color is more open to criticism, but this remark applies much less to the frescoes than the tempera-pictures, which are sometimes too broadly and crudely bright. He worked in these two methods alone—never in oils; and his frescoes are what the Italians term "buon fresco," without any finishing in tempera. A certain hardness of outline, not unlike the character of bronze sculpture, may attest his early training in metal work. He first introduced into Florentine art that mixture of the sacred and the profane which had already been practised in Siena. His types in figures of Christ, the Virgin, and angels are not of the highest order; and a defect of drawing, which has been often pointed out, is the meagreness of his hands and feet. It was one of his maxims that "painting is designing." Ghirlandajo was an insatiate worker, and expressed a wish that he had the entire circuit of the walls of Florence to paint upon. He told his shop-assistants not to refuse any commission that might offer, were it even for a lady's petticoat-panniers: if they would not execute such work, *he* would. Not that he was in any way grasping or sordid in money-matters, as is proved by the anecdote of the readiness with which he gave up a bonus upon the stipulated price of the Ricci chapel frescoes, offered by the wealthy Tornabuoni in the first instance, but afterwards begrudged. Vasari says that Ghirlandajo was the first to abandon in great part the use of gilding in his pictures, representing by genuine painting any objects supposed to be gilded; yet this does not hold good without some considerable exceptions—the high lights of the landscape, for instance, in the Adoration of the Shepherds, now in the Florence Academy, being put in in gold. Many drawings and sketches by this painter are in the Uffizi Gallery, remarkable for vigor of outline. One of the great glories of Ghirlandajo is that he gave some early art-education to Michelangelo, who cannot, however, have remained with him long. Granacci was another of his pupils.

This renowned artist died of pestilential fever on 11th January, 1494, and was buried in S. Maria Novella. He had been twice married, and left six children, three of them being sons. He had a long and honorable line of descendants, which came to a close in the 17th century, when the last members of the race entered monasteries. It is probable that Domenico died poor; he appears to have been gentle, honorable, and conscientious, as well as energetically diligent. (W. M. R.)

GHIRLANDAJO, Ridolfo (1483-1560), son of Domenico, was also a painter of considerable celebrity. Born on 14th February, 1483, and being thus less than eleven years old when his father died, he was brought up by his uncle David. To this second-rate artist he owed less in the way of professional training than to Granacci, Piero di Cosimo, and perhaps Cosimo Rosselli. It has been said that Ridolfo studied also under Fra Bartolommeo, but this is not clearly ascertained. He was certainly one of the earliest students of the famous cartoons of Leonardo da Vinci and Michelangelo. His works between the dates 1504 and 1508 show a marked influence from Fra Bartolommeo and Raphael, with the latter of whom he was on terms of familiar friendship; hence he progressed in selection of form and in the modelling and relief of his figures. Raphael, on reaching Rome in 1508, wished Ridolfo to join him; but the Florentine painter was of a particularly home-keeping humor, and he neglected the opportunity. He soon rose to the head of the Florentine oil-painters of his time; and, like his father, accepted all sorts of commissions, of whatever kind. He was prominent in the execution of vast scenic canvases for various public occasions, such as the Wedding of Giuliano de' Medici, and the Entry of Leo X. into Florence in 1515. In his prime he was honest and conscientious as an artist; but from about 1527 he declined, having already accumulated a handsome property, more than sufficient for maintaining in affluence his large family of fifteen children, and his works became comparatively mannered and self-repeating. His sons traded in France and in Ferrara; he himself took a part in commercial affairs, and began paying some attention to mosaic work, but it seems that, after completing one mosaic, the Annunciation over the door of the Nunziata, patience failed him for continuing such minute labors. In his old age Ridolfo was greatly disabled by gout. He appears to have been of a kindly, easy-going character, much regarded by his friends and patrons.

The following are some of his leading works, the great majority of them being oil-pictures:—

Christ and the Maries on the road to Calvary, now in the Palazzo Antinori, Florence, an early example, with figures of half life-size. An Annunciation in the Abbey of Montoliveto, near Florence. Leonardesque in style. In 1504, the Coronation of the Virgin, now in the Louvre. A Nativity, very carefully executed, now in the Hermitage, St. Petersburg, and ascribed in the catalogue to Granacci. A Predella, in the oratory of the Bigallo, Florence, five panels, representing the Nativity and other subjects, charmingly finished. In 1514, on the ceiling of the chapel of St. Bernard in the Palazzo Pubblico, Florence, a fresco of the Trinity, with heads of the twelve apostles and other accessories, and the Annunciation; also the Assumption of the Virgin, who bestows her girdle on St. Thomas, in the choir loft of Prato cathedral. Towards the same date, a picture showing his highest skill, replete with expression, vigorous life, and firm accomplished pictorial method, now in the gallery of the Uffizi, St. Zenobius resuscitating a child; also the Translation of the remains of the same Saint. The Virgin and various saints, at S. Pier Maggiore, Pistoja. In 1521, the Pietà, at S. Agostino, Colle di Valdelsa, life-sized. Towards 1526, the Assumption, now in the Berlin Museum, containing the painter's own portrait. An excellent portrait of Cosmo de' Medici (the Great) in youth. In 1543, a series of frescoes in the monastery of the Angeli. A great number of altar-pieces were executed by Ghirlandajo, with the assistance of his favorite pupil, currently named Michele di Ridolfo. Another of his pupils was Mariano da Pescia. (W. M. R.)

GHIZNI. See Ghazni.

GHOORKAS. See Nepal.

GHÚR (*Ghor*, *Ghoor*, *Gour*, etc.) is the name of a territory in Asia, and Ghúri (*Ghori*, *Ghoory*, etc.) that of a dynasty deriving its origin from that territory.

The name of Ghúr was, in the Middle Ages, and, indeed, locally still is, applied to the highlands east of Herat, and extending eastward to the upper Helmand valley, or nearly so. There is hardly any region of Asia regarding which we continue to be more in the dark than about this. Ghúr is the southern portion of that great peninsula of strong mountain country which forms the western part of modern Afghanistan, and which may be taken in a general way to represent the Paropamisus of the ancients. The northern portion of the said peninsula was in the Middle Ages comprehended under the names of *Gharjistán* (on the west), and *Juzjáná* (on the east), whilst the basin of the Herat river, and all south of it, constituted Ghúr. The name as now used does not perhaps include the valley of the Herat river; on the south the limit seems to be the declivity of the higher mountains (about 32° 45′ N. lat.) dominating the descent to the lower Helmand, and the road from Farrah to Kandahar. It is in Ghúr that rise all those affluents of the closed basin of Seistán, the Harút, the Farrah-rúd, the Khásh-rúd (see AFGHANISTAN), besides other considerable streams joining the Helmand above Girishk.

Ghúr is mentioned in the Shahnamah of Firdousi (1010 A. D.), and in the Arab geographers of that time, though these latter fail in details almost as much as we moderns, thus indicating how little accessible the country has been through all ages. Ibn Haukal's map of Khorasan (*c.* 976) shows *Jibál-al-Ghúr*, "the hill-country of Ghúr," as a circle ring-fenced with mountains. His brief description speaks of it as a land fruitful in crops, cattle, and flocks, inhabited by infidels, except a few who passed for Mahometans, and indicates that, like other pagan countries surrounded by Moslem populations, it was regarded as a store of slaves for the faithful. The boundary of Ghúr in ascending the valley of the Hari-rúd was six and a half easy marches from Herat, at Chist, two marches above Obah (both of which are still in our maps).

The chief part of the present population of Ghúr are *Taimúnis* belonging to the class of nomad or semi-nomad clans called *Eimáks* (see AFGHANISTAN, vol. i. p. 211). There are also, according to Ferrier, *Súris*, who were formerly the main part of the population, apparently the same as the *Zoorees* of Elphinstone (*Caubul*, ii. 204), another of the Eimák clans; and in the north of Ghúr Ferrier mentions Mongols. Camels are kept in great numbers by the Eimáks, chiefly for their wool. Though the country is very mountainous, there are fruitful valleys of considerable width. But our knowledge is too slight for us to say more.

The people and princes of Ghúr first become known to us in connection with the Ghaznevid dynasty, and the early mediæval histories of Ghúr and Ghazni are so intertwined that little need be added on that subject to what will be found under GHAZNI (*q. v.*). What we read of Ghúr shows it as a country of lofty mountains and fruitful valleys, and of numerous strongholds held by a variety of hill-chieftains ruling warlike clans whose habits were rife with feuds and turbulence,—indeed, in character strongly resembling the tribes of modern Afghanistan, though there seems no good reason to believe that they were of Afghan race. It is probable that they were of old Persian blood, like the older of those tribes which still occupy the country. It is possibly a corroboration of this that, in the 14th century, when one of the Ghúri kings, of the Kurt dynasty reigning in Herat, had taken to himself some of the insignia of independent sovereignty, an incensed Mongol prince is said to have reviled him as "an insolent *Tajik*" (*Journal Asiat.*, ser. v. tom. xvii. p. 509). Sabuktigín of Ghazni, and his famous son Mahmúd, repeatedly invaded the mountain country which so nearly adjoined their capital, subduing its chiefs for the moment, and exacting tribute; but when the immediate pressure was withdrawn, the yoke was thrown off, and the tribute withheld. In 1020 Masa'ud, the son of Mahmúd, being then governor of Khorasan, made a systematic invasion of Ghúr from the side of Herat, laying siege to its strongholds one after the other, and subduing the country more effectually than ever before. About a century later one of the princely families of Ghúr, deriving the appellation of Shansabi, or Shansabáníah, from a certain ancestor Shansab, of local fame, and of alleged descent from Zohák, acquired predominance in all the country, and at the time mentioned Malik 'Izzuddin al Husain of this family came to be recognized as lord of Ghúr. He was known afterwards as "the Father of Kings," from the further honor to which several of his seven sons rose. Three of these (see GHAZNI) were —(1) Amir Kutbuddin Mahommed, called the lord of the Jibál or mountains; (2) Sultán Saifuddín Súrí, for a brief period master of Ghazni,—both of whom were put to death by Bahram the Ghaznevid: and (3) Sultán Aláuddín Jahánsoz, who wreaked such terrible vengeance upon Ghazni. Aláuddín began the conquests which were afterwards immensely extended both in India and in the west by his nephews Ghiyássuddín Mahommed ibn Sám and Muízuddín Mahommed Sám (the Shahábuddín Ghúri of the historians), and for a brief period during their rule it was boasted, with no great exaggeration, that the public prayer was read in the name of the Ghúrí from the extremity of India to the borders of Babylonia, and from the Oxus to the Straits of Ormus. After the death of Muízuddín (*alias* Shahábuddín), Mahmúd the son of Ghiyássuddín was proclaimed sovereign (1206) throughout the territories of Ghúr, Ghazni, and Hindustan. But the Indian dominion, from his uncle's death, become entirely independent, and his actual authority was confined to Ghúr, Seistán, and Herat. The whole kingdom fell to pieces before the power of Mahommed Sháh of Khwarazm and his son Jaláluddín (*c.* 1214–1215), a power in its turn to be speedily shattered by the Mongol flood (see GHAZNI).

Besides the thrones of Ghúr and Ghazni, the Shansabaníah family, in the person of Fakhruddin, the eldest of the seven sons of Malek 'Izzuddín, founded a kingdom in the Oxus basin, having its seat at BÁMIÁN (*q. v.*), which endured for two or three generations, till extinguished by the power of Khwarazm (1214). And the great Mussulman empire of Delhi was based on the conquests of Muízuddín the Ghurian, carried out and consolidated by his Turki freedmen, Kutbuddín Aibak and his successors. The princes of Ghúr experienced, about the middle of the 13th century, a revival of power, which endured for 140 years. This later dynasty bore the name of Kurt or Kărt. The first of historical prominence was Malik Shamsuddín Kurt, descended by his mother from the great king Ghiyassuddín Ghúrí, whilst his other grandfather was that prince's favorite minister. In 1245 Shamsuddín held the lordship of Ghúr in some kind of alliance with, or subordination to, the Mongols, who had not yet definitively established themselves in Persia, and in 1248 he received from the Great Khan Mangu an investiture of all the provinces from Merv to the Indus, including by name Sijistan (or Seistán), Cabul, Tírah (adjoining the Khaibar pass), and Afghanistan (a very early occurrence of this name), which he ruled from Herat. He stood well with Hulákú, and for a long time with his son Abaka, but at last incurred the latter's jealousy, and was poisoned when on a visit to the court at Tabriz (1276). His son Ruknuddín Kurt was, however, invested with the government of Khorasan (1278), but after some years, mistrusting his Tartar suzerains, he withdrew into Ghúr, and abode in his strong fortress of Kaissar till his death there in 1305. The family held on through a succession of eight kings in all, sometimes submissive to the Mongol, sometimes aiming at independence, sometimes for a series of prosperous years adding to the strength and splendor of Herat, and sometimes sorely buffeted by the hosts of masterless Tartar brigands that tore Khorasan and Persia in the decline of the dynasties of Hulákú and Chagatai. It is possible that the Kurts might have established a lasting Tajik kingdom at Herat, but in the time of the last of the dynasty, Ghiyassuddín Pir-'Ali, Tartardom, re-organized and re-embodied in the person of Timur, came against Herat, and carried away the king and the treasures of his dynasty (1380). A revolt and massacre of his garrison provoked Timur's vengeance; he put the captive king to death, came against the city a second time, and showed it no mercy (1383). Ghúr has since been as obscure in history as it is in its topography.

The proper capital of the kingdom of Ghúr when its princes were rising to dominion in the 12th century was Firúz-Koh, where a city and fortress were founded by Saífuddin Súri. The true position of Firúz-Koh does not seem to have been determined, but it was probably on or near the upper waters of the Hari-rúd or river of Herat; and it is possible that it may be represented by Shahrak, a place in that valley (about 65° 30′ E. long.), once a populous and flourishing town, which was described to Ferrier, who passed not far from it, as having been anciently the capital of Ghúr. The name of *Firúz-Kohis* has been appropriated to one of the most numerous of the nomad tribes occupying the upper part of the Hari-rúd and part of the Murgháb, but it is doubtful if this has to do with the Ghúr capital, as the name is otherwise explained. Other places claim to have been the old capital. Thus Karrukh, a place visited by Khanikoff in 1858, in a rapid excursion from Herat, and lying on the north side of the valley, is one. But this seems too near Herat (only 30 miles distant). Ferrier, again, describes as the ancient capital a place, which he reached in his journey, called *Zarni*, about 150 miles by road from Herat towards the S. E. The population did not exceed 1200, belonging to the Súrí and Taimúni tribes. The peak of Chalap Dalan, "one of the highest in the world," rose before Zarni in imposing majesty. The mountain, at half its height, has a compass of some 40 miles; the sides are covered with forests and pastures, villages and tents, and also exhibit naturally impregnable positions where successive chiefs have built strongholds. Ferrier, in accompanying the Afghan governor, who lived at Zarni, saw three ancient towns on the skirts of this mountain, all large and fortified, viz., Kala' Kaissar, Kala' Sangi, and Fakhrábád. These are described as only a few *farsakhs*, or hours' march, north-east of Teivereh, which last is in some of our maps. Doubts have indeed been cast on the authenticity of this part of Ferrier's book, chiefly on account of the extreme brevity of the time which he allows. But the professed journal was probably, under the circumstances, only an expansion from memory of the merest jottings; and several things are in favor of authenticity. His notices of the country, slight as they are, correspond notably in the impression conveyed with those of the *Tabakáti-i-Násiri* (see below). *Kaissar*, which he mentions, is a place that has already been referred to as the stronghold of Ruknuddín Kurt. *Zarni*, as roughly located by him, corresponds fairly with what was told Conolly on his journey between Herat and Kandahar, of the position and character of "the old city of

Ghore . . . now a ruinous, ill-inhabited town, the capital of a petty province, governed by one of Shah Kamran's sons, who has his residence there" (*Journey*, vol. ii. p. 61). Zarni is mentioned by Major Leech in connection with Taiwara (Teivereh of Ferrier) and other places in the south of the Ghúr country, but not so as to determine its position. In some other points, moreover, as to names of chiefs, etc., Ferrier's statements agree with Leech's.

See the "Tabakát-i-Násiri," in the *Bibl. Indica*, transl. by Raverty; *Journal Asiatique*, ser. v., tom. xvii.; "Ibn Haukal," in *J. As. Soc. Beng.*, vol. xxii.; Ferrier's *Caravan Journeys*; Hammer's *Ilkhans*, etc. (H. Y.)

GIAMBELLI, or GIANIBELLI, FEDERIGO, a military engineer, was born at Mantua about the middle of the 16th century. Having had some experience as a military engineer in Italy, he went to Spain to offer his services to Philip II. His proposals were, however, somewhat lukewarmly received, and as he could obtain from the king no immediate employment, he took up his residence at Antwerp, where he soon gained considerable reputation for his knowledge in various departments of science. He is said to have vowed to be revenged for his rebuff at the Spanish court; and when Antwerp was besieged by the duke of Parma in 1584, he put himself in communication with Queen Elizabeth, who having satisfied herself of his abilities, engaged him to aid by his counsels in its defence. His plans for provisioning the town were rejected by the senate, but they agreed to a modification of his scheme for destroying the famous bridge which closed the entrance to the town from the side of the sea, by the conversion of two ships of 60 and 70 tons into infernal machines. One of these exploded, and, besides destroying more than 1000 soldiers, effected a breach in the structure of more than 200 feet in width, by which, but for the hesitation of Admiral Jacobzoon, the town might at once have been relieved. After the surrender of Antwerp Giambelli went to England, where he was engaged for some time in fortifying the river Thames; and when the Spanish Armada was attacked by fire-ships in the Calais roads, the panic which ensued was due to the conviction among the Spaniards that the fire-ships were infernal machines constructed by Giambelli. He is said to have died in London, but the year of his death is unknown. See Motley's *History of the United Netherlands*, vols. i. and ii., and the authorities therein referred in.

GIANNONE, PIETRO (1676-1748), the most distinguished historian of whom Naples can boast, and amongst all Italian historians second alone to Fra Paulo Sarpi for the strong and clear light thrown in his works on the growth of the papal power, was born at Ischitella, in the province of Capitanata, on the 7th of May, 1676. Arriving in Naples at the age of eighteen, he devoted himself to the study of law, but his legal pursuits were much surpassed in importance by his literary labors. He devoted twenty years to the composition of his great work, *The Civil History of Naples*, which was ultimately published in 1723. Here, in his account of the rise and progress of the Neapolitan laws and government, he warmly espoused the side of the civil power in its conflicts with the Romish hierarchy. The position thus taken up by him, and the manner in which that position was assumed, gave rise to a life-long conflict between Giannone and the church; and we must know much more accurately than we at present do all the facts concerning his alleged retractation in prison at Turin, before we can withhold from him the palm—as he certainly endured the sufferings—of a confessor and martyr in the cause of what he deemed historical truth. Hooted by the mob of Naples, and excommunicated by the archbishop's court, he was forced to leave Naples and repair to Vienna. Meanwhile the Inquisition had attested after its own fashion the value of his history by putting it on the *Index*. At Vienna the favor of the emperor Charles VI. and of many leading personages at the Austrian court obtained for him a pension and other facilities for the prosecution of his historical studies. Of these the most important result was *Il Triregno, ossia del regno del cielo, della terra, e del papa.* On the transfer of the Neapolitan crown to Charles of Bourbon, Giannone lost his Austrian pension, and was compelled to remove to Venice. There he was at first most favorably received. The post of consulting lawyer to the republic, in which he might have continued the special work of Fra Paulo Sarpi, was offered to him, as well as that of professor of public law in Padua; but he declined both offers. Unhappily there arose a suspicion that his views on maritime law were not favorable to the pretensions of Venice, and, notwithstanding all his efforts to dissipate that suspicion, it was resolved to expel him from the state. On the 23d of September, 1735, he was seized and conveyed to Ferrara. After wandering, under the assumed name of Antonio Rinaldo, for three months through Modena, Milan, and Turin, he at last reached Geneva, where he enjoyed the friendship of the most distinguished citizens, and was on excellent terms with the great publishing firms. But in an evil hour he was induced to visit a Catholic village within the Sardinian territory, where he was kidnapped by the agents of the Sardinian Government, conveyed to the castle of Miolan, and thence successively transferred to Ceva and Turin. In the fortress of Turin he remained immured during the last twelve years of his life, though part of his time was spent in composing a defence of the Sardinian interests as opposed to those of the papal court, and though he was led to sign a retractation of the statements in his history most obnoxious to the Vatican. He died March 7, 1748, in his seventy-second year.

Giannone's style as an Italian writer has been pronounced to be below a severe classical model. But his very ease and freedom, if not classical, have helped to make his volumes more popular than many works of greater classical renown. In England the just appreciation of his labors by Gibbon, and the ample use made of them in the later volumes of *The Decline and Fall*, early secured his rightful place for him in the estimation of English scholars.

A good and complete edition of Giannone's works is still a desideratum. The more important facts of his life have been recorded by the Abbe Fernando Parizini in Italian, and in Latin by Fabroni; whilst a more complete estimate of his literary and political importance may be formed by the perusal of the collected edition of the works written by him in his Turin prison, published in Turin in 1859—under the care of the distinguished statesman Pasquale Stanislao Mancini, late minister of grace and justice, universally recognized as one of the first authorities in Italy on questions relating to the history of his native Naples, and especially to the conflicts between the civil power and the church.

GIANT is the Old English *geant*, derived through French and Latin from Greek *gigas* (*gigant*). The idea conveyed by the word in classic mythology is that of beings more or less manlike, but monstrous in size and strength. Figures like the Titans and the Giants whose birth from Heaven and Earth is sung by Hesiod in the *Theogony*, such as can heap up mountains to scale the sky, and war beside or against the gods, must be treated, with other like monstrous figures of the wonder-tales of the world, as belonging altogether to the realms of mythology. But there also appear in the legends of giants some with historic significance. The ancient and commonly-repeated explanation of the Greek word γίγας, as connected with or derived from γηγενής, or "earth-born," seems by no means sound as a matter of etymology, but at any rate the idea conveyed by it was familiar to the ancient Greeks, that the giants were earth-born or indigenous races (see Welcker, *Griechische Götterlehre*, vol. i. p. 787). The Bible (the English reader must be cautioned that the word giant has been there used ambiguously, from the Septuagint downwards) touches the present matter in so far as it records the traditions of the Israelites of fighting in Palestine with tall races of the land such as the Anakim (Numb. xiii. 33; Deut. ii. 10, iii. 11; 1 Sam. xvii. 4). When reading in Homer of "the Cyclopes and the wild tribes of the Giants," or of the adventures of Odysseus in the cave of Polyphemus (Homer, *Odyss.*, vii. 206; ix.), we seem to come into view of dim traditions, exaggerated through the mist of ages, of pre-Hellenic barbarians, godless, cannibal, skin-clothed, hurling huge stones in their rude warfare. Giant-legends of this class are common in Europe and Asia, where the big and stupid giants have often every token of uncouth native barbarians, exaggerated into monsters in the legends of the later tribes who dispossessed and slew them.

Besides the conception of giants as special races distinct from mankind, it was a common opinion of the ancients that the human race had itself degenerated, the men of primeval ages having been of so far greater stature and strength as to be in fact gigantic. This, for example, is received by Pliny (*Hist. Nat.*, vii. c. 16), and it becomes a common doctrine of theologians such as Augustine (*De Civitate Dei*, xv. 9), lasting on into times so modern that it may be found in Cruden's *Concordance*. Yet so far as can be judged from actual remains, it does not appear that giants, in the sense of tribes of altogether superhuman stature, ever existed, or that the men of ancient time were on the whole taller than those now living. It is now usual to apply the word giant to beings not superhuman in their height, but merely the tallest men and women of our nations. In every race of mankind the great mass of individuals do not depart far from a certain mean or average height, while the very tall or very short men become less and less numerous as they depart from the mean standard, till the utmost divergence is reached in a very few giants on the one hand, and a very few dwarfs on the other. At both ends of the scale the body is markedly out of the ordinary proportions; thus a giant's head is smaller and a dwarf's head larger than it would be if an average man had been magnified or diminished. The principle of the distribution of individuals of different sizes in a race or nation has been ably set forth by Quetelet (*Physique Sociale*, vol. ii.; *Anthropométrie*, books iii and iv.). Had this principle been understood formerly, we might have been spared the pains of criticising assertions as to giants 20 feet high, or even more, appearing among mankind. The appearance of an individual man 20 feet high involves the existence of the race he is an extreme member of, whose mean stature would be at least 12 to 14 feet, which is a height no human being has been proved on sufficient evidence to have approached (*Anthropom.*, p. 302). In fact, Quetelet considers the tallest man whose stature has been authentically recorded to have been Frederick the Great's Scottish giant, who was not quite 8 feet 3 inches. Modern statisticians, though admitting that this may not be the extreme limit of human stature, cannot accept the loose conclusion in Buffon (*Hist. Nat.*, ed. Sonnini, vol. iv. p. 134), that there is no doubt of giants having been 10, 12, and perhaps 15 feet high. Confidence is not even to be placed in ancient asserted measurements, as where Pliny gives to one Gabbaras, an Arabian, the stature of 9 feet 9 inches (about 9 feet 5½ inches English), capping this with the mention of Posio and Secundilla, who were half a foot higher. That two persons should be described as both having this same extraordinary measure suggests to the modern critic the notion of a note jotted down on the philosopher's tablets, and never tested afterwards.

Under these circumstances, it is worth while to ask how it is that legend and history so abound in mentions of giants outside all probable dimensions of the human frame. One cause is that, when the story-teller is asked the actual stature of the huge men who figure in his tales, he is not sparing of his inches and feet. What exaggeration can do in this way may be judged from the fact that the Patagonians, whose average height (5 feet 11 inches) is really about that of the Chirnside men in Berwickshire, are described in Pigafetta's *Voyage round the World* as so monstrous that the Spaniards' heads hardly reached their waists. It is reasonable to suppose, with Professor Nilsson (*Primitive Inhabitants of Scandinavia*, chap. vi.), that in the traditions of early Europe tribes of savages may have thus, if really tall, expanded into giants, or, if short, dwindled into dwarfs. Another cause which is clearly proved to have given rise to giant-myths of yet more monstrous type, has been the discovery of great fossil bones, as of mammoth or mastodon, which have from early ages been supposed to be bones of giants, and have given rise to a whole class of giant-myths (see Tylor, *Early History of Mankind*, chap. xi.; *Primitive Culture*, chap. x.). Such anatomical inferences from the leg-bone or tooth of some huge extinct animal are rather creditable to the ingenuity of natives of America, or of barbarians of the Old World; but their late continuance in the midst of European culture shows how recently the principles of comparative anatomy obtained their present hold on the public mind. A tooth weighing 4¾ ℔, and a thigh-bone 17 feet long, having been found in New England in 1712 (they were probably mastodon), Dr. Increase Mather thereupon communicated to the Royal Society of London his confirmation from them of the existence of men of prodigious stature in the antediluvian world (see the *Philosophical Transactions*, vol. xxiv. p. 85; D. Wilson, *Prehistoric Man*, vol. i. p. 54). The giants in the streets of Basel and supporting the arms of Lucerne appear to have originated from certain fossil bones found in 1577, examined by the physician Felix Plater, and pronounced to have belonged to a giant some 16 or 19 feet high. These bones have since been referred to a very different geological genus, but within the present century Plater's giant skeleton was accepted as a genuine relic of the giants who once inhabited the earth. See the dissertation of Le Cat, cited in the 5th edition of the *Encyclopædia Britannica* (1817).

(E. B. T.)

GIANT'S CAUSEWAY, a promontory of columnar basalt, situated on the coast of Antrim in the north of Ireland. It is divided by whin-dykes into the Little Causeway, the Middle Causeway or "Honeycomb," as it is locally termed, and the Larger or Grand Causeway. The pillars composing it are close-fitting, and for the most part somewhat irregular hexagons, made up of articulated portions varying from a few inches to some feet in depth, and concave or convex at the upper and lower surfaces. In diameter the pillars vary from 15 to 20 inches, and in height some are as much as 20 feet. The Great Causeway is chiefly from 20 to 30, and for a few yards in some places nearly 40 feet in breadth, exclusive of outlying broken pieces of rock. It is highest at its narrowest part. At about half a dozen yards from the cliff, widening and becoming lower, it extends outwards into a parade or platform, which has a slight seaward inclination, but is easily walked on, and for nearly 100 yards is always above water. At the distance of about 150 yards from the cliff it turns a little to the eastward for 20 or 30 yards, and then sinks into the sea. The neighboring cliffs exhibit in many places columns similar to those of the Giant's Causeway, a considerable exposure of them being visible at a distance of about 100 roods in the bay to the eastward. A group of these columns, from their arrangement, have been fancifully named the "Giant's Organ." The most remarkable of the cliffs is the Pleaskin, the upper pillars of which have the appearance of a colonnade, and are 60 feet in height; beneath these is a mass of coarse black amygdaloid, of the same thickness, underlain by a second range of basaltic pillars, from 40 to 50 feet in height. Near the Giant's Causeway are the ruins of the castles of Dunseverick and Dunluce, situated high above the sea on insulated crags, and the swinging bridge of Carrick-a-Rede, spanning a chasm of 80 feet deep, and connecting a rock, which is used as a salmon-fishing station, with the mainland. Fairhead, a promontory composed of columnar greenstone, the highest point on the coast, has an altitude of 550 feet.

See Hamilton, *Letters from the Coast of Antrim*; Dubourdiew, *Statistical Survey of Antrim*; and articles ANTRIM and GEOLOGY.

GIARRE, a town of Sicily, in the province of Catania, between Etna and the sea, with a station on the railway from Messina to Catania, distant from the former 40 miles, and from the latter nearly 19. It is a flourishing place of 6956 inhabitants, according to the census of 1871, or of 9990 if the suburbs of Macchia, St. Giovanni, and St. Alfio are included; but it has little to show except a handsome modern church, and is mainly of interest as the point from which tourists start to visit the remains of the gigantic chestnut tree of the hundred horses (*di cento cavalli*).

GIAVENO, a market-town of Italy, in the province of Turin, and circondario of Susa, about 16 miles W. of Turin, at the foot of the Cottian Alps, and on the left bank of the Sangone, a head water of the Po. It possesses a fine old castle, an almshouse, a gymnasium, a children's asylum, several well-built churches, and an ancient abbatial residence; and its inhabitants manufacture paper and silk, and maintain a trade in wine and timber. Population of the town in 1871, 5722, and of the commune 9638.

GIB, ADAM (1714–1788), the leader of the Antiburgher section of the Scottish Secession Church, was born April 14, 1714, in the parish of Muckhart, Perthshire, and, on the completion of his literary and theological studies at Edinburgh and Perth, was licensed as a preacher in 1740. In the following year he was ordained minister of the large Secession congregation of Bristo, Edinburgh, being the first in the city inducted into such a charge; and there his powerful intellect and his intensity of character soon secured for him a position of considerable prominence. In 1742 he caused some stir by the publication of an invective entitled *A warning against countenancing the ministrations of Mr. George Whitefield;* and in 1745 he was almost the only minister of Edinburgh who continued to preach, and to preach against rebellion, while the troops of Charles Edward were in occupation of the town. When in 1747 "the Associate Synod," by a narrow majority, decided not to give full immediate effect to a judgment which had been passed in the previous year against the lawfulness of the "Burgess

Oath,"[1] Gib led the protesting minority, who forthwith separated from their brethren and formed the Antiburgher Synod. It was chiefly under his influence that it was agreed by this ecclesiastical body at subsequent meetings to summon to the bar their "Burgher" brethren, and finally to depose and excommunicate them for contumacy. In 1765 he made a vigorous and able reply to the General Assembly of the Church of Scotland, which had stigmatized the Secession as "threatening the peace of the country;" and this apology was further developed in his *Display of the Secession Testimony*, published in 1774. From 1753 (when after protracted litigation he was compelled to leave the Bristo church) till within a short period of his death, which took place June 18, 1788, he preached regularly in Nicolson Street church, which is said to have been filled every Sunday with an audience of 2000 persons. Besides other publications, he wrote a volume of *Sacred Contemplations* (1786), to which was appended an "Essay on Liberty and Necessity" in reply to Lord Kames.

GIBBON. See APE, vol. ii. p. 132.

GIBBON, EDWARD (1737–1794), one of the most celebrated historians of any age or country, was also his own historian. He has left us one of the most piquant autobiographies ever written. In the following sketch the chief incidents of his life will be condensed from that authentic source. For more than facts, even for the setting of these, it is needless to say that it would be unwise to trust to any man's autobiography—though Gibbon's is as frank as most. There are points on which vanity will say too much, and perhaps others on which modesty will say too little.

Gibbon was descended, he tells us, from a Kentish family of considerable antiquity; among his remoter ancestors he reckons the Lord High Treasurer Fiennes, Lord Say and Sele, whom Shakespeare has immortalized in his *Henry VI.* His grandfather was a man of ability, an enterprising merchant of London, one of the commissioners of customs under the Tory ministry during the last four years of Queen Anne, and, in the judgment of Lord Bolingbroke, as deeply versed in the "commerce and finances of England" as any man of his time. He was not always wise, however, either for himself or his country; for he became deeply involved in the South Sea Scheme, in the disastrous collapse of which (1720) he lost the ample wealth he had amassed. As a director of the company, moreover, he was suspected of fraudulent complicity, taken into custody, and heavily fined; but £10,000 was allowed him out of the wreck of his estate, and with this his skill and enterprise soon constructed a second fortune. He died at Putney in 1736, leaving the bulk of his property to his two daughters—nearly disinheriting his only son, the father of the historian, for having married against his wishes. This son (by name Edward) was educated at Westminster[2] and Cambridge, but never took a degree, travelled, became member of Parliament, first for Petersfield (1734), then for Southampton (1741), joined the party against Sir Robert Walpole, and (as his son confesses, not much to his father's honor) was animated in so doing by "private revenge" against the supposed "oppressor" of his family in the South Sea affair. If so, revenge, as usual, was blind; for Walpole had sought rather to moderate than to inflame public feeling against the projectors.

The historian was born at Putney, Surrey, April 27 (Old Style), 1737. His mother, Judith Porten, was the daughter of a London merchant. He was the eldest of a family of six sons and a daughter, and the only one who survived childhood; his own life in youth hung by so mere a thread as to be again and again despaired of. His mother, between domestic cares and constant infirmities (which, however, did not prevent an occasional plunge into fashionable dissipation in compliance with her husband's wishes), did but little for him. The "true mother of his mind as well as of his health" was a maiden aunt—Catherine Porten by name—with respect to whom he expresses himself in language of the most grateful remembrance. "Many anxious and solitary days," says Gibbon, "did she consume with patient trial of every mode of relief and amusement. Many wakeful nights did she sit by my bedside in trembling expectation that each hour would be my last." As circumstances allowed, she appears to have taught him reading, writing, and arithmetic—acquisitions made with so little of remembered pain that "were not the error corrected by analogy," he says, "I should be tempted to conceive them as innate." At seven he was committed for eighteen months to the care of a private tutor, John Kirkby by name, and the author, among other things, of a "philosophical fiction," entitled the *Life of Automathes.* Of Kirkby, from whom he learned the rudiments of English and Latin grammar, he speaks gratefully, and doubtless truly, so far as he could trust the impressions of childhood. With reference to *Automathes* he is much more reserved in his praise, denying alike its originality, its depth, and its elegance; but, he adds, "the book is not devoid of entertainment or instruction."

In his ninth year (1746), during a "lucid interval of comparative health," he was sent to a school at Kingston-upon-Thames; but his former infirmities soon returned, and his progress, by his own confession, was slow and unsatisfactory. "My timid reserve was astonished by the crowd and tumult of the school; the want of strength and activity disqualified me for the sports of the play-field. . . . By the common methods of discipline, at the expense of many tears and some blood, I purchased the knowledge of the Latin syntax," but manifestly, in his own opinion, the *Arabian Nights*, Pope's *Homer*, and Dryden's *Virgil*, eagerly read, had at this period exercised a much more powerful influence on his intellectual development than Phædrus and Cornelius Nepos, "painfully construed and darkly understood."

In December, 1747, his mother died, and he was taken home. After a short time his father removed to the "rustic solitude" of Buriton (Hants), but young Gibbon lived chiefly at the house of his maternal grandfather, at Putney, where, under the care of his devoted aunt, he developed, he tells us, that passionate love of reading "which he would not exchange for all the treasures of India," and where his mind received its most decided stimulus. Of 1748 he says, "This year, the twelfth of my age, I shall note as the most propitious to the growth of my intellectual stature." After detailing the circumstances which unlocked for him the door of his grandfather's "tolerable library," he says, "I turned over many English pages of poetry and romance, of history and travels. Where a title attracted my eye, without fear or awe I snatched the volume from the shelf." In 1749, in his twelfth year, he was sent to Westminster, still residing, however, with his aunt, who, rendered destitute by her father's bankruptcy, but unwilling to live a life of dependence, had opened a boarding-house for Westminster school. Here in the course of two years (1749–50), interrupted by danger and debility, he "painfully climbed into the third form;" but it was left to his riper age to "acquire the beauties of the Latin and the rudiments of the Greek tongue." The continual attacks of sickness which had retarded his progress induced his aunt, by medical advice, to take him to Bath; but the mineral waters had no effect. He then resided for a time in the house of a physician at Winchester; the physician did as little as the mineral waters; and, after a further trial of Bath, he once more returned to Putney, and made a last futile attempt to study at Westminster. Finally, it was concluded that he would never be able to encounter the discipline of a school; and casual instructors, at various times and places, were provided for him. Meanwhile his indiscriminate appetite for reading had begun to fix itself more and more decidedly upon history; and the list of historical works devoured by him during this period of chronic ill-health is simply astonishing. It included, besides Hearne's *Ductor Historicus* and the successive volumes of the *Universal History*, which was then in course of publication, Littlebury's *Herodotus*, Spelman's *Xenophon*, Gordon's *Tacitus*, an anonymous translation of Procopius; "many crude lumps of Speed, Rapin, Mezeray, Davila, Machiavel, Father Paul, Bower, etc., were hastily gulped. I devoured them like so many novels; and I swallowed with the same voracious appetite the descriptions of India and China, of Mexico and Peru." His first introduction to the historic scenes the study of which afterwards formed the passion of his life took place in 1751, when, while along with his father visiting a friend in Wiltshire, he discovered in the library "a common book, the continuation of Echard's *Roman History*." "To me the reigns of the successors of Constantine were absolutely new; and I was immersed in the passage of the Goths over the Danube, when the summons of the dinner bell reluctantly dragged me from my intellectual feast." Soon afterwards his fancy kindled with the first glimpses into Oriental history, the wild "barbaric" charm of which he never ceased to feel. Ockley's book on the Saracens "first opened his eyes" to the striking career of Mahomet and his hordes; and with his characteristic ardor of literary research, after exhausting all that could be learned in English of the Arabs and Persians, the Tartars and Turks, he forthwith plunged into the French of D'Herbelot, and the Latin of Pocock's version of Abulfaragius, sometimes understanding them, but oftener only guessing their meaning. He soon learned to call to his aid the subsidiary sciences of geography and chronology, and before he was quite capable of reading them had already attempted to weigh in his childish balance the competing systems of Scaliger and Petavius, of Marsham and Newton. At this early period he seems already to have adopted in some degree the plan of study he followed in after life, and recommended in his *Essai sur l'Étude*—that is, of letting his subject rather than his author determine his course, of suspending the perusal of a book to reflect, and to compare the statements with those of other authors,—so that he often read portions of many volumes while mastering one.

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[1] This was an oath imposed upon all burgesses of Edinburgh, Glasgow, Perth, and some other towns, by which they "professed and allowed the true religion presently professed within this realm, and authorized by the laws thereof." The question was whether these words implied an approbation of the Established Church, with all its "corruptions."

[2] The celebrated William Law had been for some time the private tutor of this Edward Gibbon, who is supposed to have been the original of the rather clever sketch of "Flatus" in the *Serious Call.*

Towards his sixteenth year he tells us "nature displayed in his favor her mysterious energies," and all his infirmities suddenly vanished. Thenceforward, while never possessing or abusing the insolence of health, he could say "few persons have been more exempt from real or imaginary ills." His unexpected recovery revived his father's hopes for his education, hitherto so much neglected if judged by ordinary standards; and accordingly in January, 1752, he was placed at Esher, Surrey, under the care of Dr. Francis, the well known translator of Horace. But Gibbon's friends in a few weeks discovered that the new tutor preferred the pleasures of London to the instruction of his pupils, and in this perplexity decided to send him prematurely to Oxford, where he was matriculated as a gentleman commoner of Magdalen College, 3d April, 1752. According to his own testimony, he arrived at the university "with a stock of information which might have puzzled a doctor, and a degree of ignorance of which a school-boy might be ashamed." And indeed his huge wallet of scraps stood him in little stead at the trim banquets to which he was invited at Oxford, while the wandering habits by which he had filled it absolutely unfitted him to be a guest. He was not well grounded in any of the elementary branches, which are essential to university studies, and to all success in their prosecution. It was natural therefore that he should dislike the university, and as natural that the university should dislike him. Many of his complaints of the system were certainly just; but it may be doubted whether any university system would have been profitable to him, considering his antecedents. He complains especially of his tutors, and in one case with abundant reason; but, by his own confession, they might have recriminated with justice, for he indulged in gay society, and kept late hours. His observations, however, on the defects of the English university system, some of which have only very recently been removed, are acute and well worth pondering, however little relevant to his own case. He remained at Magdalen about fourteen months. "To the university of Oxford," he says, "I acknowledge no obligation; and she will as cheerfully renounce me for a son as I am willing to disclaim her for a mother. I spent fourteen months at Magdalen College; they proved the fourteen months the most idle and unprofitable of my whole life."

But thus "idle" though he may have been as a "student," he already meditated authorship. In the first long vacation—during which he, doubtless with some sarcasm, says that "his taste for books began to revive"—he contemplated a treatise on the age of Sesostris, in which (and it was characteristic) his chief object was to investigate not so much the events as the probable epoch of the reign of that semi-mythical monarch, whom he was inclined to regard as having been contemporary with Solomon. "Unprovided with original learning, unformed in the habits of thinking, unskilled in the arts of composition, I resolved to write a book;" but the discovery of his own weakness, he adds, was the first symptom of taste. On his first return to Oxford the work was "wisely relinquished," and never afterwards resumed. The most memorable incident, however, in Gibbon's stay at Oxford was his temporary conversion to the doctrines of the church of Rome. The bold criticism of Middleton's recently (1749) published, *Free Enquiry into the Miraculous Powers which are supposed to have subsisted in the Christian Church*, appears to have given the first shock to his Protestantism, not indeed by destroying his previous belief that the gift of miraculous powers had continued to subsist in the church during the first four or five centuries of Christianity, but by convincing him that within the same period most of the leading doctrines of popery had been already introduced both in theory and in practice. At this stage he was introduced by a friend (Mr. Molesworth) to Bossuet's *Variations of Protestantism*, and *Exposition of Catholic Doctrine* (see Gibbon, *Decline and Fall*, c. xv., note 79). "These works," says he, "achieved my conversion, and I surely fell by a noble hand." In bringing about this "fall," however, Parsons the Jesuit appears to have had a considerable share; at least Lord Sheffield has recorded that on the only occasion on which Gibbon talked with him on the subject he imputed the change in his religious views principally to that vigorous writer, who, in his opinion, had urged all the best arguments in favor of Roman Catholicism. But be this as it may, he had no sooner adopted his new creed than he resolved to profess it; "a momentary glow of enthusiasm" had raised him above all temporal considerations, and accordingly, on June 8, 1753, he records that having "privately abjured the heresies" of his childhood before a Catholic priest of the name of Baker, a Jesuit, in London, he announced the same to his father in an elaborate controversial epistle which his spiritual adviser much approved, and which he himself afterwards described to Lord Sheffield as having been "written with all the pomp, the dignity, and self-satisfaction of a martyr."

The elder Gibbon heard with indignant surprise of this act of juvenile apostacy, and, indiscreetly giving vent to his wrath, precipitated the expulsion of his son from Oxford, a punishment which the culprit, in after years at least, found no cause to deplore. In his *Memoirs* he speaks of the results of his "childish revolt against the religion of his country" with undisguised self-gratulation. It had delivered him for ever from the "port and prejudice" of the university, and led him into the bright paths of philosophic freedom. That his conversion was sincere at the time, that it marked a real if but a transitory phase of genuine religious conviction, we have no reason to doubt, notwithstanding the scepticism he has himself expressed. "To my present feelings it seems incredible that I should ever believe that I believed in transubstantiation," he indeed declares; but his incredulous astonishment is not unmixed with undoubting pride. "I could not blush that my tender mind was entangled in the sophistry which had reduced the acute and manly understandings of a Chillingworth or a Bayle." Nor is the sincerity of the Catholicism he professed in these boyish days in any way discredited by the fact of his subsequent lack of religion. Indeed, as one of the acutest and most sympathetic of his critics has remarked, the deep and settled grudge he has betrayed towards every form of Christian belief, in all the writings of his maturity, may be taken as evidence that he had at one time experienced in his own person at least some of the painful workings of a positive faith.

But little time was lost by the elder Gibbon in the formation of a new plan of education for his son, and in devising some method which if possible might effect the cure of his "spiritual malady." The result of deliberation, aided by the advice and experience of Lord Eliot, was that it was almost immediately decided to fix Gibbon for some years abroad under the roof of M. Pavilliard, a Calvinist minister at Lausanne. In as far as regards the instructor and guide thus selected, a more fortunate choice could scarcely have been made. From the testimony of his pupil, and the still more conclusive evidence of his own correspondence with the father, Pavilliard seems to have been a man of singular good sense, temper, and tact. At the outset, indeed, there was one considerable obstacle to the free intercourse of tutor and pupil: M. Pavilliard appears to have known little of English, and young Gibbon knew practically nothing of French. But this difficulty was soon removed by the pupil's diligence; the very exigencies of his situation were of service to him in calling forth all his powers, and he studied the language with such success that at the close of his five years' exile, he declares that he "spontaneously thought" in French rather than in English, and that it had become more familiar to "ear, tongue, and pen." It is well known that in after years he had doubts whether he should not compose his great work in French; and it is certain that his familiarity with that language, in spite of considerable efforts to counteract its effects, tinged his style to the last.

Under the judicious regulations of his new tutor a methodical course of reading was marked out, and most ardently prosecuted; the pupil's progress was proportionately rapid. With the systematic study of the Latin, and to a slight extent also of the Greek classics, he conjoined that of logic in the prolix system of Crousaz; and he further invigorated his reasoning powers, as well as enlarged his knowledge of metaphysics and jurisprudence, by the perusal of Locke, Grotius, and Montesquieu. He also read largely, though somewhat indiscriminately, in French literature, and appears to have been particularly struck with Pascal's *Provincial Letters*, which he tells us he reperused almost every year of his subsequent life with new pleasure, and which he particularly mentions as having been, along with Bleterie's *Life of Julian* and Giannone's *History of Naples*, a book which probably contributed in a special sense to form the historian of the Roman empire. The comprehensive scheme of study included mathematics also, in which he advanced as far as the conic sections in the treatise of L'Hôpital. He assures us that his tutor did not complain of any inaptitude on the pupil's part, and that the pupil was as happily unconscious of any on his own; but here he broke off. He adds, what is not quite clear from one who so frankly acknowledges his limited acquaintance with the science, that he had reason to congratulate himself that he knew no more. "As soon," he says, "as I understood the principles, I relinquished for ever the pursuit of the mathematics; nor can I lament that I desisted, before my mind was hardened by the habit of rigid demonstration, so destructive of the finer feelings of moral evidence, which must, however, determine the actions and opinions of our lives."

Under the new influences which were brought to bear on him, he in less than two years resumed his Protestantism. "He is willing," he says, to allow M. Pavilliard a "handsome share in his reconversion," though he maintains, and no doubt rightly, that it was principally due "to his own solitary reflections." He particularly congratulated himself on having discovered the "philosophical argument" against transubstantiation, "that the text of Scripture which seems to inculcate the real presence is attested only by a single sense—our sight, while the real presence itself is disproved by three of our senses—the sight, the touch, and the taste. Before a similar mode of reasoning, all the other distinctive articles of the Romish creed "disappeared like a dream;" and "after a full conviction," on Christmas day, 1754, he received the sacrament in the church of Lausanne. Although, however, he adds that at this point he suspended his religious inquiries, "acquiescing with implicit belief in the tenets and mysteries which are adopted by the general consent of Catholics and Protestants," his readers will probably do him no great injustice if they assume that even then it was rather to the negations than to the affirmations of Protestantism that he most heartily assented.

With all his devotion to study at Lausanne[1] (he read ten or twelve hours a day), he still found some time for the acquisition of some of the lighter accomplishments, such as riding, dancing, drawing, and also for mingling in such society as the place had to offer. In September, 1755, he writes to his aunt, "I find a great many agreeable people here, see them sometimes, and can say upon the whole, without vanity, that, though I am the Englishman here who spends the least money, I am he who is most generally liked." Thus his "studious and sedentary life" passed pleasantly enough, interrupted only at rare intervals by boyish excursions of a day or a week in the neighborhood, and by at least one memorable tour of Switzerland, by Basel, Zürich, Lucerne, and Bern, made along with Pavilliard in the autumn of 1755. The last eighteen months of this residence abroad saw the infusion of two new elements—one of them at least of considerable importance—into his life. In 1757 Voltaire came to reside at Lausanne; and although he took but little notice of the young Englishman of twenty, who eagerly sought and easily obtained an introduction, the establishment of the theatre at Monrepos, where the brilliant versifier himself declaimed before select audiences his own productions on the stage, had no small influence in fortifying Gibbon's taste for the French theatre, and in at the same time abating that "idolatry for the gigantic genius of Shakespeare which is inculcated from our infancy as the first duty of an Englishman." In the same year—apparently about June—he saw for the first time, and forthwith loved, the beautiful, intelligent, and accomplished Mademoiselle Susan Curchod, daughter of the pasteur of Crassier. That the passion which she inspired in him was tender, pure, and fitted to raise to a higher level a nature which in some respects was much in need of such elevation will be doubted by none but the hopelessly cynical; and probably there are few readers who can peruse the paragraph in which Gibbon "approaches the delicate subject of his early love" without discerning in it a pathos much deeper than that of which the writer was himself aware. During the remainder of his residence at Lausanne he had good reason to "indulge his dream of felicity;" but on his return to England, "I soon discovered that my father would not hear of this strange alliance, and that without his consent I was myself destitute and helpless. After a painful struggle I yielded to my fate; I sighed as a lover, I obeyed as a son; my wound was insensibly healed by time, absence, and the habits of a new life."[2]

In 1758 he returned with mingled joy and regret to England, and was kindly received at home. But he found a stepmother there; and this apparition on his father's hearth at first rather appalled him. The cordial and gentle manners of Mrs. Gibbon, however, and her unremitting care for his happiness, won him from his first prejudices, and gave her a permanent place in his esteem and affection. He seems to have been much indulged, and to have led a very pleasant life of it; he pleased himself in moderate excursions, frequented the theatre, mingled, though not very often, in society; was sometimes a little extravagant, and sometimes a little dissipated, but never lost the benefits of his Lausanne exile; and easily settled into a sober, discreet, calculating Epicurean philosopher, who sought the *summum bonum* of man in temperate, regulated, and elevated pleasure. The first two years after his return to England he spent principally at his father's country seat at Buriton, in Hampshire, only nine months being given to the metropolis. He has left an amusing account of his employments in the country, where his love of study was at once inflamed by a large and unwonted command of books and checked by the necessary interruptions of his otherwise happy domestic life. After breakfast "he was expected," he says, to spend an hour with Mrs. Gibbon; after tea his father claimed his conversation; in the midst of an interesting work he was often called down to entertain idle visitors; and, worst of all, he was periodically compelled to return the well-meant compliments. He mentions that he dreaded the "recurrence of the full moon," which was the period generally selected for the more convenient accomplishment of such formidable excursions.

His father's library, though large in comparison with that he commanded at Lausanne, contained, he says, "much trash;" but a gradual process of reconstruction transformed it at length into that "numerous and select" library which was "the foundation of his works, and the best comfort of his life both at home and abroad." No sooner had he returned home than he began the work of accumulation, and records that, on the receipt of his first quarter's allowance, a large share was appropriated to his literary wants. "He could never forget," he declares, "the joy with which he exchanged a bank note of twenty pounds for the twenty volumes of the *Memoirs* of the Academy of Inscriptions," an academy which has been well characterized (by Sainte-Beuve) as Gibbon's intellectual fatherland. It may not be uninteresting here to note the principles which guided him both now and afterwards in his literary purchases. "I am not conscious," says he, "of having ever bought a book from a motive of ostentation; every volume, before it was deposited on the shelf, was either read or sufficiently examined;" he also mentions that he soon adopted the tolerating maxim of the elder Pliny, that no book is ever so bad as to be absolutely good for nothing.

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[1] The *Journal* for 1755 records that during that year, besides writing and translating a great deal in Latin and French, he had read, amongst other works, Cicero's *Epistolæ ad Familiares*, his *Brutus*, all his *Orations*, his dialogues *De Amicitia* and *De Senectute*, Terence (twice), and Pliny's *Epistles*. In January, 1756, he says:—"I determined to read over the Latin authors in order, and read this year Virgil, Sallust, Livy, Velleius Paterculus, Valerius Maximus, Tacitus, Suetonius, Quintus Curtius, Justin, Florus, Plautus, Terence, and Lucretius. I also read and meditated Locke *Upon the Understanding*." Again in January, 1757, he writes:—"I began to study algebra under M. de Traytorrens, went through the elements of algebra and geometry, and the three first books of the Marquis de l'Hôpital's *Conic Sections*. I also read Tibullus, Catullus, Propertius, Horace (with Dacier's and Torrentius's notes), Virgil, Ovid's *Epistles*, with Meziriac's commentary, the *Ars Amandi*, and the *Elegies;* likewise the *Augustus* and *Tiberius* of Suetonius, and a Latin translation of Dion Cassius from the death of Julius Cæsar to the death of Augustus. I also continued my correspondence, begun last year, with M. Allamand of Bex, and the Professor Breitinger of Zürich, and opened a new one with the Professor Gesner of Göttingen. *N.B.*—Last year and this I read St. John's Gospel, with part of Xenophon's *Cyropædia*, the *Iliad*, and Herodotus; but, upon the whole, I rather neglected my Greek."

[2] The affair, however, was not finally broken off till 1763. Mdlle. Curchod soon afterwards became the wife of Necker, the famous financier; and Gibbon and the Neckers frequently afterwards met on terms of mutual friendship and esteem.

In London he seems to have seen but little select society,—partly from his father's taste, "which had always preferred the highest and the lowest company," and partly from his own reserve and timidity, increased by his foreign education, which had made English habits unfamiliar, and the very language in some degree strange. And thus he was led to draw that interesting picture of the literary recluse among the crowds of London: "While coaches were rattling through Bond Street, I have passed many a solitary evening in my lodging with my books. My studies were sometimes interrupted with a sigh, which I breathed towards Lausanne; and on the approach of spring I withdrew without reluctance from the noisy and extensive scene of crowds without company, and dissipation without pleasure." He renewed former acquaintance, however, with the "poet" Mallet, and through him gained access to Lady Hervey's circle, where a congenial admiration, not to say affectation, of French manners and literature made him a welcome guest. It ought to be added that in each of the twenty-five years of his subsequent acquaintance with London "the prospect gradually brightened," and his social as well as his intellectual qualities secured him a wide circle of friends. In one respect Mallet gave him good counsel in those early days. He advised him to addict himself to an assiduous study of the more idiomatic English writers, such as Swift and Addison,—with a view to unlearn his foreign idiom, and recover his half-forgotten vernacular,—a task, however, which he never perfectly accomplished. Much as he admired these writers, Hume and Robertson were still greater favorites, as well from their subject as for their style. Of his admiration of Hume's style, of its nameless grace of simple elegance, he has left us a strong expression, when he tells us that it often compelled him to close the historian's volumes with a mixed sensation of delight and despair.

In 1761 Gibbon, at the age of twenty-four, after many delays, and with many flutterings of hope and fear, gave to the world, in French, his maiden publication, an *Essai sur l'Étude de la Littérature*, which he had composed two years before. It was published partly in compliance with his father's wishes, who thought that the proof of some literary talent might introduce him favorably to public notice, and secure the recommendation of his friends for some appointment in connection with the mission of the English plenipotentiaries to the congress at Augsburg which was at that time in contemplation. But in yielding to paternal authority, Gibbon frankly owns that he "complied, like a pious son, with the wish of his own heart."

The subject of this youthful effort was suggested, its author says, by a refinement of vanity—"the desire of justifying and praising the object of a favorite pursuit," namely, the study of ancient literature. Partly owing to its being written in French, partly to its character, the *Essai* excited more attention abroad than at home. Gibbon has criticised it with the utmost frankness, not to say severity; but, after every abatement, it is unquestionably a surprising effort for a mind so young, and contains many thoughts which would not have disgraced a thinker or a scholar of much maturer age. His account of its first reception and subsequent fortunes in England deserves to be cited as a curious piece of literary history. "In England," he says, "it was received with cold indifference, little read, and speedily forgotten. A small impression was slowly dispersed; the bookseller murmured, and the author (had his feelings been more exquisite) might have wept over the blunders and baldness of the English translation. The publication of my history fifteen years afterwards revived the memory of my first performance, and the essay was eagerly sought in the shops. But I refused the permission which Becket solicited of reprinting it; the public curiosity was imperfectly satisfied by a pirated copy of the booksellers of Dublin; and when a copy of the original edition has been discovered in a sale, the primitive value of half-a-crown has risen to the fanciful price of a guinea or thirty shillings."[1]

Some time before the publication of the essay, Gibbon had entered a new and, one might suppose, a very uncongenial scene of life. In an hour of patriotic ardor he became (June 12, 1759) a captain in the Hampshire militia, and for more than two years (May 10, 1760, to December 23, 1762) led a wandering life of "military servitude." Hampshire, Kent, Wiltshire, and Dorsetshire formed the successive theatres of what he calls his "bloodless and inglorious campaigns." He complains of the busy idleness in which his time was spent; but, considering the circumstances, so adverse to study, one is rather surprised that the military student should have done so much, than that he did so little; and never probably before were so many hours of literary study spent in a tent. In estimating the comparative advantages and disadvantages of this wearisome period of his life, he has summed up with the impartiality of a philosopher and the sagacity of a man of the world. Irksome as were his employments, grievous as was the waste of time, uncongenial as were his companions, solid benefits were to be set off against these things: his health became robust, his knowledge of the world was enlarged, he wore off some of his foreign idiom, got rid of much of his reserve; he adds—and perhaps in his estimate it was the benefit to be most prized of all—"the discipline and evolutions of a modern battalion gave me a clearer notion of the phalanx and the legion, and the captain of the Hampshire grenadiers (the reader may smile) has not been useless to the historian of the Roman empire."

It was during this period that he read Homer and Longinus, having for the first time acquired some real mastery of Greek; and after the publication of the *Essai*, his mind was full of projects for a new literary effort. The Italian expedition of Charles VIII. of France, the crusade of Richard I., the wars of the barons, the lives and comparisons of Henry V. and the emperor Titus, the history of the Black Prince, the life of Sir Philip Sydney, that of Montrose, and finally that of Sir W. Raleigh, were all of them seriously contemplated and successively rejected. By their number they show how strong was the impulse to literature, and, by their character, how determined the bent of his mind in the direction of history; while their variety makes it manifest also that he had then at least no special purpose to serve, no preconceived theory to support, no particular prejudice or belief to overthrow.

The militia was disbanded in 1762, and Gibbon joyfully shook off his bonds; but his literary projects were still to be postponed. Following his own wishes, though with his father's consent, he had early in 1760 projected a Continental tour as the completion "of an English gentleman's education." This had been interrupted by the episode of the militia; now, however, he resumed his purpose, and left England in January, 1763. Two years were "loosely defined as the term of his absence," which he exceeded by half a year—returning June, 1765. He first visited Paris, where he saw a good deal of D'Alembert, Diderot, Barthélemy, Raynal, Helvétius, Baron d'Holbach, and others of that circle, and was often a welcome guest in the saloons of Madame Geoffrin and Madame du Deffand.[2] Voltaire was at Geneva, Rousseau at Montmorency, and Buffon he neglected to visit; but so congenial did he find the society for which his education had so well prepared him, and into which some literary reputation had already preceded him, that he declared, "Had I been rich and independent, I should have prolonged, and perhaps have fixed my residence at Paris."

From France he proceeded to Switzerland, and spent nearly a year at Lausanne, where many old friendships and studies were resumed, and new ones begun. His reading was largely designed to enable him fully to profit by the long contemplated Italian tour which began in April, 1764, and lasted somewhat more than a year. He has recorded one or two interesting notes on Turin, Genoa, Florence, and other towns at which halt was made on his route; but Rome was the great object of his pilgrimage, and the words in which he has alluded to the feelings with which he approached it are such as cannot be omitted from any sketch of Gibbon, however brief: "My temper is not very susceptible of enthusiasm, and the enthusiasm which I do not feel I have ever scorned to affect. But at the distance of twenty-five years, I can neither forget nor express the strong emotions which agitated my mind as I first approached and entered the Eternal City. After a sleepless night I trod with a lofty step the ruins of the forum; each memorable spot where Romulus stood, or Tully spoke, or Cæsar fell, was at once present to my eye; and several days of intoxication were lost or enjoyed before I could descend to a cool and minute investigation." Here at last his long yearning for some great theme worthy of his historic genius was gratified. The first conception of the *Decline and Fall* arose as he lingered one evening amidst the vestiges of ancient glory. "It was at Rome, on the 15th of October, 1764, as I sat musing amidst the ruins of the Capitol, while the barefooted friars were singing vespers in the temple of Jupiter, that the idea of writing the decline and fall of the city first started to my mind."

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[1] The *Essai*, in a good English translation, now appears in the *Miscellaneous Works*. Villemain finds in it "peu de vues, nulle originalité surtout, mais une grande passion littéraire, l'amour des recherches savantes et du beau langage." Sainte-Beuve's criticism is almost identical with Gibbon's own; but though he finds that "La lecture en est assez difficile et parfois obscure, la liaison des idées échappe souvent par trop de concision et par le désir qu'a eu le jeune auteur d'y faire entrer, d'y condenser la plupart de ses notes," he adds, "Il y a, chemin faisant, des vues neuves et qui sentent l'historien."

[2] Her letters to Walpole about Gibbon contain some interesting remarks by this "aveugle clairvoyante," as Voltaire calls her; but they belong to a later period (1777).

The five years and a half which intervened between his return from this tour, in June, 1765, and the death of his father, in November, 1770, seem to have formed the portion of his life which "he passed with the least enjoyment, and remembered with the least satisfaction." He attended every spring the meetings of the militia at Southampton, and rose successively to the rank of major and lieutenant-colonel commandant; but was each year "more disgusted with the inn, the wine, the company, and the tiresome repetition of annual attendance and daily exercise." From his own account, however, it appears that other and deeper causes produced this discontent. Sincerely attached to his home, he yet felt the anomaly of his position. At thirty, still a dependant, without a settled occupation, without a definite social status, he often regretted that he had not "embraced the lucrative pursuits of the law or of trade, the chances of civil office or India adventure, or even the fat slumbers of the church." From the emoluments of a profession he "might have derived an ample fortune, or a competent income, instead of being stinted to the same narrow allowance, to be increased only by an event which he sincerely deprecated." Doubtless the secret fire of a consuming, but as yet ungratified, literary ambition also troubled his repose. He was still contemplating "at an awful distance" *The Decline and Fall*, and meantime revolved some other subjects, that seemed more immediately practicable. Hesitating for some time between the revolutions of Florence and those of Switzerland, he consulted M. Deyverdun, a young Swiss with whom he had formed a close and intimate friendship during his first residence at Lausanne, and finally decided in favor of the land which was his "friend's by birth" and "his own by adoption." He executed the first book in French; it was read (in 1767) as an anonymous production, before a literary society of foreigners in London, and condemned. Gibbon sat and listened unobserved to their strictures. It never got beyond that rehearsal; Hume, indeed, approved of the performance, only deprecating as unwise the author's preference for French; but Gibbon sided with the majority.

In 1767 also he joined with M. Deyverdun in starting a literary journal under the title of *Mémoires Littéraires de la Grande Bretagne*. But its circulation was limited, and only the second volume had appeared (1768) when Deyverdun went abroad. The materials already collected for a third volume were suppressed. It is interesting, however, to know that in the first volume is a review by Gibbon of Lord Lyttelton's *History of Henry II.*, and that the second volume contains a contribution by Hume on Walpole's *Historic Doubts*.

The next appearance of the historian made a deeper impression. It was the first distinct print of the lion's foot. "Ex ungue leonem" might have been justly said, for he attacked, and attacked successfully, the redoubtable Warburton. Of the many paradoxes in the *Divine Legation*, few are more extravagant than the theory that Virgil, in the sixth book of his *Æneid*, intended to allegorize, in the visit of his hero and the Sibyl to the shades, the initiation of Æneas, as a lawgiver, into the Eleusinian mysteries. This theory Gibbon completely exploded in his *Critical Observations* (1770),—no very difficult task, indeed, but achieved in a style, and with a profusion of learning, which called forth the warmest commendations both at home and abroad. Warburton never replied; and few will believe that he would not, if he had not thought silence more discreet. Gibbon, however, regrets that the style of his pamphlet was too acrimonious; and this regret, considering his antagonist's slight claims to forbearance, is creditable to him. "I cannot forgive myself the contemptuous treatment of a man who, with all his faults, was entitled to my esteem; and I can less forgive, in a personal attack, the cowardly concealment of my name and character."

Soon after his "release from the fruitless task of the Swiss revolution" in 1768, he had gradually advanced from the wish to the hope, from the hope to the design, from the design to the execution of his great historical work. His preparations were indeed vast. The classics, "as low as Tacitus, Pliny the Younger, and Juvenal," had been long familiar. He now "plunged into the ocean of the Augustan history," and "with pen almost always in hand," pored over all the original records, Greek and Latin, between Trajan and the last of the Western Cæsars. "The subsidiary rays of medals and inscriptions, of geography and chronology, were thrown on their proper objects; and I applied the collections of Tillemont, whose inimitable accuracy almost assumes the character of genius, to fix and arrange within my reach the loose and scattered atoms of historical information." The Christian apologists and their pagan assailants; the Theodosian Code, with Godefroy's commentary; the *Annals and Antiquities* of Muratori, collated with "the parallel or transverse lines" of Sigonius and Maffei, Pagi and Baronius, were all critically studied. Still following the wise maxim which he had adopted as a student, "multum legere potius quam multa," he reviewed again and again the immortal works of the French and English, the Latin and Italian classics. He deepened and extended his acquaintance with Greek, particularly with his favorite authors Homer and Xenophon; and, to crown all, he succeeded in achieving the third perusal of Blackstone's *Commentaries*.

The course of his study was for some time seriously interrupted by his father's illness and death in 1770, and by the many distractions connected with the transference of his residence from Buriton to London. It was not, indeed, until October, 1772, that he found himself at last independent, and fairly settled in his house and library, with full leisure and opportunity to set about the composition of the first volume of his history. Even then it appears from his own confession that he long brooded over the chaos of materials he had amassed before light dawned upon it. At the commencement, he says, "all was dark and doubtful;" the limits, divisions, even the title of his work were undetermined; the first chapter was composed three times, and the second and third twice, before he was satisfied with his efforts. This prolonged meditation on his design and its execution was ultimately well repaid by the result: so methodical did his ideas become, and so readily did his materials shape themselves, that, with the above exceptions, the original MS. of the entire six quartos was sent uncopied to the printers. He also says that not a sheet had been seen by any other eyes than those of author and printer, a statement indeed which must be taken with a small deduction; or rather we must suppose that a few chapters had been submitted, if not to the "eyes," to the "ears" of others; for he elsewhere tells us that he was "soon disgusted with the modest practice of reading the manuscript to his friends." Such, however, were his preliminary difficulties that he confesses he was often "tempted to cast away the labor of seven years;" and it was not until February, 1776, that the first volume was published. The success was instant, and, for a quarto, probably unprecedented. The entire impression was exhausted in a few days; a second and a third edition were scarcely adequate to the demand. The author might almost have said, as Lord Byron after the publication of *Childe Harold*, that "he awoke one morning and found himself famous." In addition to public applause, he was gratified by the more select praises of the highest living authorities in that branch of literature: "the candor of Dr. Robertson embraced his disciple;" Hume's letter of congratulation "overpaid the labor of ten years." The latter, however, with his usual sagacity, anticipated the objections which he saw could be urged against the famous fifteenth and sixteenth chapters. "I think you have observed a very prudent temperament; but it was impossible to treat the subject so as not to give grounds of suspicion against you, and you may expect that a clamor will arise."

The "clamor" thus predicted was not slow to make itself heard. Within two years the famous chapters had elicited what might almost be called a library of controversy. The only attack, however, to which Gibbon deigned to make any reply was that of Davies, who had impugned his accuracy or good faith. His *Vindication* appeared in February, 1779; and, as Milman remarks, "this single discharge from the ponderous artillery of learning and sarcasm laid prostrate the whole disorderly squadron" of his rash and feeble assailants.[1]

Two years before the publication of this first volume Gibbon was elected member of parliament for Liskeard (1774). His political duties did not suspend his prosecution of his history, except on one occasion, and for a little while, in 1779, when he undertook, on behalf of the ministry, a task which, if well performed, was also, it must be added, well rewarded. The French Government had issued a manifesto preparatory to a declaration of war, and Gibbon was solicited by Chancellor Thurlow and Lord Weymouth, secretary of state, to answer it. In compliance with this request he produced the able *Mémoire Justificatif*, composed in French, and delivered to the courts of Europe; and shortly afterwards he received a seat at the Board of Trade and Plantations,—little more than a sinecure in itself, but with a very substantial salary of nearly £800 per annum. His acceptance displeased some of his former political associates, and he was accused of "deserting his party." In his *Memoir*, indeed, Gibbon denies that he had ever enlisted with the Whigs. A note of Fox, however, on the margin of a copy of *The Decline and Fall* records a very distinct remembrance of the historian's previous vituperation of the ministry; within a fortnight of the date of his acceptance of office, he is there alleged to have said that "there was no salvation for this country until six heads of the principal persons in administration were laid upon the table." Lord Sheffield merely replies, somewhat weakly it must be said, that his friend never intended the words to be taken literally. More to the point is the often-quoted passage from Gibbon's letter to Deyverdun, where the frank revelation is made: "You have not forgotten that I went into parliament without patriotism and without ambition, and that all my views tended to the convenient and respectable place of a lord of trade."

In April, 1781, the second and third quartos of his *History* were published. They excited no controversy, and were comparatively little talked about—so little, indeed, as to have extorted from him a half murmur about "coldness and prejudice." The volumes, however, were bought and read with silent avidity. Meanwhile public events were developing in a manner that had a considerable influence upon the manner in which the remaining years of the historian's life were spent. At the general election in 1780 he had lost his seat for Liskeard, but had subsequently been elected for Lymington. The ministry of Lord North, however, was tottering, and soon after fell; the Board of Trade was abolished by the passing of Burke's bill in 1782, and Gibbon's salary vanished with it,—no trifle, for his expenditure had been for three years on a scale somewhat disproportionate to his private fortune. He did not like to depend on statesmen's promises, which are proverbially uncertain of fulfilment; he as little liked to retrench; and he was wearied of parliament, where he had never given any but silent votes. Urged by such considerations, he once more turned his eyes to the scene of his early exile, where he might live on his decent patrimony in a style which was impossible in England, and pursue unembarrassed his literary studies. He therefore resolved to fix himself at Lausanne.

A word only is necessary on his parliamentary career. Neither nature nor acquired habits qualified him to be an orator; his late entrance on public life, his natural timidity, his feeble voice, his limited command of idiomatic English, and even, as he candidly confesses, his literary fame, were all obstacles to success. "After a fleeting, illusive hope, prudence condemned me to acquiesce in the humble station of a mute.[2] . . . I was not armed by nature and education with the intrepid energy of mind and voice—'Vincentem strepitus et natum rebus agendis.' Timidity was fortified by pride, and even the success of my pen discouraged the trial of my voice." His repugnance to public life had been strongly expressed to his father in a letter of a very early date, in which he begged that the money which a seat in the House of Commons would cost, might be expended in a mode more agreeable to him. Gibbon was eight-and-thirty when he entered parliament; and the obstacles which even at an earlier period he had not had courage to encounter, were hardly likely to be vanquished then. Nor had he much political sagacity. He was better skilled in investigating the past than in divining the future. While Burke and Fox and so many great statesmen proclaimed the consequences of the collision with America, Gibbon saw nothing but colonies in rebellion, and a paternal Government justly incensed. His silent votes were all given on that hypothesis. In a similar manner, while he abhorred the French Revolution when it came, he seems to have had no apprehension, like Chesterfield, Burke, or even Horace Walpole, of its approach; nor does he appear to have at all suspected that it had had anything to do with the speculations of the philosophic coteries in which he had taken such delight. But while it may be doubted whether his presence in Parliament was of any direct utility to the legislative business of the country, there can be no question of the present advantage which he derived from it in the prosecution of the great work of his life,—an advantage of which he was fully conscious when he wrote: "The eight sessions that I sat in parliament were a school of civil prudence, the first and most essential virtue of an historian."

Having sold all his property except his library—to him equally a necessary and a luxury—Gibbon repaired to Lausanne in September, 1783, and took up his abode with his early friend Deyverdun, now a resident there. Perfectly free from every engagement but those which his own tastes imposed, easy in his circumstances, commanding just as much society, and that as select, as he pleased, with the noblest scenery spread out at his feet, no situation can be imagined more favorable for the prosecution of his literary enterprise; a hermit in his study as long as he chose, he found the most delightful recreation always ready for him at the threshold. "In London," says he, "I was lost in the crowd; I ranked with the first families in Lausanne, and my style of prudent expense enabled me to maintain a fair balance of reciprocal civilities. . . . Instead of a small house between a street and a stable-yard, I began to occupy a spacious and convenient mansion, connected on the north side with the city, and open on the south to a beautiful and boundless horizon. A garden of four acres had been laid out by the taste of M. Deyverdun; from the garden a rich scenery of meadows and vineyards descends to the Leman Lake, and the prospect far beyond the lake is crowned by the stupendous mountains of Savoy." In this enviable retreat, it is no wonder that a year should have been suffered to roll round before he vigorously resumed his great work,—and with many men it would never have been resumed in such a paradise. We may remark in passing, that the retreat was often enlivened, or invaded, by friendly tourists from England, whose "frequent incursions" into Switzerland our recluse seems half to lament as an evil. Among his more valued visitors were M. and Mme. Necker; Mr. Fox also gave him two welcome "days of free and private society" in 1788. Differing as they did in politics, Gibbon's testimony to the genius and character of the great statesman is highly honorable to both: "Perhaps no human being," he says, "was ever more perfectly exempt from the taint of malevolence, vanity, or falsehood."

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[1] For a very full list of publications in answer to Gibbon's attack on Christianity reference may be made to the *Bibliographer's Manual*, pp. 885–6 (1858). Of these the earliest were Watson's *Apology* (1776), Salisbury's *Strictures* (1776), and Chelsum's (anonymous) *Remarks* (1776). In 1778 the *Few Remarks* by a Gentleman (Francis Eyre), the *Reply* of Loftus, the *Letters* of Apthorpe, and the *Examination* of Davies appeared. Gibbon's *Vindication* (1779) called forth a *Reply* by Davies (1779), and *A Short Appeal to the Public* by Francis Eyre (1779). Laughton's polemical treatise was published in 1780, and those of Milner and Taylor in 1781. Chelsum returned to the attack in 1785 (*A Reply to Mr. Gibbon's Vindication*), and Sir David Dalrymple (*An Inquiry into the Secondary Causes*, etc.) made his first appearance in the controversy in 1786. Travis's *Letters on 1 John v. 7* are dated 1784; and Spedalieri's *Confutazione dell' Esame del Cristianismo fatto da Gibbon* was published at Rome (2 vols. 4to) in the same year. It is impossible not to concur in almost every point with Gibbon's own estimate of his numerous assailants. Their crude productions, for the most part, were conspicuous rather for insolence and abusiveness than for logic or learning. Those of Bishop Watson and Lord Hailes were the best, but simply because they contented themselves with a dispassionate exposition of the general argument in favor of Christianity. The most foolish and discreditable was certainly that of Davies; his unworthy attempt to depreciate the great historian's learning, and his captious, cavilling, acrimonious charges of petty inaccuracies and discreditable falsification gave the object of his attack an easy triumph.

[2] In 1775 he writes to Holroyd, "I am still a mute; it is more tremendous than I imagined; the great speakers fill me with despair; the bad ones with terror."

When once fairly reseated at his task, he proceeded in this delightful retreat leisurely, yet rapidly, to its completion. The fourth volume, partly written in 1782, was completed in June, 1784; the preparation of the fifth volume occupied less than two years; while the sixth and last, begun 18th May, 1786, was finished in thirteen months. The feelings with which he brought his labors to a close must be described in his own inimitable words: "It was on the day, or rather night, of the 27th of June, 1787, between the hours of eleven and twelve, that I wrote the last lines of the last page in a summer house in my garden. After laying down my pen, I took several turns in a *berceau* or covered walk of acacias, which commands a prospect of the country, the lake, and the mountains. The air was temperate, the sky was serene, the silver orb of the moon was reflected from the waters, and all nature was silent. I will not dissemble the first emotions of joy on the recovery of my freedom, and, perhaps, the establishment of my fame. But my pride was soon humbled, and a sober melancholy was spread over my mind by the idea that I had taken an everlasting leave of an old and agreeable companion, and that whatsoever might be the future date of my *History*, the life of the historian must be short and precarious."

Taking the manuscript with him, Gibbon, after an absence of four years, once more visited London in 1787; and the 51st anniversary of the author's birthday (27th April, 1788) witnessed the publication of the last three volumes of *The Decline and Fall*. They met with a quick and easy sale, were very extensively read, and very liberally and deservedly praised for the unflagging industry and vigor they displayed, though just exception, if only on the score of good taste, was taken to the scoffing tone he continued to maintain in all passages where the Christian religion was specially concerned, and much fault was found with the indecency of some of his notes.[1]

He returned to Switzerland in July, 1788, cherishing vague schemes of fresh literary activity; but genuine sorrow caused by the death of his friend Deyverdun interfered with steady work, nor was it easy for him to fix on a new subject which should be at once congenial and proportioned to his powers; while the premonitory mutterings of the great thunderstorm of the French Revolution, which reverberated in hollow echoes even through the quiet valleys of Switzerland, further troubled his repose. For some months he found amusement in the preparation of the delightful *Memoirs* (1789) from which most of our knowledge of his personal history is derived; but his letters to friends in England, written between 1788 and 1793 occasionally betray a slight but unmistakable tone of *ennui*. In April, 1793, he unexpectedly received tidings of the death of Lady Sheffield; and the motive of friendship thus supplied combined with the pressure of public events to urge him homewards. He arrived in England on the following June, and spent the summer at Sheffield Place, where his presence was even more highly prized than it had ever before been. Returning to London early in November, he found it necessary to consult his physicians for a symptom which, neglected since 1761, had gradually become complicated with hydrocele, and was now imperatively demanding surgical aid; but the painful operations which had to be performed did not interfere with his customary cheerfulness, nor did they prevent him from paying a Christmas visit to Sheffield Place. Here, however, fever made its appearance; and a removal to London (January 6, 1794) was considered imperative. Another operation brought him some relief; but a relapse occurred during the night of the 15th, and on the following day he peacefully breathed his last. His remains were laid in the burial place of the Sheffield family, Fletching, Sussex, where an epitaph by Dr. Parr describes his character and work in the language at once of elegance, of moderation, and of truth.

The personal appearance of Gibbon as a lad of sixteen is brought before us somewhat dimly in M. Pavilliard's description of the "thin little figure, with a large head, disputing and arguing, with the greatest ability, all the best arguments that had ever been used in favor of popery." What he afterwards became has been made more vividly familiar by the clever silhouette prefixed to the *Miscellaneous Works* (Gibbon himself, at least, we know, did not regard it as a caricature), and by Sir Joshua Reynolds's portrait so often engraved. It is hardly fair perhaps to add a reference to Suard's highly-colored description of the short Silenus-like figure, not more than 56 inches in height, the slim legs, the large turned-in feet, the shrill piercing voice; but almost every one will remember, from Croker's *Boswell*, Colman's account of the great historian "tapping his snuff-box, smirking and smiling, and rounding his periods" from that mellifluous mouth. It has already been seen that Gibbon's early ailments all left him on the approach of manhood; thenceforward, "till admonished by the gout," he could truly boast of an immunity well-nigh perfect from every bodily complaint; an exceptionally vigorous brain, and a stomach "almost too good," united to bestow upon him a vast capacity alike for work and for enjoyment. This capacity he never abused so as to burden his conscience or depress his spirits. "The madness of superfluous health I have never known." To illustrate the intensity of the pleasure he found alike in the solitude of his study and in the relaxations of genial social intercourse, almost any page taken at random, either from the *Life* or from the *Letters*, would suffice; and many incidental touches show that he was not a stranger to the delights of quiet contemplation of the beauties and grandeurs of nature. His manners, if formal, were refined; his conversation, when he felt himself at home, interesting and unaffected; and that he was capable alike of feeling and inspiring a very constant friendship there are many witnesses to show. That his temperament at the same time was frigid and comparatively passionless cannot be denied; but neither ought this to be imputed to him as a fault; hostile criticisms upon the grief for a father's death, that "was soothed by the conscious satisfaction that I had discharged all the duties of filial piety," seem somewhat out of place. His most ardent admirers, however, are constrained to admit that he was deficient in large-hearted benevolence; that he was destitute of any "enthusiasm of humanity;" and that so far as every sort of religious yearning or aspiration is concerned, his poverty was almost unique. Gibbon was such a man as Horace might have been, had the Roman Epicurean been fonder of hard intellectual work, and less prone than he was to the indulgence of emotion.

Of Gibbon's mental qualities it is interesting to read the estimate formed and recorded by himself on his twenty-sixth birthday [May 8th, N. S., 1762]: "Wit I have none. My imagination is rather strong than pleasing. My memory both capacious and retentive. The shining qualities of my understanding are extensiveness and penetration; but I want both quickness and exactness." Twenty-six years afterwards he wrote on the same subject in his *Memoirs*:—"The original soil has been highly improved by cultivation; but it may be questioned whether some flowers of fancy, some grateful errors, have not been eradicated with the weeds of prejudice." No student of *The Decline and Fall* will accuse its author of immodesty or vanity in these self-appreciations, but will rather be surprised that he should have so considerably underestimated both his endowments and his acquirements. Of the kind and amount of varied ability displayed in that truly immortal work it would be almost impossible to speak in language of exaggerated praise,—the grandeur and vastness of conception, the artistic grouping, the masterly fulness and accuracy of detail, the richness and vividness of description, the coruscating liveliness, the polished sarcasm, the pungent wit. The history of Rome is, for the many centuries which Gibbon treats, the history of the world; and it is nothing less than astonishing that he should have been able to work with so much ease the vast and incongruous materials into such a unity of design. It is the amplest historic canvas ever spread, the largest historic painting ever executed by a single hand; and only a comprehensive and orderly intellect of the highest rank could have grappled as Gibbon has done with the task of blending that vast array of nations, in all their varieties of costume, habit, language, and religion, into one picturesque and harmonious whole. If Gibbon had ever been conscious of any inexactitude in his mental habit, it was a defect which he very early and very successfully remedied. No man could declare more honestly than he that "curiosity as well as duty had led him carefully to examine all the original documents that could illustrate the subject which he had undertaken to treat." With incredible labor he was able to bring at last to his great life-work a mind capable equally of ascending to the most comprehensive, and of descending to the most minute surveys; of appreciating the beautiful and sublime in classic literature, and yet of delighting in the verbal criticism, the tedious collation, and dry antiquarian research by which the text is established or illustrated; of celebrating the more imposing events of history with congenial pomp of description, and of investigating with the dullest plodder's patience and perseverance the origin of nations, the emigrations of obscure tribes, and the unpromising yet instructive problems which ethnology presents. In his pages the widest deductions of historic philosophy alternate with attempts to fix the true reading of an obscure passage or a minute point of chronology or geography. It may even be said that in these last investigations he took almost as much delight as in depicting the grander scenes of history, and surrendered himself as absolutely for the time to the early migrations of the Goths and Scythians as to the campaigns of Belisarius or the conquests of the Saracens. Never has historian evinced greater logical sagacity in making comparatively obscure details yield important inferences, or held with firmer hand the balance in the case of conflicting probabilities; by no one has sounder judgment or greater self-control been, on the whole, more uniformly exhibited in cases where it is so easy for learned enthusiasm to run into fanciful hypotheses.

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[1] An anonymous pamphlet, entitled *Observations on the three last volumes of the Roman History*, appeared in 1788; Disney's *Sermon, with Strictures*, in 1790; and Whitaker's *Review*, in 1791. With regard to the second of the above complaints, surprise will probably be felt that it was not extended to portions of the text as well as to the notes.

While thus entitled to great and manifold praise, *The Decline and Fall* has not been, and can never be, exempt from a certain measure of just censure. Even when the occasional Gallicisms and grammatical absurdities pointed out by the industry of critics have been willingly overlooked, there yet remains something to be said on the defects of its style. Precise, energetic, massive it is; splendid, when the pictorial demands of the narrative require it, as that of Livy; and sometimes, where profound reflections are to be concisely expressed, as sententious and graphic as that of Tacitus. But with all its great merits it is too often formal and inflexible, and is apt to pall on the ear by the too frequent recurrence of the same cadence at equal intervals, and the too unsparing use of antithesis. It is not veined marble, but an exquisite tesselation; not the fluent naturally-winding stream, but a stately aqueduct, faced with stone, adorned with wooded embankments, or flowing over noble arches, but an aqueduct still. It is a just criticism of Sir James Mackintosh that probably no great writer ever derived less benefit from his professed models. Pascal, Voltaire, Hume, were his delight; and he acknowledges, as so unsuccessful a pupil well might, that he often closed the pages of the last with a feeling of despair. Addison and Swift he read for the very purpose of improving his acquaintance with idiomatic English, yet, as the above critic remarks, "with so little success, that in the very act of characterizing these writers, he has deviated not a little from that beautiful simplicity which is their peculiar distinction."

In a work of such extent it is a venial fault that the workmanship should not in all parts be equally perfect; "aliquando bonus dormitat." That Gibbon has sometimes failed in that lucidity of statement which is one of his very strongest characteristics has often been successfully pointed out; and special reference may be made to the 59th chapter, where he treats of the crusades. In this instance by "a brief parallel" he has sought to save himself "the repetition of a tedious narrative," but has only succeeded in presenting a superficial sketch that cannot be otherwise characterized than as confused and badly written. Nor has his penetration enabled him in all cases to reach the true significance of some of the grander facts which, in order to the adequate discharge of his task, it was of the highest importance that he should have rightly understood. Here it is not necessary to adduce any minor instances, when it can be shown that he is out of harmony with the truth, or at least with the truth as apprehended by the 19th century, in a matter so fundamental as his conception of that empire which declined and fell, and of that Christianity which, as he rightly supposes, contributed to its overthrow.

In Mirabeau's correspondence there occurs a letter to Sir Samuel Romilly containing the following criticism:—"I have never been able to read the work of M. Gibbon without being astounded that it should ever have been written in English; or without being tempted to turn to the author and say, 'You an Englishman? No, indeed! That admiration for an empire of more than two hundred millions of men, where not one had the right to call himself free; that effeminate philosophy which has more praise for luxury and pleasures than for all the virtues; that style always elegant and never energetic, reveal at the most the elector of Hanover's slave.'"[1] Here Mirabeau speaks in his own language what every one who in the least values the characteristic features of modern political life must, however inarticulately, have often felt. Gibbon's enthusiasm for the empire of Trajan and the Antonines—that "solid fabric of human greatness"—is undisguised and perfectly sincere; to his thinking, if the earth ever enjoyed a golden age, it was then. The world was happy because it was under a government which it could never think of questioning or resisting,—happy because for once it had got rid of all unavailing enthusiasms, whether political or religious. Whether it was happy, and whether any happiness it really possessed was not rather in spite of than because of the prevalent political and religious indifference, are questions which not many historians will care to answer as Gibbon did. It is manifest, however, that to him, thinking of the Roman empire as he did, it was well nigh impossible to be just to Christianity. He could never forgive a religion which, in his opinion, had overthrown "the solid fabric of human greatness," and given to the world the sorry sight of bare-footed friars chanting psalms on the spot where once had been the august worship in which everybody took part and positively no one believed. This explains why one who can treat each and all of the ethnic religions with the cold impartiality of a Chinese literatus[2] is unable when Christianity comes to be discussed to conceal his heartfelt dislike. Comparing "superstition" with "superstition," virtue with virtue, vice with vice, Gibbon had formed a deliberate preference for the religion and ethics of ancient Rome. Philosophical students of history, even though they may feel themselves unable to subscribe the Athanasian creed, may now be said to be almost unanimous, however, in finding that the phenomenon called Christianity did mean for mankind a higher conception of truth and a nobler conception of duty.

Upon the famous fifteenth and sixteenth chapters it is not necessary to dwell, because at this time of day no Christian apologist dreams of denying the substantial truth of any of the more important allegations of Gibbon. Christians may complain of the suppression of some circumstances which might influence the general result; and they must remonstrate against the unfair construction of their case. But they no longer refuse to hear any reasonable evidence tending to show that persecution was less severe than had once been believed; and they have slowly learned that they can afford to concede the validity of all the secondary causes assigned by Gibbon, and even of others still more discreditable. The fact is, as the historian himself has again and again admitted, that his account of the secondary causes which contributed to the progress and establishment of Christianity leaves the question as to the natural or supernatural origin of Christianity practically untouched; that question still continues to be agitated, but the battle is fought on a new field and with other weapons than those selected by Gibbon.

Of the original quarto edition of *The Decline and Fall*, vol. i. appeared, as has already been stated, in 1776, vols. ii. and iii. in 1781, and vols. iv.–vi. (inscribed to Lord North) in 1788. In later editions vol. i. was considerably altered by the author; the others hardly at all. The number of modern reprints has been very considerable; but the most important and valuable English edition is that of Milman (1839 and 1845), still more recently enriched under the editorship of Dr. W. Smith (8 vols. 8vo, 1854 and 1872). As a curiosity of literature Bowdler's edition, "adapted to the use of families and young persons" by the expurgation of "the indecent expressions and all allusions of an improper tendency" (5 vols. 8vo, 1825), may be specially noticed. The French translation of Le Clerc de Septchênes, continued by Démeunier, Boulard, and Cantwell (1788–1795), has been frequently reprinted in France. It seems to be certain that the portion usually attributed to Septchênes was, in part, at least, the work of his distinguished pupil, Louis XVI. A new edition of the complete translation, prefaced by a letter on Gibbon's life and character, from the pen of Suard, and annotated by Guizot, appeared in 1812 (and again in 1828). There are at least two German translations of *The Decline and Fall*, one by Wenck, Schreiter, and Beck (1805–1807), and a second by Sporschil (1862). The Italian translation (alluded to by Gibbon himself) was, along with Spedalieri's *Confutazione*, reprinted at Milan in 1823. Gibbon's *Miscellaneous Works, with Memoirs of his Life and Writings, composed by himself; illustrated from his letters, with occasional Notes and Narrative*, published by Lord Sheffield in two volumes in 1796, has been often reprinted. The new edition in five volumes (1814) contained some previously unpublished matter, and in particular the fragment on the revolutions of Switzerland. A French translation of the *Miscellaneous Works* by Marigné appeared at Paris in 1798. There is also a German translation (Leipsic, 1801). It may be added that a special translation of the chapter on Roman Law (*Gibbon's historische Uebersicht des Römischen Rechts*) was published by Hugo at Göttingen in 1839, and has frequently been used as a text-book in German universities. (H. RO.—J. S. BL.)

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[1] See Sainte-Beuve, *Causeries*, viii. 460.

[2] "Il a du lettré chinois dans sa manière d'apprécier les religions."—Sainte-Beuve.

GIBBONS, GRINLING (1648–1721), a celebrated English wood-carver, was born in 1648, according to some authorities, of Dutch parents at Rotterdam, and according to others, of English parents at London. By the former he is said to have come to London after the great fire in 1666. He early displayed great cleverness and ingenuity in his art, on the strength of which he was recommended by Evelyn to Charles II., who employed him in the execution both of statuary and of ornamental carving in wood. In statuary one of his principal works is a life-size bronze statue in the court of Whitehall, representing James II. in the dress of a Roman emperor, and he also designed the base of the statue of Charles I. at Charing Cross. It is, however, chiefly as an engraver in wood that he has acquired a reputation. He was employed to execute the ornamental carving for the chapel at Windsor, the foliage and festoons in the choir of St. Paul's, the baptismal fonts in St. James's, and an immense quantity of ornamental work at Burleigh, Chatsworth, and other aristocratic mansions. The finest of all his productions in this style is believed to be the ceiling which he devised for a room at Petworth. His subjects are chiefly birds, flowers, foliage, fruit, and lace, and many of his works, for delicacy and elaboration of details, and truthfulness of imitation, have never been surpassed. He, however, sometimes wasted his ingenuity on trifling subjects: many of his flowers used to move on their stems like their natural prototypes when shaken by a breeze. In 1714 Gibbons was appointed master carver in wood to George I. He died at London, August 3, 1721.

GIBBONS, ORLANDO (1583–1625), like Johann Sebastian Bach, was the most illustrious of a family of musicians all more or less able. We know of at least three generations of musical Gibbons, for Orlando's father, William Gibbons, having been one of the waits of Cambridge, may be assumed to have acquired some proficiency in the art. His three sons, and at least one of his grandsons, inherited and further developed his talent. The eldest, Edward, was made bachelor of music at Cambridge, and successively held important musical appointments at the cathedrals of Bristol and Exeter; Ellis, the second son, was organist of Salisbury Cathedral, and is the composer of two madrigals in the collection known as the *The Triumphs of Oriana*. Orlando Gibbons, the youngest and by far the most celebrated of the brothers, was born at Cambridge in 1583. Where and under whom he studied is not known, but in his twenty-first year he was sufficiently advanced and celebrated to receive the important post of organist of the Chapel Royal. His first published composition, "Fantasies in three parts, composed for viols," appeared in 1610. It seems to have been the first piece of music printed in England from engraved plates, or "cut in copper, the like not heretofore extant." In 1622 he was created doctor of music by the university of Oxford. For this occasion he composed an anthem for eight parts, *O clap your Hands*, still extant. In the following year he became organist of Westminster Abbey. Orlando Gibbons died before the beginning of the civil war, or it may be supposed that, like his eldest brother, he would have been a staunch royalist. In a different sense, however, he died in the cause of his master; for having been summoned to Canterbury to produce a composition written in celebration of Charles's marriage, he there fell a victim to small-pox on June 5, 1625. Of his life very little is known, but that little is well summed up in the article contributed by Mr. W. H. Husk to Dr. Grove's *Dictionary of Music and Musicians*, where a complete list of his compositions is also given. His portrait may be found in Hawkins's well-known *History*. The works of Gibbons may be divided into secular and sacred compositions, the latter being by far the most important portion. His vocal pieces, madrigals, motets, canons, songs, etc., are admirable specimens of part-writing, and prove him to have been a perfect master of polyphonous treatment. Many of them are for five voices, a very common number in those days; but pieces for four and for six voices also are by no means rare. To the first-named class belong a *Te Deum* in D minor, two sets of *Preces* and other compositions for church service, also most of the madrigals. We have also some specimens of his instrumental music, such as the six pieces for the virginals published in *Parthenia*, a collection of instrumental music produced by Gibbons in conjunction with Dr. Bull and Byrd.

GIBEON, a town famous in Old Testament history, known under the name of El Jîb, situated 5 miles north-west of Jerusalem. It is now a small village standing on an isolated hill above a flat corn valley. The famous spring (2 Sam. ii. 13) comes out from under a cliff on the south-east side of the hill, and the water runs to a reservoir lower down. The sides of the hill are rocky, and remarkable for the regular stratification of the limestone, which gives the hill at a distance the appearance of being stepped. Scattered olive groves surround the place. The name is derived from the Hebrew root *gabah*, signifying "prominence," and there are throughout Palestine many ancient sites situate on rocky knolls which receive names (*e. g.*, Gibeah, Geba, Gabe, Gaba—nearly all represented by the present Jeba) derived from this same root.

GIBRALTAR, a British fortress and town in the south of Spain, occupying a grand peninsular headland, which stretches almost due south in a line with the eastern coast of the province of Andalusia, separating the Bay of Algeciras from the open sea of the Mediterranean, and commanding the strait by which the Mediterranean communicates with the Atlantic. Its latitude is 36° 6′ 23″ N., and its longitude 5° 20′ 55″ W. The "rock," as the promontory is familiarly called, is about 2½ miles in length, with a varying breadth of from 2 to 6 furlongs. Rising abruptly from the low sandy isthmus which connects it with the mainland to a height of 1200 feet, the main ridge continues south for about 1½ miles, being separated by two transverse depressions, known respectively as the Northern and Southern Quebrada, into three pretty distinct summits—the Wolf's Crag or North Front, the Middle Hill or Signal Station (1255 feet high), and the Pan de Azucar or Sugar Loaf Hill, dominated by O'Hara's tower (1408 feet). This last summit descends somewhat abruptly on the south to the Windmill Plateau, an almost level area about half a mile in length by a quarter in breadth, which, from a height of 400 feet above the sea, slopes south till it is only 300 feet above the sea, and then in its turn sinks abruptly for about 200 feet to the Europa Plateau, which, also sloping seaward, terminates in a cliff about 50 feet high. Towards the east or Mediterranean side the promontory presents as precipitous and inaccessible a front as towards the north, but towards the west the ascent is comparatively gradual, though interrupted by longitudinal cliffs and ravines, and a considerable space of fairly level ground at the foot affords a site for the town.

The basement rock of Gibraltar is for the most part a greyish white or pale grey limestone, of compact and sometimes crystalline texture, arranged in beds, but in some places apparently amorphous. Above the limestone is a series of dark greyish blue shales with intercalated beds and bands of grit, sandstone, and limestone; and distributed here and there about the promontory are various limestone breccias, bone-breccias, and calcareous sandstones, as well as loose sand and debris. It is evident that the whole promontory has had an eventful geological history in comparatively recent periods. The limestone and the shales are both of Lower Jurassic age, but the rest of the formations are of much more ancient date. According to the researches of Professors Ramsay and Geikie ("Geology of Gibraltar," in the *Quarterly Journal of the Geological So-*

ciety, London, 1878), the oldest superficial accumulation is the unfossiliferous limestone breccia of Buena Vista, which must have been formed under somewhat severer climatic conditions than the present, and when the rock had a wider area of low ground at its base. This period was probably followed by one with a genial climate, during which the promontory, if indeed it was not rather an isthmus between Europe and Africa, was clothed with vegetation and inhabited by a rich mammalian fauna, whose remains are still found in the Genista caves. Next there came a subsidence of a large proportion of the rock to the extent of 700 feet below the present level, the consequent erosion of ledges and platforms, and the formation of the calcareous sandstones which have incorporated shells of recent Mediterranean species. The process of depression was apparently interrupted by pauses. On its re-elevation, the land was again of greater extent than now; Africa and Europe were perhaps reunited, and the climate was probably genial. By a new depression the rock was brought into its present geographical relations.

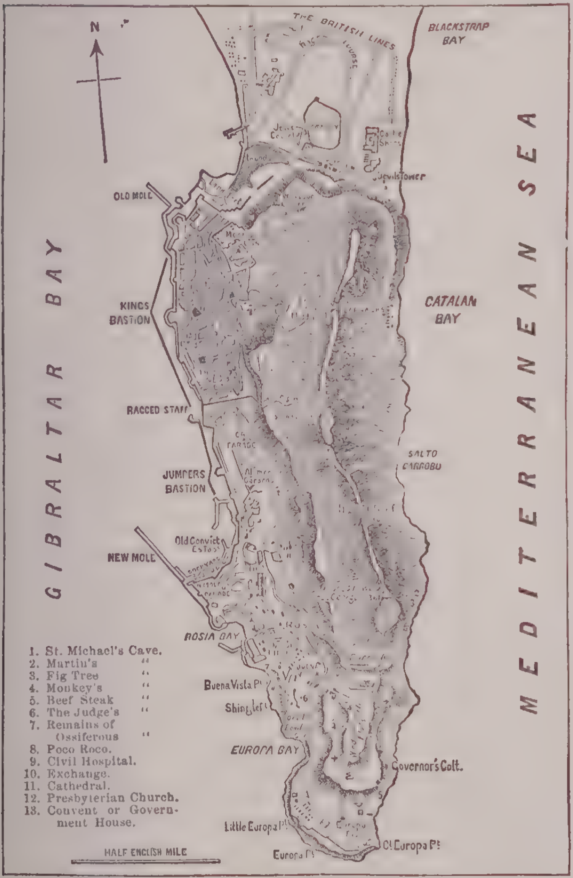

Chart of Gibraltar.

Like most masses of limestone formation, the promontory of Gibraltar is honeycombed with caverns and subterraneous passages, and the Genista cave, already incidentally mentioned, is only one of the many to which it owes the title of the Hill of Caves. A special interest attaches to some of them for the palæontological and archæological remains which they yielded to the explorations of Captain Brome between 1863 and 1868. St. Michael's Cave, which is the most frequently visited by strangers, has its entrance about 1100 feet above the sea on the western face of the rock in the line of the Southern Quebrada. A rapid slope of earth gives admission to a hall 200 feet long by 70 feet high, the roof of which appears as if it were supported by massive stalactite pillars; and from this hall access is obtained to a series of four similar caves connected with each other by tortuous passages, the last cave being situated about 300 feet below the surface and about 400 feet of travelling distance south by west from the entrance. The first of the four was called Victoria cave by its discoverer Captain Brome, and the three others, being more closely associated, received the common name of Leonora's caves. "Nothing," says Captain Brome, "can exceed the beauty of the stalactites; they form clusters of every imaginable shape—statuettes, pillars, foliages, figures. Even the American visitors have been compelled to acknowledge that, as regards beauty and picturesqueness, even the Mammoth Cave would not come near them." The mammalian remains of the Genista cave have been investigated by Mr. Busk ("Quaternary Fauna of Gibraltar," in *Trans. of Zool. Soc.*, vol. x., p. 2, 1877), and found to comprise specimens of a bear, probably *Ursus fossilis* of Goldfuss; a hyæna, probably *H. crocuta* or *spelæa;* various species of cats, from the size of a leopard to that of a wild cat; a rhinoceros similar to the species found in the valley of the Thames; two forms of ibex; and the hare and the rabbit. No trace has been discovered of *Rhinoceros tichorinus*, of *Ursus spelæus*, or of the reindeer, and the only relic of the elephant as yet registered within the peninsula is a perfect specimen of the penultimate upper molar tooth of *Elephas antiquus*. For further details see James Smith of Jordanhill "On the geology of Gibraltar," in *Quart. Journ. of Geol. Soc.*, vol. ii., and G. Busk and Hugh Falconer "On the Fossil Contents of the Genista Cave," in *Quart. Journ. of Geol. Soc.*, vol. xxi., reprinted in Falconer's *Palæontological Memoirs*, London, 1868.

To the voyager entering the straits the rock presents a bare and almost barren aspect, especially when the summer suns have dried up the verdure; but as he approaches he discovers a considerable clothing of vegetation, and closer acquaintance reveals the existence of an extensive flora. Here and there a grassy glen gives shelter to a group of trees, and the villas of the English residents are surrounded with luxuriant gardens and copses. Dr. E. F. Kelaart in his *Flora Calpensis* (London, 1846) enumerates upwards of 400 flowering plants and ferns as indigenous to Gibraltar, and about fifty as introduced. Of the former a few appear to be species peculiar to the rock. White poplars, the cotton-tree, the pepper-tree or pimenta, the ilex, and the pine are the most noticeable of the larger trees; the bella-sombra (*Phytolacca dioica*), introduced by General Don, the aloe, and the prickly pear are common; and on the eastern side of the rock the dwarf palm (*Chamærops humilis*) covers large areas. Among the fruit trees, which, however, are cultivated rather for ornament than for profit, may be mentioned the almond, the olive, the orange, the lemon, the pomegranate, the fig, and the loquat. In January and February many portions of the rock present a charming sight from the profusion and beauty of the wild flowers. The fauna of Gibraltar is naturally poor,—rabbits, foxes, partridges, pigeons, and woodcocks being the principal species. The little Barbary apes, of which every schoolboy has heard, but which not every resident in Gibraltar has seen, are few in number, not more than twenty perhaps, and they usually inhabit the higher and eastern parts of the rock, except when they are driven towards the lower grounds by the cold winds from the north-east. They then do a little damage to the fruit trees; but they enjoy impunity as perfect as that of the storks in Holland or the ibis in Egypt. As to its climate Gibraltar belongs to the subtropical zone, with a dry summer and a rainy season in winter. More than half the rainfall of the year, which only amounts to about 28 or 30 inches, occurs in November, December, and January; and the three months of June, July, and August are hardly refreshed by a shower. The temperature is subject to frequent disturbances: from 93° to 87° is the highest reached (July), and 43° the lowest (February), and the mean for the summer months is from 74° to 79°. In summer the heat is tempered by a sea-breeze which blows from about 10 A. M. till shortly before sunset. Easterly winds or levanters are common from July to November, and during their prevalence every living creature seems to suffer. Heavy dews and thick fogs occur in autumn, and are as disagreeable as they are unhealthy. In the early part of the present century Gibraltar was notoriously filthy and ill-drained, and epidemic diseases committed great ravages from time to time; but great improvements have been effected, especially through the sanitary commission instituted in 1865. The inhabitants were formerly dependent on the rainfall for most of their water supply, the springs in the rock being both scanty and brackish; but in 1869 an abundant source of fairly good water was found to exist under the sands of the North Front, and pumps and conduits have been constructed for its distribution. In 1876 the quality of the water was reported to be deteriorating. Besides the private tanks, still numerous throughout the town, there are eight bomb-proof cisterns for rain-water, of a total capacity of 40,000 tons. The navy tank, for the supply of ships, holds from 9000 to 11,000 tons.

Gibraltar is emphatically a fortress, and in some respects its fortifications are unique. On the eastern side the rock needs no defence beyond its own precipitous cliffs, and in all other directions it has been rendered practically impregnable. Besides a sea-wall extending at intervals round the western base of the rock, and strengthened by curtains and bastions and three formidable forts, there are batteries in all available positions from the sea-wall up to the summit 1350 feet above the sea; and a remarkable series of galleries has been hewn out of the solid face of the rock towards the north and north-west. These galleries have an aggregate length of between 2 and 3 miles, and their breadth is sufficient to let a carriage pass. Port-holes are cut at intervals of 12 yards, so contrived that the gunners are safe from the shot of any possible assailants. At the end of one of the galleries hollowed out in a prominent part of the cliff is St. George's Hall, 50 feet long by 35 feet wide, in which the governor was accustomed to give fêtes. Alterations, extensions, and improvements are continually taking place in the defensive system, and new guns of the most formidable sort are gradually displacing or supplementing the old-fashioned ordnance. The whole population of Gibraltar, whether civil or military, is subjected to certain stringent rules. For even a day's sojourn the alien must obtain a pass from the town-major, and if he wish to remain longer a consul or householder must become security for his good behavior. Licenses of residence are granted only for short periods—ten, fifteen, or twenty days—but they can be renewed if occasion require. Military officers may introduce a stranger for thirty days. A special permit is necessary if the visitor wishes to sketch.

Though the town of Gibraltar may be said to date from the 14th century, it has preserved very little architectural evidence of its antiquity. Rebuilt on an enlarged and improved plan after its almost complete destruction during the great siege, it is still on the whole a mean-looking town, with narrow streets and lanes and an incongruous mixture of houses after the English and the Spanish types. As a proprietor may at any moment be called upon to give up his house and ground at the demand of the military authorities, he is naturally deterred from spending his money on substantial or sumptuous erections. The area of the town is about 100 acres. The public buildings comprise the cathedral of the Holy Trinity, a poor imitation of Moorish architecture; the governor's house, formerly a Franciscan monastery and still familiarly known as "The Convent;" the exchange; the court-house; the civil hospital; the revenue offices; and the garrison library, planned by Colonel Drinkwater in 1793. The library has excellent reading-rooms, and contains from 40,000 to 45,000 volumes. At the north-east corner of the town stand the remains of the Moorish castle. Towards the south the lower grounds are occupied by the Grand Parade and the Alameda Gardens, laid out by General Don in 1814; and beyond these are the old convict establishment, the dockyard, and the new-mole parade. Further south, at Rosia, is the naval hospital, erected in 1771.

Gibraltar has been a free port since the year 1705,—a distinction which it owes in part to the refusal of the emperor of Morocco to allow the export of materials for the fortifications unless his subjects obtained full liberty of trade. In the early part of the present century the commercial activity of the little colony was remarkably great. While the average value per annum of British manufactures exported to the rest of Spain during the ten years from 1831 to 1840 was less than £385,000, the corresponding average for Gibraltar was more than £486,000; and in the year 1840 the ratio of Spain and Gibraltar was £404,252 to £1,111,176. Since that date there has been comparatively little advance,—the average annual value of all the British and colonial produce and manufactures for the ten years from 1868 to 1877 being £1,074,785. Besides the legitimate trade fostered by the demands of the garrison and the neighboring cities of Spain, Gibraltar has long had a large contraband traffic, especially in tobacco and Manchester goods. Mainly carried on by Spaniards, it continued to thrive in spite of the exertions of the Spanish authorities, and is now kept down mainly by the action of British officials. About 1200 tons of tobacco are sold annually in the Jews' Market; no fewer than eleven houses import upwards of 1000 tons annually; and its manufacture and manipulation give employment, it is said, to about 1550 persons. Fully two-thirds of the tobacco comes from Calcutta and other Indian ports. "Wool, grain, and wax from Morocco, fruit, wine, oil, and other produce from Spain, are sent to Gibraltar for transshipment to England, France, Germany, Belgium, Holland, Portugal, America, ports in the Mediterranean, India, and China." As a port of call the Bay of Gibraltar has recently increased in importance. Upwards of 5000 vessels enter the port annually, and of these more than half are propelled by steam. The average annual tonnage of the ships that entered between 1871 and 1875 was 2,069,508; and of this no less than 1,594,174 was British. Quarantine was established in 1830. By the shipping act of 1868 the governor was empowered to remove from the register any vessel guilty of a violation of the Spanish revenue laws discreditable to the British flag. In 1865 a duty was imposed on wines and spirits. Great commotion was caused among the mercantile population of Gibraltar in 1871 by a proposed customs ordinance, framed for the suppression of the smuggling. One of its chief provisions was that no tobacco should be exported or imported in vessels of less than 100 tons burden, or in packets of less than 80 ℔.

The population of Gibraltar in 1840 was 15,554, of whom 11,313 were British subjects and 4241 aliens; and by 1850 it had increased to 15,823, with 3641 aliens. In 1860 the civil population, including foreigners visiting the garrison, amounted to 17,647; but the number of resident inhabitants was only 15,467. According to returns for 1872 the total population was 18,695 (8969 males and 9726 females), the aliens numbering 2241 and the military 6521. The death-rate of the civil population varies from 25 to 31 per thousand, but it is almost always exceeded by the birth-rate. During the five years 1871–1875 the average number of births per annum was 592·4, and of deaths 538·2. Besides the natives, who themselves are of various origin, there are always in the town considerable numbers of Spaniards, Portuguese, and Italians, as well as stray representatives of almost every nationality engaged in the trade of the Mediterranean. Though by the treaty of Utrecht it was specially bargained by Spain that "no leave shall be given under any pretence whatever either to Jews or Moors to reside or have their dwelling in the town of Gibraltar," the native Jews by 1844 numbered no fewer than 1385.

The greater part of the population is Roman Catholic, but full religious liberty is of course enjoyed. The church of the Holy Trinity was constituted to be a cathedral and bishop's see of the Church of England in 1843. The Wesleyans and the Presbyterians have places of worship. St. Andrew's, the new Presbyterian church, was built by the Free Church of Scotland in 1854. A proposal for concomitant endowment of "church bodies for the Anglican and Roman Catholic communities" with the annual sum of £500 was made by the governor in 1876, but it was not sanctioned by parliament. An annual grant to this amount is made to both bodies, but the Government no longer keeps the cathedral in repair. The Roman Catholic bishop of Antinoe is vicar apostolic of Gibraltar.

Gibraltar was long an ill-managed and expensive colony; but its expenditure is now sometimes even less than its revenue. During the five years from 1871 to 1875 the average expenditure, increased by several unusual items, was £43,988; and the average income was £42,464. For 1877 the expenditure was £41,585, or £1739 more than the income. The chief sources of the revenue are the port and quarantine dues, the excise on the consumption of wines and spirits, and the ground and house rents,—the three departments yielding respectively on the average from 1871 to 1875 £11,011, £11,512, and £6206. It is worthy of note that the ground and house rentals have increased from £5629 in 1871 to £7078 in 1875. Among the heavier items of outlay are the governor's salary, which amounts to £5000 per annum, and the judicial and ecclesiastical expenses, which were, on an average, from 1871 to 1875 respectively £3909 and £1061. The total cost of the military establishment was, on the average of four years from 1869 to 1873, £315,454—of which £250,340 was the average cost of the regular troops, £1610 for the jails, and £19,293 for the barracks. The convict establishment was abolished in 1875. At that date it contained 238 prisoners, who were managed on the associated system; and grievous complaints were made of the difficulty of maintaining satisfactory discipline.

History.—Gibraltar was known to the Greek and Roman geographers as Calpe or Alybe, the two names being probably corruptions of the same local (perhaps Phœnician) word. The eminence on the African coast near Ceuta, which bears the modern English name of Apes' Hill, was then designated Abyla; and Calpe and Abyla, at least according to an ancient and widely current interpretation, formed the renowned Pillars of Hercules (Herculis columnæ, Ἡρακλέους στῆλαι) which for centuries were the limits of enterprise to the seafaring peoples of the Mediterranean world. The strategic importance of the rock appears to have been first discovered by the Moors, who, when they crossed over from Africa in the 8th century, selected it as the site of a fortress. From their leader Tarik ibn Zeyad it was called Gebel Tarik or Tarik's Hill; and, though the name had a competitor in Gebel af Futah or Hill of the Entrance, it gradually gained acceptance, and still remains sufficiently recognizable in the corrupted form of the present day. The first siege of the rock was in 1309, when it was taken by Alonzo Perez de Guzman for Ferdinand IV. of Spain, who, in order to attract inhabitants to the spot, offered an asylum to swindlers, thieves, and murderers, and promised to levy no taxes on the import or export of goods. The attack of Ismail ben Ferez in 1315 (2d siege) was frustrated: but in 1333 Vasco Paez de Meira, having allowed the fortifications and garrison to decay, was obliged to capitulate to Mahomet IV. (3d siege). Alphonso's attempts to recover possession (4th siege) were futile, though pertinacious and heroic, and he was obliged to content himself with a tribute for the rock from Abdul Melek of Granada; but after his successful attack on Algeciras in 1344 he was encouraged to try his fortune again at Gibraltar. In 1349 he invested the rock, but the siege (5th siege) was brought to an untimely close by his death from the plague in February, 1350. The next or 6th siege resulted simply in the transference of the coveted position from the hands of the king of Morocco to those of Yussef III. of Granada; and the 7th, undertaken by the Spanish count of Niebla, Enrico de Guzman, proved fatal to the besieger and his forces. In 1462, however, success attended the efforts of Alonzo de Arcos (8th siege), and in August the rock passed once more under Christian sway. The duke of Medina Sidonia, a powerful grandee who had assisted in its capture, was anxious to get possession of the fortress, and though Henry IV. at first managed to maintain the claims of the crown, the duke ultimately made good his ambition by force of arms (9th siege), and in 1469 the king was constrained to declare his son and his heirs perpetual governors of Gibraltar. In 1479 Ferdinand and Isabella made the second duke marquis of Gibraltar, and in 1492 the third duke Don Juan was reluctantly allowed to retain the fortress. At length in 1501 Garcilaso de la Vega was ordered to take possession of the place in the king's name, and it was formally incorporated with the domains of the crown. After Ferdinand and Isabella were both dead the duke Don Juan tried in 1506 to recover possession, and added a tenth to the list of sieges. Thirty-four years afterwards the garrison had to defend itself against a much more formidable attack (11th siege)—the pirates of Algiers having determined to recover the rock for Mahomet and themselves. The conflict was severe, but resulted in the repulse of the besiegers. After this the Spaniards made great efforts to strengthen the place, and they succeeded so well that throughout Europe Gibraltar was regarded as impregnable.

In the course of the War of the Spanish Succession, however, it was taken by a combined English and Dutch fleet under Sir George Rooke, assisted by a body of troops under Prince George of Hesse-Darmstadt. The captors had ostensibly fought in the interests of Charles archduke of Austria (afterwards Charles III.), but, though his sovereignty over the rock was proclaimed on July 24, 1704, Sir George Rooke on his own responsibility caused the English flag to be hoisted, and took possession in name of Queen Anne. It is hardly to the honor of England that it was both unprincipled enough to sanction and ratify the occupation, and ungrateful enough to leave unrewarded the general to whose unscrupulous patriotism the acquisition was due. The Spaniards keenly felt the injustice done to them, and the inhabitants of the town of Gibraltar in great numbers abandoned their homes rather than recognize the authority of the invaders. In October, 1704, the rock was invested by sea and land; but the Spanish ships were dispersed by Sir John Leake, and the marquis of Villadarias fared so ill with his forces that he was replaced by Marshal Tessé, who was at length compelled to raise the siege in April, 1705. During the next twenty years there were endless negotiations for the peaceful surrender of the fortress, and in 1726 the Spaniards again appealed to arms. But the Conde de la Torres, who had the chief command, succeeded no better than his predecessors, and the defence of the garrison under General Clayton and the earl of Portmore was so effective that the armistice of June 23d practically put a close to the siege, though two years elapsed before the general pacification ensued. The most memorable siege of Gibraltar, indeed one of the most memorable of all sieges, was that which it sustained from the combined land and sea forces of France and Spain during the years 1779–1783. The grand attack on the place was made on the 13th September, 1782, and all the resources of power and science were exhausted by the assailants in the fruitless attempt. On the side of the sea they brought to bear against the fortress forty-six sail of the line, and a countless fleet of gun and mortar boats. But their chief hope lay in the floating batteries planned by D'Arçon, an eminent French engineer, and built at the cost of half a million sterling. They were so constructed as to be impenetrable by the red-hot shot which it was foreseen the garrison would employ; and such hopes were entertained of their efficiency that they were styled invincible. The Count d'Artois (afterwards Charles X.) hastened from Paris to witness the capture of the place. He arrived in time to see the total destruction of the floating batteries, and a considerable portion of the combined fleet, by the English fire. Despite this disaster, however, the siege continued till brought to a close by the general pacification, February 2d, 1783. The history of the four eventful years' siege is fully detailed in the work of Drinkwater, who himself took part in the defence, and in the *Life* of its gallant defender Sir George Augustus Eliott, afterwards Lord Heathfield, whose military skill and moral courage place him among the best soldiers and noblest men whom Europe produced during the 18th century.

Since 1783 the history of Gibraltar has been comparatively uneventful. In the beginning of 1801 there were rumors of a Spanish and French attack, but the Spanish ships were defeated off Algeciras in June by Admiral Saumarez. Improvements in the fortifications, maintenance of military discipline, and legislation in regard to trade and smuggling are the principal matters of recent interest.

See Col. Thomas James, *History of the Herculean Ghaitz*, Lond., 1777; Ayala, *Historia de Gibraltar*, Madrid, 1782, English translation by Bell, Lond., 1845; Ancell, *A Circumstantial Journal of the Blockade and Siege of Gibraltar*, 1779–1783, Liverpool, 1784; Chevalier d'Arçon, *Memoires pour servir a l'histoire du siège de Gibraltar*, Paris, 1783; Hennen, *Sketches of the Medical Topography of the Mediterranean*, Lond., 1830; Boissier, *Voyage botanique dans la Midi de l'Espagne*, Paris, 1839; Major Hort, *Descriptions and Legends of Gibraltar*, Lond., 1839; J. M. Carter, *Select Views in Gibraltar*, Lond., 1846; Sayer, *The History of Gibraltar*, Lond., 1862; *A History of Gibraltar; with Photographic Illustrations by J. H. Mann*, Lond., 1870; Fenton, *Sorties from Gibraltar*, 1872.

GIBSON, EDMUND (1669–1748), bishop of London, the learned compiler of the *Codex Juris Ecclesiastici Anglicani*, was born at Bampton, in Westmoreland, in 1669. After a promising career at one of the local schools, he was in 1686 entered a scholar at Queen's College, Oxford, where, at the early age of twenty-two (1692), he distinguished himself by the publication of a valuable edition of the *Saxon Chronicle*, with a Latin translation, indices, and notes. This was followed in 1693 by an annotated edition of the *De Institutione Oratoria* of Quintilian, and in 1694 by a translation in two volumes folio of Camden's *Britannia*, "with additions and improvements," in the preparation of which he had been largely assisted by the volunteered aid of various English antiquaries. Shortly after Tenison's elevation to the see of Canterbury in 1694, Gibson was appointed chaplain and librarian to the archbishop, and at a somewhat later period he became rector of Lambeth and archdeacon of Surrey. In the discussions which arose during the reigns of William and Anne relative to the rights and privileges of the Convocation, Gibson took a very active part, and in a series of pamphlets warmly argued for the right of the archbishop to continue or prorogue that assembly. The controversy suggested to him the idea of those researches which resulted in the *Codex Juris Ecclesiastici Anglicani*, published in two vols. folio in 1713,—a work which discusses more learnedly and comprehensively than any other the legal rights and duties of the English clergy, and the constitution, canons, and articles of the English Church. In 1715 Gibson was presented to the see of Lincoln, whence he was in 1723 translated to that of London, where for twenty-five years he exercised an immense influence, being the authority chiefly consulted by the court on all ecclesiastical affairs. While a conservative in church politics, he yet respected the various forms of dissent, and discouraged all attempts to prevent dissenters from worshipping in the manner and according to the principles which they preferred. He exercised a vigilant oversight over the morals of all ranks and classes of the community committed to his charge; and his fearless denunciation of the licentious masquerades which had become highly popular at court finally lost him the royal favor. Among the literary efforts of his later years the principal were a series of *Pastoral Letters* in defence of the "gospel revelation," against "lukewarmness" and "enthusiasm," and on various topics of the day; also the *Preservative against Popery*, in 3 vols. folio (1738), a compilation of numerous controversial writings of eminent Church of England divines, dating chiefly from the period of James II. Gibson died on the 6th September, 1748.

A second edition of the *Codex Juris*, "revised and improved, with large additions by the author," was published at Oxford in 1761. Besides the works already mentioned, Gibson published a number of *Sermons*, and other works of a religious and devotional kind. The *Vita Thomæ Bodleii* with the *Historia Bibliothecæ Bodleianæ* in the *Catalogi librorum manuscriptorum* (Oxford, 1697), and the *Reliquiæ Spelmannianæ* (Oxford, 1698), are also from his pen.

GIBSON, JOHN (1790–1866), sculptor, was born near Conway, in 1790, in very humble circumstances, his father being a market gardener. He is a notable example of one who, with no so-called start in life, carved his way to distinction by the force of a steady purpose and strong will. To his mother, whom he described as ruling his father and all the family, he owed, like many other great men, the energy and determination which carried him over every obstacle. He narrowly escaped emigration to America, the first step towards which took the family to Liverpool, where his mother's will interposed to keep them. He was then nine years of age, and was sent to school. The windows of the print shops of Liverpool riveted his attention; and, having no means to purchase the commonest print, he acquired the habit of committing to ocular memory the outline of one figure after another, drawing it on his return home. Thus early did he form the system of observing, remembering, and noting, sometimes even a month later, scenes and momentary actions from nature—a habit peculiar in that degree to himself, but of the utmost importance to all artists to practise. In this way he, by degrees, transferred from the shop window to his paper at home the chief figures from David's picture of Napoleon crossing the Alps, which, by particular request, he copied in bright colors as a frontispiece to a little schoolfellow's new prayer-book, for sixpence. At fourteen years of age Gibson was apprenticed to a firm of cabinetmakers,—portrait and miniature painters in Liverpool requiring a premium which his father could not give. This employment so disgusted him that after a year (being interesting and engaging then apparently as in after life) he persuaded his masters to change his indentures, and bind him to the wood-carving with which their furniture was ornamented. This satisfied him for another year, when an introduction to the foreman of some marble works, and the sight of a small head of Bacchus, unsettled him again. He had here caught a glimpse of his true vocation, and in his leisure hours began to model with such success that his efforts found their way to the notice of Mr. Francis, the proprietor of the marble works. The wood-carving now, in turn, became his aversion; and having in vain entreated his masters to set him free, he instituted a strike. He was every day duly at his post, but did no work. Threats, and even a blow, moved him not. At length the offer of £70 from Francis for the rebellious apprentice was accepted, and Gibson found himself at last bound to a master for the art of sculpture. Francis paid the lad 6s. a week, and received good prices for his works,—sundry early works by the youthful sculptor, which exist in Liverpool and the neighborhood, going by the name of Francis to this day. It was while thus apprenticed that Gibson attracted the notice of Mr. Roscoe, whose taste in Greek art seems to have been superior to his judgment in Italian history. For him Gibson executed a basso rilievo in terra cotta, now in the Liverpool Museum. Roscoe opened to the sculptor the treasures of his library at Allerton, by which he became acquainted with the designs of the great Italian masters. A cartoon of the Fall of the Angels marked this period,—now also in the Liverpool Museum. We must pass over his studies in anatomy, pursued gratuitously by the kindness of a medical man, and his introductions to families of refinement and culture in Liverpool. Roscoe was an excellent guide to the young aspirant, pointing to the Greeks as the only examples for a sculptor. Gibson here found his true vocation. A basso rilievo of Psyche carried by the Zephyrs was the result. He sent it to the Royal Academy, where Flaxman, recognizing its merits, gave it an excellent place. Again he became unsettled. The ardent young breast panted for "the great university of Art"—Rome; and the first step to the desired goal was to London. Here he stood between the opposite advice and influence of Flaxman and Chantrey—the one urging him to Rome as the highest school of sculpture in the world, the other maintaining that London could do as much for him. It is not difficult to guess which was Gibson's choice. He arrived in Rome in October, 1817, at a comparatively late age for a first visit. There he immediately experienced the charm and goodness of the true Italian character in the person of Canova, to whom he had introductions,—the Venetian putting not only his experience in art but his purse at the English student's service. Up to this time, though his designs show a fire and power of imagination in which no teaching is missed, Gibson had had no instruction, and had studied at no Academy. In Rome he first became acquainted with rules and technicalities, in which the merest tyro was before him. Canova introduced him into the Academy supported by Austria, and, as is natural with a mind like Gibson's, the first sense of his deficiencies in common matters of practice was depressing to him. He saw Italian youths already excelling, as they all do, in the drawing of the figure. But the tables were soon turned. His first work in marble—a Sleeping Shepherd modelled from a beautiful Italian boy—has qualities of the highest order. Gibson was soon launched, and distinguished patrons, first sent by Canova, made their way to his studio in the Via Fontanella. His aim, from the first day that he felt the power of the antique, was purity of character and beauty of form. He very seldom declined into the prettiness of Canova, and if he did not often approach the masculine strength which redeems the faults of Thorwaldsen, he more than once surpassed him even in that quality. We allude specially to his Hunter and Dog, and to the grand promise of his Theseus and Robber, which take rank as the highest productions of modern sculpture. He was essentially classic in feeling and aim, but here the habit of observation we have mentioned enabled him to snatch a grace beyond the reach of a mere imitator. His subjects were gleaned from the free actions of the splendid Italian people noticed in his walks, and afterwards baptized with such mythological names as best fitted them. Thus a girl kissing a child, with a sudden wring of the figure, over her shoulder, became a Nymph and Cupid; a woman helping her child with his foot on her hand on to her lap, a Bacchante and Faun; his Amazon thrown from her Horse, one of his most original productions, was taken from an accident he witnessed to a female rider in a circus; and the Hunter holding in his Dog was also the result of a street scene. The prominence he gave among his favorite subjects to the little god "of soft tribulations" was no less owing to his facilities for observing the all but naked Italian children, in the hot summers he spent in Rome.

In monumental and portrait statues for public places, necessarily represented in postures of dignity and repose, Gibson was very happy. His largest effort of this class—the group of Queen Victoria supported by Justice and Clemency, in the palace of Westminster—we agree with himself in pronouncing his finest work in the round. Of noble character also in execution and expression of thought is the statue of Mr. Huskisson with the bared arm; and no less, in effect of aristocratic ease and refinement, the seated figure of Dudley North. He lays down the axiom in his journal that the Greeks represented "men thinking, and women tranquil," and to the departure from this rule we attribute the unattractive colossal statue of Sir Robert Peel in Westminster Abbey. The very animation he has given to the head is too individual to harmonize with the classic drapery, or with the real character of the man. The great statesman is here colloquial rather than eloquent in expression, while the position of the right foot suggests the idea of a walking figure. Great as he was in the round, Gibson's chief excellence lay in basso rilievo, and in this less disputed sphere he obtained his greatest triumphs. His thorough knowledge of the horse, and his constant study of the Elgin marbles—casts of which are in Rome—resulted in the two matchless bassi rilievi, the size of life, which belong to the earl of Fitzwilliam—the Hours leading the Horses of the Sun, and Phaethon driving the Chariot of the Sun. Most of his monumental works are also in basso rilievo. Some of these are of a truly refined and pathetic character, such as the monument to the countess of Leicester, that to his friend Mrs. Huskisson in Chichester Cathedral, and that of the Bonomi children. In reviewing the qualities most characteristic of this great artist, that of passionate expression may be said to stand foremost. Passion, either indulged or repressed, was the natural impulse of his art:—repressed as in the Hours leading the Horses of the Sun, and as in the Hunter and Dog; indulged, as scarcely before seen in the same intensity in the whole range of sculpture, as in the meeting of Hero and Leander, a drawing executed before he left England. Gibson's power of drawing may be pronounced to have been unsurpassed by any modern. He had an iron hand, and used the pen in rapid action with as much certainty as if it had been the graver. Nowhere is the fire of his genius so unmistakably seen as in these first-hand productions. Nor can we wonder that marble, however highly wrought, could never entirely compensate for what was necessarily lost in the translation. Gibson was the first to introduce color on his statues,—first, as a mere border to the drapery of a portrait statue of the Queen, and by degrees extended to the entire flesh, as in his Venus, and in the Cupid tormenting the Soul, belonging to Mr. Holford. In both of these it amounts to no more than the slightest tint. Gibson's individuality was too strongly marked to be affected by any outward circumstances. In all worldly affairs and business of daily life he was simple and guileless in the extreme; but he was resolute in matters of principle, determined to walk straight at any cost of personal advantage. Unlike most artists, he was neither nervous nor irritable in temperament. It was said of him that he made the heathen mythology his religion; and indeed in serenity of nature, feeling for the beautiful, and a certain philosophy of mind, he may be accepted as a type of what a pure-minded Greek pagan, in the zenith of Greek art, may have been. Gibson was elected R. A. in 1836, and bequeathed all his property and the contents of his studio to the Royal Academy, where his marbles and casts are open to the public. He died at Rome, in January, 1866.

The letters between Gibson and Mrs. Henry Sandbach, granddaughter of Mr. Roscoe, and a sketch of his life that lady induced him to write, furnish the chief materials for his biography. A volume of engravings from his finished works renders them very indifferent justice. A volume of facsimiles from his drawings is more worthy of him. (E. E.)

GICHTEL, Johann Georg (1638–1710), founder of the mystic sect of Gichtelians or Angelic Brethren, was born at Ratisbon, where his father was a member of senate, on the 14th of March, 1638. Having acquired at school, besides an ordinary elementary education, a considerable acquaintance with Greek, Hebrew, Syriac, and even Arabic, he proceeded to Strasburg to study divinity; but finding that the theological prelections of Schmidt and Spener there were not conducive to the growth of his piety, he removed to Spires, where he entered the faculty of law. In 1664 he was admitted an advocate at Ratisbon; but having become acquainted with the Baron von Weltz, an Hungarian nobleman who cherished enthusiastic if not extravagant schemes for the reunion of Christendom and the conversion of the world, he abandoned all interest in his profession, and became an energetic promoter of the "Christerbauliche Jesusgesellschaft," or Christian Edification Society of Jesus, in the interests of which he visited many parts of Germany and Holland. The movement in its beginnings provoked at least no active hostility; but when Gichtel began to attack the teaching of the Lutheran clergy and church, especially upon the fundamental doctrine of justification by faith, he exposed himself to a prosecution which ultimately resulted in sentence of banishment and confiscation (1665). After many months of wandering and occasionally romantic adventure, he, in January, 1667, reached Holland, and settled at Zwoll, where he co-operated with Breckling, a man who shared his views and aspirations. Having become involved in the troubles of this friend, Gichtel, after a period of imprisonment, was banished for a term of years from Zwoll, but finally, in 1668, found a home in Amsterdam, where in a state of poverty (which, however, never became destitution), he lived out his strange life of visions and day-dreams, of prophecy and prayer. He became an ardent student and disciple of Jacob Boehme, whose works he published in 1682 (Amsterdam, 2 vols.); but before the time of his death, which occurred January 21, 1710, he had attracted to himself a small band of followers known as Gichtelians or Angelic Brethren, who propagated certain views at which he had arrived independently of Boehme. Seeking ever to hear the authoritative voice of God within them, and endeavoring to attain to a life altogether free from carnal desires, like that of "the angels in heaven, who neither marry nor are given in marriage," they claimed to exercise a priesthood "after the order of Melchizedek," appeasing the wrath of God, and ransoming the souls of the lost by sufferings endured vicariously after the example of Christ. The sect, never a numerous one, is said still to subsist in some districts of Holland and North Germany. Gichtel's correspondence was published without his knowledge by Gottfried Arnold, a disciple, in 1701 (2 vols.), and again in 1708 (3 vols.). It has been frequently reprinted under the title *Theosophia Practica.* The seventh volume of the Berlin edition (1768) contains a notice of Gichtel's life.

GIDEON, liberator, reformer, and "judge" of Israel, was the youngest son of Joash, of the "house" of Abiezer, and tribe of Mannasseh, and had his home at Ophrah, the site of which is probably to be sought westward of Jordan, somewhat to the south of the plain of Jezreel. Gideon lived at a time when Israel, grown idolatrous, had been brought very low by periodic incursions of the "Midianites" and "Amalekites," nomad tribes from the east of Jordan, who in great numbers were wont to overrun the country, destroying all that they could not carry away. In the beginning of the narrative of his public life he is represented as an unambitious man, quietly engaged in agricultural pursuits, who yet had already distinguished himself as a "mighty man of valor," probably in guerilla warfare against the common foe. According to that narrative, his first exploit worthy of special commemoration was the destruction, by divine command, of the altar of Baal belonging to his father, and of the Ashera beside it, and the substitution of an altar to Jehovah. But immediately before this he had also been summoned by "the angel of the Lord" to undertake, in dependence on supernatural direction and help, the work of liberating his country from its long oppression, and, in token that he accepted the mission, had already erected in Ophrah an altar which he called "Jahveh-Shalom" (Jehovah is prosperity). The great gathering of the Midianites and their allies on the north side of the plain of Jezreel "stretching from the hill of Moreh;" the general muster first of Abiezer, then of all Manasseh, and lastly of the neighboring tribes of Asher, Zebulun, and Naphtali; the signs by which the wavering faith of Gideon was steadied; the methods by which an unwieldy mob was reduced to a small but trusty band of energetic and determined men; and the stratagem by which the vast army of Midian was surprised and routed by the handful of Israelites descending from "above Endor," are indicated with sufficient clearness in the Scripture narrative, and need not be detailed minutely here. There is some difficulty in following the account of the subsequent flight of the Midianites, which seems to have taken place in two directions,—Oreb and Zeeb making for the lower fords of Jordan, towards the south-east, while Zebah and Zalmunna took the upper passage, a little below the place where the river flows out of the Sea of Galilee. Leaving the Ephraimites (who had now risen in force) to deal with the former, Gideon with his 300 appears to have kept up the pursuit of the latter to Nobah and Jogbehah, points beyond Succoth and Penuel, where a bloody contest resulted in the destruction of that portion of the Midianite army, and in the ultimate capture and execution of Zebah and Zalmunna. Almost simultaneously with these occurrences eastward of Jordan, messengers from Ephraim bearing the heads of Oreb ("raven") and Zeeb ("wolf"), who with their followers had been crushed at "the raven's rock" and "the wolf's den" respectively, announced the completeness of Israel's victory. Having taken unrelenting vengeance on the men of Penuel and Succoth, who had shown a timid neutrality when the patriotic struggle was at its crisis, Gideon returned to his native Ophrah, where he further distinguished himself by his pious magnanimity in refusing the kingship which had been put within his reach—an act of self-denial, however, which, according to the sacred historian, was somewhat neutralized by his subsequent folly in establishing a shrine which proved a snare to all Israel, not excluding his family or even himself. For forty years after the great victory he lived at his own house in Ophrah in considerable wealth and magnificence, yet always in a private station—there being no direct scriptural evidence at least that his judgeship lasted during all that period, or that it ever gave him any position of legally recognized authority. The name of Gideon occurs in Heb. xi. 32, in the list there given of those who became heroes by faith; but, except in Judges vi.–viii., it is not to be met with anywhere in the Old Testament. In 1 Sam. xii. 11 and 2 Sam. xi. 21 (LXX.) he is called Jerubbaal (the reading Jerubbesheth having been introduced into the latter passage in accordance with the usage explained in the article Baal). The fact that in Judges ix., which appears to be the oldest part of the narrative, he is invariably called Jerubbaal, has suggested to Kuenen and others that this ought to be regarded as his original and proper name, that of Gideon (גִּדְעוֹן, *i. e.* "hewer" or "warrior," *cf.* Isa. x. 33) having been a later designation. In confirmation of this it is pointed out that the derivation of ירבעל as equivalent to יָרֶב בּוֹ הַבַּעַל ("Let Baal contend against him," v. 32, or "Let Baal contend for himself," v. 31) is much less probable than that which interprets it as precisely analogous with such names as Merib-baal, Jehoiarib or Joarib, Seraiah, Israel, and perhaps also Josadec, all meaning "God fights" or "contends." The nature of the grounds on which it is conjectured that Gideon's conquest of the Midianites was somewhat slower than the narrative on a first reading would lead one to suppose, and that his religious reforms, far from being confined to a solitary act of his early manhood, were rather the principal employment of his later life, is indicated in the histories of Israel by Ewald, Hitzig, and Kuenen. See also especially Wellhausen, *Geschichte*, i. 252 *sq.*

GIEN, a town of France, at the head of an arrondissement in the department of Loiret, is situated on the right bank of the Loire, 39 miles E. S. E. of Orleans. The Loire is crossed at Gien by a stone bridge of twelve arches, built about the end of the 15th century. The town is the seat of a tribunal of the first instance and of a justice of peace court. The principal buildings are the prison, the hospital, the old castle, originally built by Charlemagne, and reconstructed in 1494 by Anne de Beaujeu, daughter of Louis XI., and the church of Saint Pierre, a modern structure of no particular merit, but possessing an old square tower dating from the end of the 15th century. There are manufactures of serge, leather, and earthenware, and some trade in corn and wine. The population in 1876 was 6493.

GIESELER, Johann Karl Ludwig (1792–1854), one of the most distinguished of the modern school of scientific writers on church history, was born at Petershagen, near Minden, where his father, a man of considerable vigor and independence of character, was minister, on the 3d of March, 1792. In his tenth year he entered the orphanage at Halle, whence he duly passed to the university, his studies being interrupted, however, from October, 1813, till the peace of 1815, by a period of military service, during which he was enrolled as a volunteer in a regiment of chasseurs. Having in 1817 taken his degree in philosophy, he in the same year became assistant head master in the Minden gymnasium, and in 1818 was appointed conrector of the gymnasium at Cleves. Here he published his earliest work (*Historisch-kritischer Versuch über die Entstehung u. die frühesten Schicksale der schriftlichen Evangelien*), a treatise which has had considerable influence on all subsequent investigations and discussions of the question as to the origin of the Gospels, in so far as it may be considered to have finally disposed of that theory of a "primitive" written gospel to which most critics in the earlier part of the century had inclined. In 1819 Gieseler was appointed a professor ordinarius in theology in the newly-founded university of Bonn, where, besides lecturing on church history, he made important contributions to the literature of that subject in Rosenmüller's *Repertorium*, Stäudlin u. Tschirner's *Archiv*, and in various university "programs." The first part of the first volume of his well-known *Church History* appeared in 1824. In 1833 he accepted a call to Göttingen, where the remainder of his life was spent, marked by few noteworthy events beyond the steady publication of volume after volume of his contributions to historical science. In 1837 he was appointed a consistorialrath, and shortly afterwards was created a knight of the Guelphic order. In the winter of 1853–4 symptoms of failing health began to appear, and towards the end of the session he was able to lecture only occasionally. His death occurred on the 8th of July, 1854. The fourth and fifth volumes of the *Kirchengeschichte*, embracing the period subsequent to 1814, were published posthumously by Redepenning (1855); and they were followed in 1856 by a *Dogmengeschichte.* which is sometimes reckoned as the sixth volume of the *Church History.* Among church historians Gieseler continues to hold a very high place. Less vivid and picturesque in style than Hase, conspicuously deficient in Neander's deep and sympathetic insight into the more spiritual forces by which church life is always more or less pervaded, he excels these and all other contemporaries in the fulness and accuracy of his information. His *Lehrbuch der Kirchengeschichte*, in which, indeed, the text as compared with the notes often occupies a very subordinate place, is invaluable to the student who wishes at each step to be brought into direct contact with all the original sources of information which it is of importance that he should know. The work, which has passed through several editions in Germany, has partially appeared also in two English translations. That published in New York (*Text Book of Ecclesiastical History*, 4 vols.), brings the work down to the peace of Westphalia, while that published in "Clark's Theological Library" (*Compendium of Ecclesiastical History*, Edin., 5 vols.) closes with the beginning of the Reformation. For the life of Gieseler reference may be made to Redepenning's biographical sketch in the fifth volume of the *Kirchengeschichte*, and to Herzog's article in the *Real-Encyclopädie* (of which great work, it may be mentioned, Gieseler was an energetic promoter). Both biographers testify that with the habits of a devoted student he combined those of an energetic man of business. He frequently held the office of pro-rector of the university, and did much useful work as a member of several of its committees. He took a warm interest also in the Göttingen orphanage, where he was a daily visitor, knew all the children personally, and taught them to regard him as a counsellor and friend.

GIESSEN, a town of Germany, capital of the province of Upper Hesse, in the grand-duchy of Hesse-Darmstadt, is situated in a beautiful and fruitful valley at the confluence of the Wieseck with the Lahn, 33 miles N. N. W. of Frankfort. It is the seat of a bailiwick, a high court, and a district penal court. The old streets are narrow and irregular, but in the suburbs outside the old walls there are many elegant houses. Besides the university, the principal buildings are the provincial Government offices, comprising a portion of the old castle dating from the 12th century, the arsenal, the town-hall, the new gymnasium, and the town church. The university, founded in 1607 by the landgrave Louis V., has a large and valuable library, a botanic garden, an observatory, an anatomical theatre, an infirmary, a maternity hospital, a museum of natural history, and a chemical laboratory which was directed by Professor Liebig. The number of professors and teachers of the university in 1875 was 52, and of students 340. There is also a gymnasium and a real school. The industries include the manufacture of woollen and cotton cloth of various kinds, leather, candles, tobacco, and beer.

Giessen was formed in the 12th century out of the villages Selters, Aster, and Kroppach, for whose protection Count William of Gleiberg built the castle of Giessen. Through marriage the town came into the possession of the palgrave of Tübingen, who sold it in 1265 to the landgrave Henry of Hesse. It was surrounded with fortifications in 1530, which were demolished in 1547 by the emperor Charles V., but rebuilt in 1560. From 1807 they were gradually pulled down, and their site converted into promenades. The population of Giessen in 1875 was 13,980.

GIFFORD, William (1757–1826), publicist and man of letters, was born at Ashburton, Devon, in April, 1757. Having as a shoemaker's apprentice manifested a remarkable aptitude for intellectual pursuits, he was by the charity of friends enabled to complete a previously imperfect school education, and ultimately to proceed in his twenty-third year to Oxford, where he was appointed a Bible reader in Exeter College. Leaving the university shortly after graduation in 1782, he for some years acted as tutor to Lord Belgrave, whom he accompanied on two prolonged Continental tours. After having settled in London, he in 1794 published his first work, a satirical piece, after Persius, entitled the *Baviad*, successfully aimed at a numerous school of second-rate writers then popularly known as the Della Cruscans. A second satire of a similar description, the *Mæviad*, directed against the corruptions of the drama, appeared in 1795. About this time Gifford became acquainted with Canning, with whose help he in August, 1797, originated a weekly newspaper of Conservative politics entitled the *Anti-Jacobin*, which, however, in the following year ceased to be published. An English version of Juvenal, on which he had been for many years engaged, appeared in 1802; to this an autobiographical notice of the translator was prefixed. Two years afterwards Gifford published an annotated edition of the plays of Massinger; and in 1809, when the *Quarterly Review* was projected, he was entrusted with the management of that publication. It is on all hands conceded that the success which attended the *Quarterly* from the outset was due in no small degree to the ability and tact with which Gifford discharged his editorial duties. His connection with the *Review* continued until within about two years of his death, which took place in London on the 31st of December, 1826. Besides numerous contributions to the *Quarterly* during the last fifteen years of his life, he wrote a metrical translation of Persius, which appeared in 1821. Gifford also edited the poems of Ben Jonson, Ford, and Shirley. His edition of the first of these appeared in 1816, those of the other two, posthumously, in 1827 and 1833. The *Autobiography* was republished in 1827.

GIFT generally means an alienation of property otherwise than for a consideration, although in law it is often used to signify alienation with or without consideration. The effect of a gratuitous gift only need be considered here. Formerly in English law property in land could be conveyed by one person to another by a verbal gift of the estate accompanied by delivery of possession. The Statute of Frauds required all such conveyances to be in writing, and a later statute (8 and 9 Vict. c. 106) requires them to be by deed. Personal property may be effectually transferred from one person to another by a simple verbal gift accompanied by delivery. If a A delivers a chattel to B, saying or signifying that he does so by way of gift, the property passes, and the chattel belongs to B. But unless the actual thing is bodily handed over to the donee, the mere verbal expression of the donor's desire or intention has no legal effect whatever. The persons are in the position of parties to an agreement which is void, as being without consideration. When the nature of the thing is such that it cannot be bodily handed over, it will be sufficient to put the donee in such a position as to enable him to deal with it as the owner. For example, when goods are in a warehouse, the delivery of the key will make a verbal gift of them effectual; but it seems that part delivery of goods which are capable of actual delivery will not validate a verbal gift of the part undelivered. So when goods are in the possession of a warehouseman, the handing over of a delivery order might, by special custom (but not otherwise it appears), be sufficient to pass the property in the goods, although delivery of a bill of lading for goods at sea is equivalent to an actual delivery of the goods themselves. A *donatio mortis causa* is a gift made by a person in contemplation of death, to take effect only in the event of his death. It is revocable so long as he lives. There must be actual or constructive delivery of the thing itself, and therefore it has been said that only chattels can be the proper subject of a *donatio mortis causa*, although policies of insurance, bills, notes, etc., have been allowed to pass by mere delivery as death-bed gifts. A *donatio mortis causa* is not an out-and-out gift, but is conditioned on death.

GIJON, a town and seaport of Spain, in the province of Oviedo or Asturias, on the coast of the Cantabrian Sea, about 13 miles E. of the Cabo de Peñas, and 2 miles E. of the Rio Aboño. The older part of the town, partly surrounded by its walls, occupies the upper slope of a peninsular headland, while the more modern portion extends to the beach. On the whole, it is a clean and flourishing place, with wide streets and good houses; but there are few buildings of individual note except the church of San Pedro of the 15th century, the town house, the mansion of the Marquis Revilla-Gigedo, and the Asturian Institute. The last, which was founded in 1797 by Jovellanos, has a fine library, and comprises classes for navigation, mathematics, Latin, French, and English. Besides the works in connection with the railways which run inland from Gijon to Mieres del Camino and Sama on the Nalon, there is a large glass work, and iron foundry, and a tobacco factory which alone gives employment to upwards of 1400 females. An extensive trade is carried on in the export of coal, iron, jet, and hazel-nuts, and in the import of fish and colonial produce. The nuts amount to upwards of 1600 tons per annum, and a large proportion finds its way to the English market. Though the harbor is a mere roadstead between the small promontories of San Lorenzo and Torres, it is of considerable value on such a coast as that of Asturias, especially as it has a good bottom. A quay was constructed by means of a grant from Charles V. in 1552–4, and a new one by Pedro Menendez in 1766–8, and an extension was effected in 1859 at a cost of £65,000. The population of Gijon in 1860 was 24,802. During the summer there is a considerable influx of strangers.

Gijon is usually identified with the Gigia of the Romans, which, however, occupied the site, not of the present town, but of the adjoining suburb of Cima da Villa. Captured and strengthened by the Moors, who used the stones of the Roman city for their fortifications, it remained in their hands till after the battle of Canicas, when its governor Munuza surrendered to Pelayo. In 844 it held out against an attack by the Normans, and in the following centuries it gradually rose into importance. In the time of Philip II. it possessed good arsenals, and was able to undertake the repairs of the Invincible Armada. Jovellanos, the statesman and poet, and Cean Bermudez, a writer on art, were both natives of Gijon, and the former is buried in the church of San Andrea.

GILBART, John William (1794–1863), the author of a number of works on banking, was descended from a Cornish family, and was born in London, March 21, 1794. From 1813 to 1825 he was clerk in a London bank, after which he went to Birmingham. Shortly after his return to London in 1827 he was appointed manager of the Kilkenny branch of the Provincial Bank of Ireland, and in 1829 he was promoted to the Waterford branch. In 1834 he became manager of the London and Westminster Bank; and to his skill in developing the system of joint-stock banking it owed much of its success. On more than one occasion he rendered valuable services to the joint-stock banks by his evidence before committees of the House of Commons; and, on the renewal of the bank charter in 1844, he procured the insertion of a clause granting to joint-stock banks the power of suing by their public officer, and also the right of accepting bills at less than six months' date. In testimony of their obligations to him, the directors and shareholders of joint-stock banks presented him in 1846 with a handsome service of plate. In the same year he was elected a Fellow of the Royal Society. He retired on a pension from the management of the London and Westminster Bank, 1st January, 1860, and died in London, August 8, 1863. From an early period Gilbart took an active part in the Athenian Debating Society of London, and he was also connected with the Union Society, which numbered among its other eminent members J. S. Mill and Lord Macaulay. He also devoted much of his attention to the promotion of literary and scientific institutions among the middle and working classes.

The following are his principal works on banking, most of which have passed through more than one edition:—*Practical Treatise on Banking*, 1827; *The History and Principles of Banking*, 1834; *The History of Banking in America*, 1837; *Lectures on the History and Principles of Ancient Commerce*, 1847; *Logic for the Million*, 1851; and *Logic of Banking*, 1857.

GILBERT, Sir Humphrey (1539–1583), a celebrated English navigator, was born in 1539 in the county of Devon, second of the three sons of Otho Gilbert of Greenway. By his mother's side he was half-brother to Sir Walter Raleigh, who resembled him in many points of character, and whose early life was largely influenced and guided by his example. Educated first at Eton and then at Oxford, he was destined by his father for the law; but being introduced at court by Raleigh's aunt, Catherine Ashley, he obtained the special favor of the queen, and was thus enabled to follow his natural inclination for active enterprise. Recommended by royal letter to Sir Philip Sidney, he received from him an appointment in the army in Ireland; and his services contributed so powerfully to put down the rebellion raging there that in 1570 he was made a knight and rewarded with the government of Munster. He next served for about five years in the Netherlands, being the first English colonel entrusted with command of English forces in that country. On his return to his native land he wrote a remarkable treatise on a subject at that time before the minds of men, the possibility of a north-west passage to India; and in 1576 it was published without his knowledge by George Gascoigne as *Discourse of a Discoverie for a New Passage to Cataia* (London, Henry Middleton for Richarde Ihones). The theory in question was supported with no small force of argument, and the discourse was probably not without its influence in leading Frobisher to set out on his first voyage to the frozen north. In June, 1578, Gilbert received letters patent authorizing himself, his heirs and assigns, to discover, occupy, and possess such remote "heathen lands not actually possessed of any Christian prince or people, as should seem good to him or them." Disposing not only of his patrimony but also of the estates in Kent which he had through his wife, daughter of John Aucher of Ollerden, he strenuously prepared to put his permission to use, and his brother Raleigh joined him in the enterprise. By the end of the summer of 1578 a fleet of 11 sail, with 400 mariners and men-at-arms, was collected off the coast of Devon; but the gallant projectors were singularly unfortunate in the character of some of their associates. Dissensions broke out among the captains and disorder among the crews. Knollys, for example, boasted that, as kinsman to royalty, he was of more value than twenty knights, and insolently rejected Gilbert's invitation to dinner; and his men, encouraged by their captain's conduct, filled the town of Plymouth with uproar and riot, which finally culminated in murder. It was not till the 19th of November that Gilbert set sail, with his forces reduced to 7 ships and 150 men. The history of the voyage is involved in obscurity; but about the beginning of summer or a little earlier in 1579, the fleet returned to England, with little, it would appear, to report except that it had lost one of its chief ships and one of its bravest captains, Miles Morgan, in an encounter with the Spaniards. Gilbert lent his three ships to the Government for service against the Spaniards on the Irish coast; but in July 11, 1582, we still find him complaining to Walsingham that he had not received the moneys that were due to him, and that thus he was prevented from doing more for his queen and country. He was already planning a new expedition; and at length in 1583 his fleet was got together. The queen, though she had at first dissuaded Gilbert from his purpose, and would not permit Raleigh to accompany him, wrote to him by his brother's hand that she wished him "as great good hap and safety to his ship as if herself were there in person," and sent him as a token a golden figure of an anchor guarded by a lady. On 11th of June he departed from Plymouth with 5 sail; but on the 13th the "Ark Raleigh," which had been built and manned at his brother's expense, "ran from him in fair and clear weather having a large wind." This desertion was a cause of no small displeasure to the admiral, and he wrote to Sir George Peckham to solicit his brother to make the crew an example to all knaves; but it appears not improbable (according to Hayes in Hakluyt's collection) that the reason of their conduct was the breaking out of a contagious sickness in the ship. On the 5th of August Gilbert landed in Newfoundland, and took formal possession of it in the queen's name; but proceeding southwards with three vessels, he lost the largest near Cape Breton, and was at last constrained to return homewards with the "Golden Hind" and the "Squirrel" as the only remnant of his fleet. "On Monday the 9th September," reports Hayes, the captain of the "Hind," "the frigate was near cast away, yet at that time recovered; and giving forth signs of joy, the general, sitting abaft with a book in his hand, cried out unto us in the 'Hind,' 'We are as near to heaven by sea as by land.' The same Monday night the frigate's lights were suddenly out, and it was devoured and swallowed up by the sea." So perished Sir Humphrey Gilbert.

See Hakluyt's *Collection*, vol. iii.; Hooker's *Supplement* to Hollinshed's *Irish Chronicle*; Roger Williams, *The Actions of the Low Countries*, 1618; Bliss's edition of Wood's *Athenæ Oxonienses*, vol. i. p. 493; *North British Review*, No. 45; and the Lives of Sir W. Raleigh by Tytler, James Augustus St. John, and Edward Edwards.

GILBERT, Nicolas Joseph Laurent (1751–1780), a French poet, was born at Fontenay-le-Château in Lorraine, in 1751. Having completed his education at the college of Dôle, he devoted himself for a time to a half scholastic half literary life at Nancy, but at length in 1774 he found his way to the capital. As he had already assumed a hostile and satirical position towards the Encyclopedists, he naturally received a warmer welcome from the conservative party; and as he did not disdain to prostitute his muse to the celebration of the heroic and royal virtues of the despicable Louis XV., he was rewarded with pensions to a considerable amount. He died in October, 1780, from the results of a fall from his horse. The satiric force of one or two of his pieces, as *Mon apologie* (1778), and *Le dix-huitième siècle* (1775), would alone be sufficient to preserve his reputation, and it has been further increased by the eulogies of those modern writers who, like Alfred de Vigny, consider him a victim to the spite of his philosophic opponents.

Among his other works may be mentioned *Les Familles de Darius et d'Éridame, histoire persane* (1770), *Le Carnaval des Auteurs* (1773), *Odes nouvelles et patriotiques* (1775). Gilbert's *Œuvres complètes* were first published in 1778, and they have since been edited by Mastrella (Paris, 1823) and by Charles Nodier (1840, 1859, etc.).

GILBERT, or Gilberd, William (*c.* 1540–1603), was the most distinguished man of science in England during the reign of Queen Elizabeth. He was born at Colchester, where his father was recorder, but was a descendant of an ancient Suffolk family, long resident at Clare. Of his early years no account is left. He entered St. John's College, Cambridge, in 1558, when eighteen years of age, and in due course took the degrees of B.A., M.A., and M.D.; he also became Symson fellow, and in 1569 was elected a senior fellow of his college. After leaving the university he went to the Continent, and, on his return in 1573, settled in London, where for thirty years,—that is, till his death,—he practised as a physician with "great success and applause." He was admitted to the College of Physicians, and filled various offices in it. He began in 1581 as censor, which duty he discharged for several years; then he became treasurer, consiliarius elect, and, at last, president in 1600. His professional skill and general ability drew the attention of Queen Elizabeth to him, and she appointed him royal physician. She also settled a pension on him to enable him to prosecute the scientific inquiries to which he was devoted. After this Gilbert seems to have removed to the court, and to have vacated his house, which was "on St. Peter's Hill, between Upper Thames Street and Little Knight-Rider Street." At this house he seems to have had a society or college, which was broken up and the members dispersed by his promotion. In the year 1600 he published his work on the magnet. In 1603 the queen died, but Gilbert was reappointed by her successor. He did not long enjoy the honor, however, for he died November 30, 1603, some say at Colchester, others at London. He was buried at Colchester, in the chancel of the church of the Holy Trinity, where a monument was erected to him. To the College of Physicians he bequeathed his books, instruments, and minerals, but he gave his portrait to the School Gallery at Oxford. In it he is represented as tall of stature and of cheerful countenance, "holding in his hand a globe inscribed 'Terella;' over his head is the inscription '1591, ætatis 48;' and a little below his left shoulder, 'Magneticarum virtutum primus indagator Gilbertus.'" The date thus given does not tally with the conclusion of the inscription on his tombstone: "Obiit anno Redemptionis Humanæ 1603, Novembris ultimo, ætatis suæ 63." If the latter be correct, he was born in 1540; if the former, in 1543.

Gilbert's principal work is his treatise on magnetism, entitled *De Magnete, Magneticisque Corporibus, et de Magno Magnete Tellure*, London, 1600 (later editions—Sedan, 1628, 1633; Frankfort, 1629, 1638). The merit of this work consists in its originality, containing, as it does, an account of the author's experiments on magnets and magnetical bodies, and also the great discovery that the whole earth is nothing but a large magnet, and that it is this which explains, not only the direction of the magnetic needle north and south, but also the variation and dipping or inclination of the needle. Gilbert's is therefore, not merely the first, but the most important systematic contribution to the science of magnetism, and its merits were freely acknowledged by his contemporaries. A posthumous work of Gilbert's was edited by his brother, also called William, from two MSS. in the possession of Sir William Boswell; its title is *De Mundo Nostro Sublunari Philosophia Nova* (Amsterdam, 1651). He is the reputed inventor, besides, of two instruments to enable sailors "to find out the latitude without seeing of sun, moon, or stars." An account of these instruments is given in Thomas Blondeville's *Theoriques of the Planets* (London, 1602). The only writing of Gilbert in English is a short epistle addressed to William Barlowe, printed at the end of his little work entitled *Magneticall Advertisements* (London, 1616),—a letter which has hitherto escaped the notice of all the writers about Gilbert. It is of interest both because it shows that he carried on a scientific correspondence with the Continent, and that his book had been very well received, and because he says that he was intending to add six or eight sheets to the book,—an intention, however, which was never carried into effect.

The letter is dated 14th February, unfortunately without the year, but it must have been written between 1600 and 1603. In his preface Barlowe says that he had numerous letters from Gilbert, but these have long since disappeared. It is a matter of great regret for the historian of chemistry that Gilbert left nothing on that branch of science, to which he was deeply devoted, "attaining to great exactness therein." So at least says Fuller, who, in his *Worthies of England* (among whom he includes Gilbert), prophesied truly how he would be afterwards known: "Mahomet's tomb at Mecha," he says, "is said strangely to hang up, attracted by some invisible loadstone; but the memory of this doctor will never fall to the ground, which his incomparable book *De Magnete* will support to eternity."

GILBERT DE LA PORRÉE (*Gilbertus Porretanus* or *Pictaviensis*), an eminent scholastic logician and theologian of the 12th century, was born at Poitiers. He was educated under Bernard de Chartres and Anselm of Laon, and after completing his studies remained attached as teacher to the church at Chartres. In 1135 he is recorded as discharging these functions, but he seems soon after to have repaired to Paris and opened public courses on dialectics and theology. His fame caused him to be called to his native town, where in 1141 he was elected bishop. The heterodox opinions he was led to express regarding the doctrine of the Trinity drew upon his works the condemnation of the church. The synod of Rheims in 1148 procured papal sanction for four propositions opposed to certain tenets of Gilbert's, and the works of the latter were condemned until they should be corrected in accordance with the principles of the church. Gilbert seems to have submitted quietly to this judgment; he yielded assent to the four propositions, and remained on friendly terms with his antagonists till his death in 1154. Gilbert is almost the solitary logician of the 12th century who is quoted by the greater scholastics of the succeeding age. His chief logical work, the treatise *De Sex Principiis*, was regarded with a reverence almost equal to that given to Aristotle, and furnished matter for numerous commentaries. Albertus Magnus did not disdain to comment upon this work of an earlier logician. The treatise itself is an elaborate discussion of the Aristotelian categories, specially of the six subordinate modes. Gilbert distinguishes in the ten categories two classes, one essential, the other derivative. Essential or inhering (*formæ inhærentes*) in the objects themselves are only *substance, quantity, quality*, and *relation* in the stricter sense of that term. The remaining six, *when, where, action, passion, position*, and *habit*, are relative and subordinate (*formæ assistentes*). This suggestion has some interest, but it cannot be said to have great value, either in logic or in the theory of knowledge. More important in the history of scholasticism are the theological consequences to which Gilbert's realism led him. In the commentary on the treatise *De Trinitate*, erroneously supposed to be by Boetius, he proceeds from the metaphysical notion that pure or abstract being is prior in nature to that which is. This pure being is God, and must be distinguished from the triune God as known to us. God is incomprehensible, and the categories cannot be applied to determine his existence. In God there is no distinction or difference, whereas in all substances or things there is duality, arising from the element of matter. Between pure being and substances stand the ideas or forms, which subsist though they are not substances. These forms, when materialized, are called *formæ substantiales* or *formæ nativæ;* they are the essences of things, and in themselves have no relation to the accidents of things. Things are temporal, the ideas perpetual, God eternal. The pure form of existence, that by which God is God, must be distinguished from the three persons who are God by participation in this form. The form or essence is one, the persons or substances three. It was this distinction between Deitas or Divinitas and Deus that led to the condemnation of Gilbert's doctrine.

See Ritter, *Gesch. d. Phil.*, vii. 437–74: Hauréau, *Phil. Scolastique*, 2d ed., i. 447–78; Stöckl, *Phil. d. Mittelalters*, i. 272–88.

GILBERT OF SEMPRINGHAM, ST. (*c.* 1083–1189), founder of the order of Gilbertines (Ordo Gilbertinorum Canonicorum, Ordo Sempringensis), was born about the year 1083, at Sempringham, Lincolnshire, where his father, Jocelyn de Sempringham, a Norman noble who had taken part in the Conquest, had settled. On the completion of a liberal education, received partly in England and partly in France, Gilbert was ordained a priest in 1123, having been presented by his father to the united livings of Sempringham and Tirington. About 1135 he established in the immediate vicinity of his parish church a religious house for the reception of some destitute girls; the rule he prescribed was substantially that of St. Benedict, but the restrictions laid upon the communication of the inmates with the outer world were unusually severe. Subsequently the laborers who tilled the lands with which this establishment had been endowed were also formed into a religious community, under a rule resembling that of the Austin Friars, their house being placed close beside that of the nuns. Similar institutions elsewhere were encouraged by various English proprietors, and placed under the superintendence of Gilbert, who at last made application to Pope Eugenius III. to have them all merged in the Cistercian order (1148). This request, however, was refused, and Gilbert continued to act as superior of the monasteries he had founded for many years; although at the time of his death, on the 3d of February, 1189, that dignity was held by Roger, one of his disciples. In 1189 the Gilbertines are said to have possessed thirteen monasteries, with almshouses, hospitals, and orphanages attached; and the community numbered in all upwards of 700 male and 1100 female members. At the time of their suppression the total number of Gilbertine houses in England and Wales had increased to about twenty-five. Gilbert, who had sided and suffered with the church in the quarrels between Henry II. and Thomas à Becket, was canonized by Innocent III. in 1202; and his name is commemorated in the martyrologies on the 4th of February. The *Gilbertinorum Statuta* and a series of *Exhortationes ad Fratres* are attributed to him (see the Bollandist *Acta Sanctorum*, Feb. 4).

GILBERT ISLANDS. See POLYNESIA.

GILDAS, or **GILDUS** (*c.* 516–570), the earliest of British historians, surnamed by some Sapiens, and by others Badonicus, seems to have been born in the year 516. Regarding him little certain is known, beyond some isolated particulars that may be gathered from hints dropped in the course of his work. Two short treatises exist, purporting to be lives of Gildas, and ascribed respectively to the 11th and 12th centuries; but the writers of both are believed to have confounded two, if not more, persons that had borne the name. It is from an incidental remark of his own, namely, that the year of the siege of Mount Badon—one of the battles fought between the Saxons and the Britons—was also the year of his own nativity, that the date of his birth has been derived; the place, however, is not mentioned. His assertion that he was moved to undertake his task mainly by "zeal for God's house and for his holy law," and the very free use he has made of quotations from the Bible, leave scarcely a doubt that he was an ecclesiastic of some order or other. In addition, we learn that he went abroad, probably to France, in his thirty-fourth year, where, after 10 years of hesitation and preparation, he composed, about 560, the work bearing his name. His materials, he tells us, were collected from foreign rather than native sources, the latter of which had been put beyond his reach by circumstances. The *Cambrian Annals* give 570 as the year of his death.

The writings of Gildas have come down to us under the title of *Gildæ Sapientis de Excidio Britanniæ Liber Querulus*. Though at first written consecutively, the work is now usually divided into three portions,—a preface, the history proper, and an epistle,—the last, which is largely made up of passages and texts of Scripture brought together for the purpose of condemning the vices of his countrymen and their rulers, being the least important, though by far the longest of the three. In the second he passes in brief review the history of Britain from its invasion by the Romans till his own times. Among other matters reference is made to the introduction of Christianity in the reign of Tiberius; the persecution under Diocletian; the spread of the Arian heresy; the election of Maximus as emperor by the legions in Britain, and his subsequent death at Aquileia; the incursions of the Picts and Scots into the southern part of the island; the temporary assistance rendered to the harassed Britons by the Romans; the final abandonment of the island by the latter; the coming of the Saxons and their reception by Guortigern (Vortigern); and, finally, the conflicts between the Britons, led by a noble Roman, Ambrosius Aurelianus, and the new invaders. Unfortunately, on almost every point on which he touches, the statements of Gildas are vague and obscure. With one exception, already alluded to, no dates are given, and events are not always taken up in the order of their occurrence. These faults are of less importance during the period when Greek and Roman writers notice the affairs of Britain; but they become more serious when, as is the case from nearly the beginning of the 5th century to the date of his death, Gildas's brief narrative is our only authority for most of what passes current as the history of our island during those years. Thus it is on his sole, though in this instance perhaps trustworthy, testimony that the famous letter rests, said to have been sent to Rome in 446 by the despairing Britons, commencing:—"To Agitius (Aetius), consul for the third time, the groans of the Britons."

Gildas's treatise was first published in 1525 by Polydore Vergil, but with many avowed alterations and omissions. Forty-three years later, Josseline, secretary to Archbishop Parker, issued a new edition of it more in conformity with manuscript authority; and in 1691 a still more carefully revised edition appeared at Oxford by Thomas Gale. It was frequently reprinted on the Continent during the 16th century, and once or twice since. The next English edition was that published by the English Historical Society in 1838, and edited by the Rev. J. Stevenson. Lastly, the text of Gildas, with elaborate introductions and the various readings of existing manuscripts, is included in the *Monumenta Historica Britannica*, edited by Petrie and Sharpe, London, 1848.

GILDING, the art of spreading or covering gold, either by mechanical or by chemical means, over the surface of a body for the purpose of ornament. The art of gilding was not unknown among the ancients. According to Herodotus, the Egyptians were accustomed to gild wood and metals; and gilding by means of gold plates is frequently mentioned in the books of the Old Testament. Pliny informs us that the first gilding seen at Rome was after the destruction of Carthage, under the censorship of Lucius Mummius, when the Romans began to gild the ceilings of their temples and palaces, the Capitol being the first place on which this enrichment was bestowed. But he adds that luxury advanced on them so rapidly that in a little time you might see all, even private and poor persons, gild the walls, vaults, and other parts of their dwellings. Owing to the comparative thickness of the gold-leaf used in ancient gilding, the traces of it which yet remain are remarkably brilliant and solid. Gilding has in all times occupied an important place in the ornamental arts of Oriental countries; and the native processes pursued in India at the present day may be taken as typical of the art as practised from the earliest periods. For the gilding of copper, employed in the decoration of temple domes and other large works, the following is an outline of the processes employed. The metal surface is thoroughly scraped, cleaned, and polished, and next heated in a fire sufficiently to remove any traces of grease or other impurity which may remain from the operation of polishing. It is then dipped in an acid solution prepared from dried unripe apricots, and rubbed with pumice or brick powder. Next the surface is rubbed over with mercury which forms a superficial amalgam with the copper, after which it is left some hours in clean water, again washed with the acid solution, and dried. It is now ready for receiving the gold, which is laid on in leaf, and, on adhering, assumes a grey appearance from combining with the mercury, but on the application of heat the latter metal volatilizes, leaving the gold a dull greyish hue. The color is brought up by means of rubbing with agate burnishers. The weight of mercury used in this process is double that of the gold laid on, and the thickness of the gilding is regulated by the circumstances or necessities of the case. For the gilding of iron or steel, the surface is first scratched over with chequered lines, then washed in a hot solution of green apricots, dried, and heated just short of red-heat. The gold leaf is then laid on, and rubbed in with agate burnishers, when it adheres by catching into the prepared scratched surface.

Modern gilding is applied to numerous and diverse surfaces and by various distinct processes, so that the art is prosecuted in many ways, and is part of widely different ornamental and useful arts. It forms an important and essential part of frame-making (see CARVING AND GILDING); it is largely employed in connection with cabinet-work, decorative painting, and house ornamentation; and it also bulks largely in bookbinding and ornamental leather work. Further, gilding is much employed for coating baser metals, as in button-making, in the gilt toy trade, in electro-gilt reproductions, and in electro-plating; and it is also a characteristic feature in the decoration of pottery, porcelain, and glass. As details of the processes employed in connection with these various substances will be found in the parts of this work where the technical processes to which they are related are described, it is only necessary here to indicate how the processes of gilding differ from each other.

The various processes fall under one or other of two heads—mechanical gilding and gilding by chemical agency.

MECHANICAL GILDING embraces all the operations by which gold-leaf is prepared (see GOLD-BEATING), and the several processes by which it is mechanically attached to the surfaces it is intended to cover. It thus embraces the burnish or water-gilding and the oil-gilding of the carver and gilder, and the gilding operations of the house decorator, the sign-painter, the bookbinder, the paper-stainer, and several others. Polished iron, steel, and other metals are gilt mechanically by applying gold-leaf to the metallic surface at a temperature just under red-heat, pressing the leaf on with a burnisher, and reheating, when additional leaf may be laid on. The process is completed by cold burnishing.

CHEMICAL GILDING embraces those processes in which the gold used is at some stage in a state of chemical combination. Of these the following are the principal:—

Cold gilding.—In this process the gold is obtained in a state of extremely fine division from a chemical compound, and applied by mechanical means. Cold gilding on silver is performed by a solution of gold in aqua-regia, applied by dipping a linen rag into the solution, burning it, and rubbing the black and heavy ashes on the silver with the finger or a piece of leather or cork. *Wet gilding* is effected by means of a solution of gold in ether, obtained by treating a dilute solution of chloride of gold with twice its quantity of ether. The liquids are agitated and allowed to rest, when the ether separates and floats on the surface of the acid. The whole mixture is then poured into a funnel with a small aperture, and allowed to rest for some time, when the acid is run off and the ether separated. The ether will be found to have taken up all the gold from the acid, and may be used for gilding iron or steel, for which purpose the metal is polished with the finest emery and spirits of wine. The ether is then applied with a small brush, and as it evaporates it deposits the gold, which can now be heated and polished. For small delicate figures a pen or a fine brush may be used for laying on the ether solution. *Fire-gilding* or *Wash-gilding* is a process by which an amalgam of gold is applied to metallic surfaces, the mercury being subsequently volatilized, leaving a film of gold or, according to Struve, an amalgam containing from 13 to 16 per cent. of mercury. In the preparation of the amalgam the gold must first be reduced to thin plates or grains, which are heated red hot, and thrown into mercury previously heated, till it begins to smoke. Upon stirring the mercury with an iron rod, the gold totally disappears. The proportion of mercury to gold is generally as six or eight to one. When the amalgam is cold it is squeezed through chamois leather for the purpose of separating the superfluous mercury; the gold, with about twice its weight of mercury, remains behind, forming a yellowish silvery mass of the consistence of butter. When the metal to be gilt is wrought or chased, it ought to be covered with quicksilver before the amalgam is applied, that this may be more easily spread; but when the surface of the metal is plain, the amalgam may be applied to it direct. When no such preparation is applied, the surface to be gilded is simply bitten and cleaned with nitric acid. A deposit of mercury is obtained on a metallic surface by means of "quicksilver water," a solution of nitrate of mercury,—the nitric acid attacking the metal to which it is applied, and thus leaving a film of free metallic mercury. The amalgam being equally spread over the prepared surface of the metal, the mercury is then sublimed by a heat just sufficient for that purpose; for, if it is too great, part of the gold may be driven off, or it may run together and leave some of the surface of the metal bare. When the mercury has evaporated, which is known by the surface having entirely become of a dull yellow color, the metal must undergo other operations, by which the fine gold color is given to it. First, the gilded surface is rubbed with a scratch brush of brass wire, until its surface be smooth; then it is covered over with a composition called "gilding wax," and again exposed to the fire until the wax is burnt off. This wax is composed of beeswax mixed with some of the following substances, viz., red ochre, verdigris, copper scales, alum, vitriol, borax; but, according to Dr. Lewis, the saline substances alone are sufficient, without any wax. By this operation the color of the gilding is heightened; and the effect seems to be produced by a perfect dissipation of some mercury remaining after the former operation. The dissipation is well effected by this equable application of heat. The gilt surface is then covered over with a saline composition, consisting of nitre, alum, or other vitriolic salts, ground together, and mixed up into a paste with water or weak ammonia. The piece of metal thus covered is exposed to a certain degree of heat, and then quenched in water. By this method its color is further improved and brought nearer to that of gold, probably by removing any particles of copper that may have been on the gilt surface. This process, when skilfully carried out, produces gilding of great solidity and beauty; but owing to the exposure of the workmen to mercurial fumes, it is very unhealthy, and further there is much loss of mercury. Numerous contrivances have been introduced to obviate these serious evils; and the gilding furnace invented by M. D'Arcet is so arranged that the whole of the mercurial fumes are caught and recondensed for further use. Gilt brass buttons used for uniforms are gilt by this process, and there is an Act of Parliament yet unrepealed which prescribes 5 grains of gold as the smallest quantity that may be used for the gilding of 12 dozen of buttons 1 inch in diameter.

Electro-gilding, which has numerous and important applications, is described under ELECTRO-METALLURGY.

Gilding of Pottery and Porcelain.—The quantity of gold consumed for these purposes is very large. The gold used is dissolved in aqua-regia, and the acid is driven off by heat, or the gold may be precipitated by means of sulphate of iron. In this pulverulent state the gold is mixed with $\frac{1}{12}$th of its weight of oxide of bismuth, together with a small quantity of borax and gum water. The mixture is applied to the articles with a camel's hair pencil, and after passing through the fire the gold is of a dingy color, but the lustre is brought out by burnishing with agate and bloodstone, and afterwards cleaning with vinegar or white lead.

GILEAD (גִּלְעָד *i. e.* "hard" or "rugged") is sometimes used, both in earlier and in later writers, to denote the whole of the territory occupied by the Israelites eastward of Jordan, extending from the Arnon to the southern base of Hermon (Deut. xxxiv. 1; Judg. xx. 1; Jos., *Ant.* xii. 8, 3, 4). More precisely, however, it was the usual name of that mountainous district which is bounded on the N. by the Hieromax (Yarmuk), on the E. by the Jordan, on the S. by the Arnon, and on the W. by a line which may be said to follow the meridian of Ammân (Philadelphia or Rabbath-Ammon). It thus lay wholly within 31° 25′ and 32° 42′ N. lat., and 35° 34′ and 36° E. long. Excluding the narrow strip of low-lying plain along the Jordan, it has an average elevation of 2500 feet above the Mediterranean; but, as seen from the west, the relative height is very much increased by the depression of the Jordan valley. The range from the same point of view presents a singularly uniform outline, having the appearance of an unbroken wall; in reality, however, it is traversed by a number of deep ravines (wadys), of which the most important are the Yâbis, the Ajlûn, the Râjib, the Zerka (Jabbok), the Hesban, and the Zerka Maîn. The great mass of the Gilead range is formed of Jura limestone, but there are also occasional veins of sandstone. The eastern slopes are comparatively bare of trees; but the western are well supplied with oak, terebinth, and pine. The pastures are everywhere luxuriant, and the wooded heights and winding glens, in which the tangled shrubbery is here and there broken up by open glades and flat meadows of green turf, exhibit a beauty of vegetation such as is hardly to be seen in any other district of Palestine.

The first mention of "Mount Gilead" in Scripture occurs in Gen. xxxi., where it is said that the place where Jacob's covenant with his father-in-law was ratified was thenceforward called "the hill of witness" (גַּלְעֵד). The locality contemplated by the sacred writer was doubtless somewhere on the ridge of what is now known as Jebel Ajlûn, and probably not far from Mahneh (Mahanaim), near the head of the wady Yâbis.[1] Gilead next comes under notice in connection with the partition of the promised land among the twelve tribes of Israel. At the period of the conquest the portion of Gilead northward of the Jabbok (Zerka) belonged to the dominions of Og, king of Bashan, while the southern half was ruled by Sihon, king of the Amorites, having been at an earlier date wrested from Moab (Numb. xxi. 24; Deut. iii. 12–16). These two sections were allotted respectively to Manasseh and to Reuben and Gad, both districts being peculiarly suited to the pastoral and nomadic character of these tribes. A somewhat wild Bedouin disposition, fostered by their surroundings, was retained by the Israelite inhabitants of Gilead to a late period of their history, and seems to be to some extent discernible in what we read alike of Jephthah, of David's Gadites, and of the prophet Elijah.

After the close of the Old Testament history the word Gilead seldom occurs. It seems to have soon passed out of use as a precise geographical designation; for though occasionally mentioned by Apocryphal writers, by Josephus, and by Eusebius, the allusions are all vague, and show that those who made them had no definite knowledge of Gilead proper. In Josephus and the New Testament the name Peræa or *πέραν τοῦ 'Ιορδάνου* is most frequently used; and the country is sometimes spoken of by Josephus as divided into small provinces called after the capitals in which Greek colonists had established themselves during the reign of the Seleucidæ. At present Gilead south of the Jabbok alone is known by the name of Jebel Jilad (Mount Gilead), the northern portion between the Jabbok and the Yarmuk being called Jebel Ajlûn. Jebel Jilad includes Jebel Osha, and has for its capital the town of Es-Salt. The cities of Gilead expressly mentioned in Scripture are Ramoth, Jabesh, and Jazer. The first of these has been satisfactorily identified with Es-Salt, and apparently ought not to be regarded as distinct from Mizpeh (Judg. xi. 11, 34), called also Mizpeh-Gilead (Judg. xi. 29), or Ramoth Mizpeh (Josh. xiii. 26).

GILES, ST. (*ÆGIDIUS*, EGIDIO, GIL, or GILLES), according to the *Breviarium Romanum* (1st September), was an Athenian of royal descent, and from his earliest years distinguished for piety and charity. On the death of his parents he, while still young, distributed amongst the poor his entire patrimony, including his very tunic, which garment effected a miraculous cure upon the poor sick man to whom it had been given. Shrinking from the publicity involved in this and many other (apparently involuntary) miracles, he betook himself to Provence, where, after a residence of two years with St. Cæsarius at Arles, he withdrew into the solitude of the neighboring desert, living upon herbs and the milk of a hind which came to his cell at stated hours. Here he was discovered after some time by the king of France, who on a hunting expedition had tracked the hind to the hermit's cave. With the reluctant consent of Ægidius, a monastery was now built on the spot, he being appointed its first abbot. The functions of this office he discharged with prudence and piety until his death, which occurred some years afterwards.

Some uncertainty attaches to the date, as well as to several other circumstances stated in this narrative. It is known that a certain Ægidius, whose name at least (*'Αιγίδιος*, from *αἴξ* or *αἰγίς*) is suggestive of a Greek origin, held an abbacy in Provence in the 6th century, and, at the instance of Bishop Cæsarius, undertook, in 514, a mission to Pope Symmachus on a question relating to certain rivalries between the sees of Arles and Vienne (Labbe, *Conc.* v. 439–40, ed. 1728); but the modern hagiologists, following the earliest *Acta*, which assign the legend to the period of a Catholic Visigothic king "Flavius" (Wamba or Ervigius), incline to distinguish the saint from the earlier abbot of the same name, and to fix the date of the former about the end of the 7th century. Of the existence of an abbey under the advocacy of St. Giles towards the end of the 9th century there can be no question (Ménard, *Hist. de Nismes*); while Benjamin of Tudela makes special mention of the crowds of foreigners from all countries who in his time (1160) frequented that shrine, which is situated on the Petit-Rhône, about 12 miles westward of Arles. In the 11th and following centuries the cultus of the saint, who came to be regarded as the special patron of lepers, beggars, and cripples, spread very extensively over Europe, especially in England, Scotland, France, Germany, and Poland. The church of St. Giles, Cripplegate, London, was built about 1090, while the hospital for lepers at St. Giles-in-the-Fields was founded by Queen Matilda in 1117. In England alone there are 146 churches dedicated to this saint; and they occur in every county except in those of Westmoreland and Cumberland (Parker, *Calendar of the Anglican Church*). In Edinburgh the church of St. Giles (*c.* 1359) could boast the possession of an arm-bone of its patron. Representations of St. Giles are very frequently met with in early French and German art, but are much less common in Italy and Spain (Jameson, *Sacred and Legendary Art*, pp. 768–770).

GILFILLAN, GEORGE (1813–1878), a clergyman of the United Presbyterian Church of Scotland, and a well-known popular writer, was born 30th January, 1813, at Comrie, Perthshire, where his father, the Rev. Samuel Gilfillan, also a man of some literary activity, was for many years minister of a Secession congregation. At Glasgow University and the theological hall, as at Comrie school, he took small help from formal lessons, and cared little for a high place in his classes or for proficiency in his prescribed studies, but applied himself to English literature, with a passion for reading, and a memory which held fast and arranged the contents of all the congenial books he met with. In March, 1836, he was ordained pastor of a Secession congregation in Dundee. His first effort beyond the pulpit was in 1839, when he issued *Five Discourses*, which, though neglected by the reading public, had many high merits, and gave the promise of more and of higher. Some time afterwards he rather unadvisedly published a sermon on "Hades," which, distinguished by bold but ill-sustained speculation, and by brilliant but irregular imagination, brought him under the scrutiny of his co-presbyters, and was ultimately withdrawn from circulation. Gilfillan next contributed a series of sketches of celebrated literary men to the *Dumfries Herald*, then edited by Thomas Aird; and these, along with several new ones, formed his first *Gallery of Literary Portraits*, a volume which appeared in 1846, and had a wide circulation. It was quickly followed by a *Second* and a *Third Gallery*, until almost all our great men were delineated. In 1851 the *Bards of the Bible* appeared; and this has been his most successful work. His aim was that it should be "a poem on the Bible;" and it was far more rhapsodical than critical. Still the little criticism that was scattered throughout it was more than enough to keep it from soaring into poetry; and the poetry, when pure, was so fragmentary, that instead of making one poem, it consisted of many small pieces, though in these there were grand strokes and exquisite touches of description. His sketching powers were next exercised upon the "Scottish Covenanters," and some of the heroes and episodes of the struggle received a glowing commemoration. At a later date he published similar representations of English Puritans and of Scotch Seceders, as champions of the rights of conscience. The most extensive publication with which Gilfillan was connected was Nichol's edition of the *British Poets;* and his office was not only to secure the utmost accuracy in the text of each poet's works, but also to furnish both a biography and a critical estimate. This engagement, taking him again and leisurely through the studies in which he had most delighted, and with which he had been most conversant, stimulated him to finish the work on which he had resolved in youth, and to which he had long given the brightest moods of his most genial hours. *Night, a Poem*, came out in 1867, when he was fifty-four years of age; but the work which had received his labor and his polishing during his best thirty years was far less successful than his most ephemeral productions. It was, indeed, an absolute failure. The theme was vast, vague, and unmanageable, even though the poem had extended to ninety, instead of nine books. Then, though his nature was largely and essentially poetic, Gilfillan had never given himself a training or even any practice in verse. Besides, he had already, in his many prose volumes, made use of all his poetic ideas and illustrations. There was not a line in *Night* that had not often sounded forth in his essays with stronger and finer melody. It was but a faint echo, and it had no music. His *History of a Man*, partly autobiographic and largely fabulous, was not written with his usual candor and geniality. Not less abundant and striking than his literature was his oratory; and wherever he appeared as a preacher, or as a lecturer on some literary or secular theme, he drew large crowds that were invariably thrilled by his eloquence. There was no token either of physical or of mental exhaustion when he died suddenly of heart disease, in the summer of 1878. He had just finished a new life of Burns, designed to accompany a new edition of the works of that poet.

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[1] See Beke, "Notes on an Excursion to Harran," etc., in vol. xxxii. of the *Journal of the Royal Geographical Society* (1862). "It was not the River Jordan, but the ridge of Mount Gilead, which formed the natural boundary of the possessions of the children of Israel."

GILGAL. Three towns of this name are mentioned in the Bible. (1.) The first and most important was situated "in the east border of Jericho" (Joshua iv. 19), on the border between Judah and Benjamin (Joshua xv. 7). Josephus places it 50 stadia from Jordan and 10 from Jericho (*Antiq.*, v. 1, 4), but these measurements do not agree with the position of Jericho with respect to Jordan. Jerome (*Onomasticon*, s. v. Galgal) places Gilgal 2 Roman miles from Jericho, and speaks of it as a deserted place held in wonderful veneration ("miro cultu") by the natives. This site, which in the Middle Ages appears to have been lost—Gilgal being shown further north—has lately been recovered by a German traveller (Schokke), and fixed by the English survey party. It is about 2 miles east of the site of Byzantine Jericho, and 1 mile from the modern Erîha. A fine tamarisk, traces of a church (which is mentioned in the 8th century), and a large reservoir, now filled up with mud, remain. The place is called Jiljûlieh, and its position north of the valley of Achor (Wâdy Kelt) and east of Jericho agrees well with the Biblical indications above mentioned. A tradition connected with the fall of Jericho is attached to the site (see *Tent Work in Palestine*, vol. ii. p. 7). (2.) The second Gilgal, mentioned in Joshua xii. 23, in connection with Dor, appears to have been situated in the maritime plain. Jerome (*Onomasticon*, s. v. Gelgel) speaks of a town of the name 6 Roman miles north of Antipatris (Râs el 'Ain). This is apparently the modern Kalkilia (vulgarly Galgilia), but about 3 miles north of Antipatris is a large village called Jiljûlieh, which is more probably the Biblical town. (3.) The third Gilgal (2 Kings iv. 38) was in the mountains (compare 2 Kings ii. 1–3) near Bethel. Jerome mentions this place also (*Onomasticon*, s. v. Galgala). It appears to be the present village of Jiljilia, about 7 English miles north of Beitîn (Bethel).

GILGIT (*Ghilghit*, etc.), probably a secluded valley-state on a tributary of the Upper Indus, but also applied to the tributary river and the whole of its basin, which is one of great interest in many respects, though as yet but imperfectly known. Captain J. Biddulph has for some time past been employed in Gilgit on the part of the Government of India, but no part of the information communicated by him has yet been made available. We shall describe the whole basin so far as materials allow.

About 10 miles below the elbow formed by the Indus (74° 42′ long., 35° 50′ lat.) in suddenly changing its course from a general direction north-west to a general direction south-west, in the vicinity of some of the highest mountains and vastest glaciers in the world, the Gilgit river enters it on the right bank, and with a general direction from the north-west. Thus the axis of the Gilgit valley is in fact a prolongation of that of the Indus valley in the direction maintained by the latter for some 300 miles above the elbow just mentioned. The length of the basin, so far as we know, on a line nearly west to east, is 120 miles; and its greatest width from north to south is about 75. The south limit of the basin is formed by the lofty watershed which divides the west-to-east Gilgit basin from the meridional basins of the (Lower) Indus, the Swat, and the Panjkora. At its intersection with the Indus-Swat watershed this limit rises to a peak of 19,400 feet, and at its intersection with the Panjkora-Chitral watershed to peaks of 18,490 and 19,440 feet. The western limit of the basin is the lofty watershed dividing it from the Mastúj valley on the upper waters of the Chitral river. This limit runs from the intersection last mentioned north-north-east and then north-east, till it joins the great mountain node in which the ranges of Hindu-Kush and the Muztagh (or Karakoram), according to our usual nomenclature, coalesce on the margin of the Pamir plateau. The northern limit of the basin is formed by the Muztagh itself, with peaks of 23,330 feet, 22,740 feet, 22,590 feet, 25,370 feet, 25,050 feet, and the basin is closed on the east by an offshoot of the Muztagh which, over the Indus elbow, forms that other great congeries of peaks and glaciers, of which the culminating point (Rákipúshi) rises to 25,550 feet, whilst seven others exceed 19,000 feet. South of the gorge through which the Gilgit waters force their way to the Indus this eastern barrier continues with summits rising to 14,000 and 15,000 feet, and joins the southern limit already described. This last-mentioned part of the barrier is known as the Niludar Hills, and has to be passed by the traveller who enters Gilgit from Kashmír, *i. e.*, from India. The remotest source of the Gilgit waters is in a lake called Shundar, close above Mastúj, and by which one of the chief passes leads from Gilgit and Yassin to Mastúj and Chitral. The Ghizar river runs out of this, and, after a course of 60 miles, is joined by the river of Yassin, coming from the north. These two may be considered to form the Gilgit river. The Yassin river itself is formed by two streams joining 6 or 8 miles above the village of Yassin, by each of which leads a pass. From the north-west comes the Tui or Moshabbar stream, by which lies the Moshabbar pass, probably at least 16,000 feet in height, and traversing a deep crevassed glacier for 8 miles. From where the road reaches the upper stream of Mastúj one path leads down the latter to Mastúj, and another upstream, crossing by the Baroghil pass (12,000 feet), over the prolongation of Hindu-Kush watershed, into Wakhán and the basin of the Upper Oxus. By the other stream, called the Warchagam river, coming from the north, a path leads over the Darkot pass to the very source of the Mastúj river, and so also to the Baroghil pass. Another important stream, the Karambar, joins the Gilgit river from the north, about 21 miles below the confluence of the Ghizar and Yassin river. This flows through the Ishkaman valley, rising in a lake called the Karambar Sar, said to have been formed in recent years by glaciers damming up the stream, and by this runs the most easterly pass of those that lead from the Gilgit basin direct to Wakhán. It is believed to be very lofty and difficult, but it has not been explored. About 36 miles below the Ghizar-Yassin confluence, and 25 miles above the confluence with the Indus, on the right bank, stand the fort and village of Gilgit. Five miles below this the river is joined by the last important confluent, called the Nagar river. Recent information suggests that this stream has a very lengthened course, flowing, in fact, from the northern side of the Muztagh in the vicinity of the Karambar lake; and, if this be so, a large addition must be made to the Gilgit basin as a whole. But of this we have no defined knowledge.

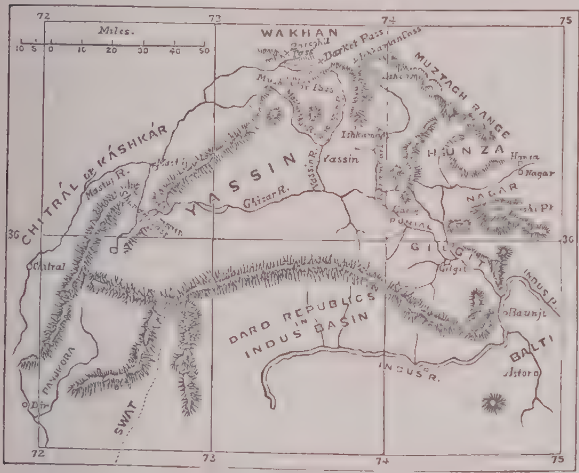

Chart of Gilgit.

The states occupying the basin of Gilgit, are, or till lately were, the following:—

1. *Yassin.*—This embraces all the upper or western part of the basin, including the Ishkaman valley. For some generations, at least, the relations of this state with Gilgit were hostile, whilst it was in intimate or dependent connexion with the kings of Chitral, and held by a member of the same family. Indeed, it was regarded and named as a subdivision of Upper Chitral. We have no present information as to the population or even the number of villages in this lofty district; but the route surveys show about thirty. The height of the chief place, Yassin, is 7770 feet. The country was visited twice in 1870 by a very gallant but not prudent traveller, Mr. George Hayward, and on the second visit in July of that year he was murdered by the agents of the chief Mir Wali, whilst on his way to the Darkot pass, in hope of penetrating to Wakhán and the exploration of Pamir. It is believed that Yassin has recently been annexed by the troops of Kashmír.

2. Next below Yassin is the small state of *Puniál* or *Punyá*, long held by separate rajas, and held by them now in dependence on Kashmír. It occupies the narrow valley of the river for a length of 25 miles, and contains nine villages, varying in height from 7000 feet down to 5500 feet. The villages are all within little forts, so that (as in Khorasan, and in Marco Polo's narrative) villages and forts are synonymous. At evening, the people who have been occupied in their fields come within the wall, and the gates are closed. Sentries guard the towers all night, and at dawn an armed patrol goes forth and makes the round of all places that might harbor an enemy, before the people issue to their avocations. In this part of the valley there are frequent *mauvais pas* on the road, where passage is difficult, and where a few men might stop a host. These are called by the old Persian name of *darband* (porta clausa), like the famous Iron Gate on the Caspian. The upper village of Puniál, called Gákúj, was till recently the furthest point to which the power of Kashmír, and therefore the influence of the British Government, extended. It stands 6940 feet above the sea. Between Gákúj and Yassin the road passes through a natural gate of rock. The ruler of Puniál is, or was in 1873, Raja 'Isa Bágdur, an old man who, in his little kingdom of nine villages, displayed some of the best characteristics of a king,—feared by his enemies, liked and implicitly obeyed by his people. On meeting him they go up and kiss his hand.

Gilgit occupies the remainder of the main valley down to the Indus, but we shall first speak of Hunza and Nagar, lying in the eastmost part of the basin, on the Nagar river.

3 and 4. *Nagar* lies on the left bank of the river, *Hunza* opposite, and the two "capitals," so to call them, lie just over against one another. They are distinct states under distinct princes, and their people of distinct Mussulman sects. Whilst Nagar sends a small complimentary tribute to the maharaja of Kashmír, Hunza (also called Kanjúd), a more warlike country, has often been at active enmity with him, coming down upon his villages in Gilgit, sweeping off the inhabitants, and selling them into slavery. Though the people of both states seem to speak the same language, Dr. Leitner says the Nagar people are shorter, stouter, and fairer than the Hunza folk, whom he calls "tall skeletons" and desperate robbers. He says he met a man of Nagar whose yellow moustache and general appearance made him believe almost that he had seen a Russian. The Kanjúdis are the terror of the Kirghiz on the upper waters of the Yarkand, and of the traders from Ladák to that territory.

5. *Gilgit* occupies all the lower part of the main valley to the Indus. If we take the whole length of the river, from the source in the Shundar lake to the Indus, at 135 miles (which, like the other distances here, is taken with a 5-mile opening of the compass, omitting minor windings), Yassin will occupy 75 miles of this, Puniál 25, and Gilgit 35. The lower part of Gilgit is a valley from 1 to 3 miles wide, bounded on each side by steep rocky mountains. The valley contains stony alluvial plateaus of various forms and at various levels above the river, which flows between cliffs worn in these. The greater part of this space is barren, but as usual in those high regions there is in front of each lateral ravine a cultivated space watered by the tributary stream, and on that a collection of houses. The village of Gilgit is 4800 feet above the sea, and stands on a flat plain of the river alluvium, forming a terrace 30 or 40 feet above the water. The cultivation here covers a square mile or thereabouts, irrigated from the nearest lateral stream. The houses are flat-roofed, scattered over the plain in twos and threes, among groups of fruit-trees. The destruction was great in the wars to which Gilgit has been subject in the last half-century, and it will take long before the village recovers the former abundance of fruit-trees. The fort of Gilgit is the chief stronghold of the maharaja of Kashmír in Dardistán.

There is very little snow-fall at Gilgit. The vegetable products are wheat, barley, naked barley, rice (at Gilgit village only), maize, millet, buckwheat, various pulses, rape, and cotton; and of fruits, mulberries, peaches, apricots, grapes, apples, quinces, pears, green-gages, figs (poor), walnuts, pomegranates, and *elæagnus*, besides musk and water-melons. Silk is grown in very small quantity. There are three fabrics from it,—one-half wool, much worn by those above the common peasant, one-half cotton, and the third all silk, strong though loosely woven, and prized for girdles. Gold is washed from the river-gravels as in many other parts of the Indus basin. The vine is much cultivated in some parts of the valley. In Puniál it is grown in small vineyards, the vines being often old trees; the whole vineyard is covered with a horizontal framework of sticks, 2 to 4 feet above the ground, and over this the vines are trained.

The people of the basin are all reckoned to be Dards, though there is this perplexing fact, that (setting aside dialects) two languages are spoken among them, which are entirely and radically different,—the *Khajuna* language, which is spoken in Hunza, Nagar, and Yassin, being one of which no relation has yet been traced to any other tongue, whilst the *Shina*, spoken, in the rest of the basin, is clearly Aryan, and kindred to the Sanskritic languages of India. Now there seems to be no doubt entertained that the Yassin people at least have all the characters of undisputed Dards. It is worth while to exhibit the numerals from these two languages.

	Shina.	Khajuna.
One	*eyk*	*hann.*
Two	*do*	*altàtz.*
Three	*tré*	*uskó.*
Four	*tshar*	*waltó.*
Five	*poñ*	*tshudó.*
Six	*shá*	*mishindó.*
Seven	*sath*	*tató.*
Eight	*atsh*	*altambu.*
Nine	*nau*	*untshò.*
Ten	*dáy*	*tóromo.*
Eleven	*akáy*	*turma-hann.*
Twelve	*báy*	*turma-altatz.*

The Dards not only occupy the Gilgit basin, but also extend down the Indus basin, in which they form a number of small republican communities (whilst the states of the Gilgit basin are all, so to speak, monarchical), reaching to Batera, where the Pushto-speaking tribes who are of Afghan blood, or at least Afghanized, commence. The Dards are described as decidedly Aryan in features, broad-shouldered, well-proportioned, active, and enduring. The hair is usually black but sometimes brown, the eyes brown or hazel, the skin sometimes fair enough to show a ruddy complexion; the voice and manner of speech are harsh. In bearing they are cheerful, bold, and independent, not disobliging when rightly handled, and as a race decidedly clever. They do not care much for human life, but still are not blood-thirsty. They are, says Mr. Drew, "a people who will meet one on even terms, without sycophancy or fear, and without impertinent self-assertion." The women are not pretty in Gilgit, but those of Yassin have a better repute, and indeed Hayward says: "The women have a more English cast of countenance than any I have yet seen in Asia, light-brown locks prevailing." The dress is entirely woollen, trousers, choga (long robe like a dressing-gown), and girdle. The cap is most characteristic; it is a long woollen bag rolled up at the edge till it fits close to the head. The feet are wrapt in scraps of leather, with a long strip as a binder. There is a distinct separation into castes, of which Drew counts five, others only four. The lowest caste is Dúm, the name of a low caste found all over India to the extreme Deccan,—a notable circumstance. The middle castes, Shin and Yashkun, form the body of the Dard people. The pure Shin looks more like a European than any high-caste Brahman of India. A Shin man may marry a Yashkun woman, but a Yashkun man may not marry a Shin woman. The Yashkuns predominate in Gilgit basin; the Shins in Haramosh (up the Indus valley) and Astor (east of Gilgit), and in the states of the Indus basin below Gilgit. It is a notable circumstance that the Dards abhor the cow, much as the Mussulmans abhor swine. They will not drink cow's milk, nor make or eat butter. In this last point the Indo-Chinese nations generally and the Chinese resemble them, but not in the dislike to the animal. The Dards will not burn cow-dung nor touch the cow if they can help it.

All the Dards of the Gilgit basin are Mahometans, and of three different sects, Sunnis, Shiahs, and Moláis (Mullahis?), the last being a Shiah offshoot and modification. The last two drink wine, the Sunnis do not. Gilgit proper is half Sunni, half Shiah; Puniál, Molái; Hunza, Molái—these are great wine drinkers; Nagar, Shiah; Ishkaman, Molái; Yassin, Molái, and Sunni, without any Shiahs. Till lately they were very loose Mahometans. Some of the Moslem officers in the Sikh and Dogra garrisons have spread greater rigidity. The wine is put in large earthenware jars, which are then buried for a time. The people do not understand clarifying the wine. Dr. Leitner tasted some which was very palatable, but looked more like mutton-broth than wine. A kind of beer is also made. Polo is a favorite game throughout Dardistán, as in Balti, which is its home, or one of its homes, and it extends to the Chitral country. Wherever Baltis or Dards live, the polo-ground may be looked for. Target archery with firearms is also a favorite amusement; they use stones for bullets, with a thin coating of lead. They are excellent shots. The Jew's harp is played; and the invention is ascribed to King David.

History.—The Dards are located by Ptolemy with surprising accuracy (*Duradæ*) on the west of the Upper Indus, beyond the head-waters of the Swat river (*Soastus*), and north of the *Gandaræ, i. e.*, the Gandháras, who occupied Peshawar and the country north of it. The *Dardas* and *Chinas* also appear in many of the old Pauranic lists of peoples, the latter probably representing the *Shin* branch of the Dards. This region was traversed by two of the Chinese pilgrims of the early centuries of our era, who have left records of their journeys, viz., Fahian, coming from the north, c. 400, and Hwen-thsang, ascending from Swat, c. 631. The latter says: "Perilous were the roads, and dark the gorges. Sometimes the pilgrim had to pass by loose cords, sometimes by light stretched iron chains. Here there were ledges hanging in mid-air; there flying bridges across abysses; elsewhere paths cut with the chisel, or footings to climb by." Yet even in these inaccessible regions were found great convents, and miraculous images of Buddha. How old the name of *Gilgit* is we do not know, but it occurs in the writings of the great Mahometan savant Al-Birúni, in his notices of Indian geography. Speaking of Kashmír, he says: "When thou hast passed the defile which forms the entrance and hast penetrated into the plain, thou hast to thy left the mountains of Balaur and Shamílán. Two days' journey distant are the Turks called *Bhatáwarián*, whose king takes the name of *Bhatsháh*. The country which these Turks occupy is called *Kilkit* (or Gilgit), *Asora*, and *Shaltás*. Their tongue is Turk; the people of Kashmír have to suffer much from their raids"—(Reinaud, "Extraits," in *Journal Asiatique*, ser. iv. tom. iv.). There are difficult matters for discussion here. It is impossible to say what ground the writer had for calling the people *Turks*. But it is curious that the *Shins* say they are all of the same race as the Moghuls of India, whatever they may mean by that. Gilgit, as far back as tradition goes, was ruled by rajas of a family called Trakane. When this family became extinct the valley was desolated by successive invasions of neighboring rajas, and in the 20 or 30 years ending with 1842 there had been five dynastic revolutions. The most prominent character in the history was a certain Gaur Rahman or Gauhar Aman, chief of Yassin, a cruel savage and man-seller, of whom many evil deeds are told. Being remonstrated with for selling a *mullah*, he said, "Why not? the Koran, the word of God, is sold: why not sell the expounder thereof?" The Sikhs entered Gilgit about 1842, and kept a garrison there. When Kashmír was made over to Maharaja Gúláb Singh of Jámú in 1846, by Lord Hardinge, the Gilgit claims were transferred with it. And when a commission was sent to lay down boundaries of the tracts made over, Mr. Vans Agnew (afterwards murdered at Multán) and Lieut. Ralph Young of the Engineers visited Gilgit, the first Englishmen who did so. The Dogras (Gúláb Singh's race) had much ado to hold their ground, and in 1852 a catastrophe occurred, parallel on a smaller scale to that of the English troops at Cabul. Nearly 2000 men of theirs were exterminated by Gaur Rahman and a combination of the Dards; only one person, a soldier's wife, escaped, and the Dogras were driven away for eight years. Gúláb Singh would not again cross the Indus, but after his death (in 1857) the present Maharaja Ranbir Singh longed to recover lost prestige. In 1860 he sent a force into Gilgit. Gaur Rahman just then died, and there was little resistance. The Dogras have twice since then taken Yassin, but did not hold it. Now, recently, it is believed, they have not only occupied Yassin, but have invaded Chitrál also. They also, in 1866, invaded Darel, one of the most secluded Dard states, to the south of the Gilgit basin, but withdrew again.

The chief source of the information in this article is an excellent work by Mr. Frederick Drew, who was long in the employment of the maharaja, *The Jummoo and Kashmir Territories, a Geographical Account*, 1875. Use has also been made of Dr. Leitner's uncompleted work, *Results of Tour in Dardistan, etc.*; of Mr. Hayward's letters (*Proc. Roy. Geog. Soc.*, vol. xv., and *Journ. Roy. Geog. Soc.*, vol. xli.); and of Col. Walker's *Report on the Survey Dept.* for 1877–78. The narrative of "the ullah," who performed the remarkable journeys noticed briefly in that report, has been for the present withheld from publication by the Indian Government, but the map corrected by his surveys is of extreme interest and value. By and by we may hope for the publication of Captain Biddulph's observations, which will doubtless throw much new light on this secluded and interesting region. (H. Y.)

GILL, John (1697–1771), a Baptist minister and learned Rabbinical scholar, was born at Kettering, Northamptonshire, in 1697. On account of the limited means of his parents, he owed his education chiefly to his own perseverance. After receiving baptism in November, 1716, he began to preach, and officiated at Higham Ferrers, as well as occasionally at his native place, until the beginning of 1719, when he became pastor of the Baptist congregation at Horsleydown, in Southwark, where he continued fifty-one years. In 1748 he received the degree of D. D. from the university of Aberdeen. He died at Camberwell, October 14, 1771.

His principal works are *Exposition of the Song of Solomon*, 1728; *The Prophecies of the Old Testament respecting the Messiah considered*, 1728; *Treatise on the Doctrine of the Trinity*, 1731; *Cause of God and Truth*, in 4 vols., 1731; *Exposition of the Bible*, in 10 vols., in preparing which he formed a large collection of Hebrew and Rabbinical books and MSS.; *Dissertation on the Antiquity of the Hebrew Language—Letters, Vowel Points, and Accents*, 1767; *A Body of Doctrinal Divinity*, 1767; *A Body of Practical Divinity*, 1770; and *Sermons and Tracts*, with a memoir of his life, 1773. An edition of his *Exposition of the Bible* appeared in 1816 with a memoir by Dr. Ripon, which has also appeared separately. Various editions of several of his other works have also appeared.

GILLESPIE, George (1613–1648), a prominent member of the presbyterian party in the Westminster Assembly, was born at Kirkcaldy, where his father was parish minister, on the 21st of January, 1613, and entered the university of St. Andrews as a "presbytery bursar" in 1629. On the completion of a brilliant student career, he became domestic chaplain to Lord Kenmure, and afterwards to the earl of Cassilis, his conscience not permitting him to accept the episcopal ordination which was at that time in Scotland an indispensable condition of induction to a parish. While with the earl of Cassilis he wrote his first work, *A Dispute against the English Popish Ceremonies obtruded upon the Church of Scotland*, which, opportunely published (but without the author's name) in the summer of 1637, attracted considerable attention, and within a few months had been found by the privy council to be so damaging that by their orders all available copies were called in and burnt. In April, 1638, soon after the authority of the bishops had been set aside by the nation, Gillespie was ordained minister of Wemyss (Fife) by the presbytery of Kirkcaldy, and in the same year was a member of the famous Glasgow Assembly, before which he preached a sermon so pronounced against royal interference in matters ecclesiastical as to call for some remonstrance on the part of Argyll, the Lord High Commissioner. In 1642 Gillespie was translated to Edinburgh; but the brief remainder of his life was chiefly spent in the conduct of public business in London. Already, in 1640, he had accompanied the commissioners of the peace to England as one of their chaplains; and in 1643 he was appointed by the Scottish church one of the four commissioners to the Westminster Assembly. Here he took a prominent part in almost all the protracted discussions on church government, discipline, and worship, supporting Presbyterianism by numerous controversial writings, as well as by an unusual fluency and readiness in debate. On the Erastian question, in particular, besides a series of vigorous pamphlets against Coleman (*A Brotherly Examination of some Passages in Mr. Colemam's late printed Sermon*, etc.; *Nihil Respondes; Male Audis*), he published in 1646 a large work entitled *Aaron's Rod Blossoming, or the Divine Ordinance of Church-government vindicated*, which is deservedly regarded as a really able statement of the case for an exclusive spiritual jurisdiction of the Church. Shortly after his return to Scotland, Gillespie was elected moderator of the Assembly (1648); but the laborious duties of that office (the court continued to sit from 12th July to the 12th of August) told fatally on a constitution which, at no time very vigorous, had of late years been much overtaxed; and, after many weeks of great weakness, he died at Kirkcaldy on the 17th of December, 1648. In acknowledgment of his great public services, a sum of £1000 Scots was voted, though destined never to be paid, to his widow and children by the committee of estates. A simple tombstone, which had been erected to his memory in Kirkcaldy parish church, was in 1661 publicly broken at the cross by the hand of the common hangman, but was restored in 1746. Among the other works of Gillespie may be mentioned the *Treatise of Miscellany Questions, wherein many useful Questions and cases of Conscience are discussed and resolved*, published posthumously (1649); and *The Ark of the Testament opened*, being a treatise on the covenant of grace, also posthumous (2 vols., 1661–1677).

GILLESPIE, THOMAS (1708–1774), one of the founders of the Scottish "Presbytery of Relief," was born in the parish of Duddingston, Midlothian, in 1708. On the completion of his literary course at the university of Edinburgh, he for a short time attended a small theological seminary at Perth, and afterwards studied divinity under Dr. Doddridge at Northampton, where he received ordination in January, 1741. In August of the same year he was admitted minister of the parish of Carnock, Fife, the presbytery of Dunfermline agreeing, not only to sustain as valid the ordination he had received in England, but also to allow a qualification of his subscription to the church's doctrinal symbol, so far as it had reference to the sphere of the civil magistrate in matters of religion. Having on conscientious grounds persistently absented himself from the meetings of presbytery held for the purpose of ordaining an unacceptable presentee as minister of Inverkeithing, he was, after an unobtrusive but useful ministry of ten years, deposed for contumacy by the Assembly of 1752; he continued, however, to preach, first at Carnock, and afterwards in Dunfermline, where a large congregation gathered round him; but it was not until 1761, and after repeated efforts to obtain readmission to the church, that, in conjunction with Boston of Jedburgh and Collier of Colinsburgh, he formed a distinct communion under the name of The Presbytery of Relief,—relief, that is to say, "from the yoke of patronage and the tyranny of the church courts." He died on the 19th January, 1774. His only literary efforts were an *Essay on the Continuation of Immediate Revelations in the Church*, and a *Treatise on Temptation*, characterized by considerable laboriousness and some ability. Both works appeared posthumously (1774). See *Lives of Fathers of the United Presbyterian Church* (Edin. 1849).

GILLIES, JOHN (1747–1836), the historian of ancient Greece, was born in 1747 at Brechin, in Forfarshire. He was educated at the university of Glasgow, where he greatly distinguished himself, and where, at the age of twenty, he officiated for a short time as substitute for the professor of Greek. Subsequently he received an engagement as tutor in the family of Lord Hopetoun, who afterwards conferred on him a pension for life. In 1784 he completed his principal work, the *History of Ancient Greece, its Colonies and Conquests*, which he published two years later in 2 vols. 4to. This work gives a clear and generally accurate account of the various states of Greece, and the progress of each in literature and the arts. The learning it displays is considerable, but its reflections are generally somewhat trite, and the style is abrupt and frequently diffuse. It enjoyed, however, for some time a great popularity, and was translated into French and German. It was long a favorite text-book for schools, but is now completely superseded. On the death of Robertson, Gillies was appointed historiographer-royal of Scotland. In his old age he retired to Clapham, where he died 15th February, 1836, in the 90th year of his age.

Of his other works, none of which are much read, the principal are—*View of the Reign of Frederick II. of Prussia, with a Parallel between that Prince and Philip II. of Macedon*, 1789; *Translation of Aristotle's Rhetoric, and of his Ethics and Politics*; and *History of the World from Alexander to Augustus*, in 2 vols., 1807.

GILLRAY, JAMES (1757–1815), one of the most eminent of caricaturists, was born at Chelsea in 1757. His father, a native of Lanark, had served as a soldier, losing an arm at Fontenoy, and was admitted first as an inmate, and afterwards as an out-door pensioner, at Chelsea Hospital. Gillray commenced life by learning letter-engraving, in which he soon became an adept. This employment, however, proving irksome, he wandered about for a time with a company of strolling players. After a very chequered experience he returned to London, and was admitted a student in the Royal Academy, supporting himself by engraving, and probably issuing a considerable number of caricatures under fictitious names. Hogarth's works were the delight and study of his early years. Paddy on Horseback, which appeared in 1779, is the first caricature which is certainly his. Two caricatures on Rodney's naval victory, issued in 1782, were among the first of the memorable series of his political sketches. The name of Gillray's publisher and printseller, Miss Humphrey—whose shop was first at 227 Strand, then in New Bond Street, then in Old Bond Street, and finally in St. James's Street—is inextricably associated with that of the caricaturist. Gillray lived with Miss (often called Mrs.) Humphrey during all the period of his fame. It is believed that he several times thought of marrying her, and that on one occasion the pair were on their way to the church, when Gillray said:—"This is a foolish affair, methinks, Miss Humphrey. We live very comfortably together; we had better let well alone." There is no evidence, however, to support the stories which scandalmongers have invented about their relations. Gillray's plates were exposed in Humphrey's shop window, where eager crowds examined them. A number of his most trenchant satires are directed against George III., who, after examining some of Gillray's sketches, said, with characteristic ignorance and blindness to merit, "I don't understand these caricatures." Gillray revenged himself for this utterance by his splendid caricature entitled A Connoisseur Examining a Cooper, which he is doing by means of a candle on a "save-all;" so that the sketch satirizes at once the king's pretensions to knowledge of art and his miserly habits.

The excesses of the French Revolution made Gillray conservative; and he issued caricature after caricature ridiculing the French and Napoleon, and glorifying John Bull. He is not, however, to be thought of as a keen political adherent of either the Whig or the Tory party; he dealt his blows pretty freely all round. His last work, from a design by Bunbury, is entitled Interior of a Barber's Shop in Assize Time, and is dated 1811. While he was engaged on it he became mad, although he had occasional intervals of sanity, which he employed on his last work. The approach of madness must have been hastened by his intemperate habits. Gillray died on the 1st of June, 1815, and was buried in St. James's churchyard, Piccadilly.

The times in which Gillray lived were peculiarly favorable to the growth of a great school of caricature. Party warfare was carried on with great vigor and not a little bitterness; and personalities were freely indulged in on both sides. Gillray's incomparable wit and humor, knowledge of life, fertility of resource, keen sense of the ludicrous, and beauty of execution, at once gave him the first place among caricaturists. He is honorably distinguished in the history of caricature by the fact that his sketches are real works of art. The ideas embodied in some of them are sublime and poetically magnificent in their intensity of meaning; while the coarseness by which others are disfigured is to be explained by the general freedom of treatment common in all intellectual departments in the eighteenth century. The historical value of Gillray's work has been recognized by accurate students of history. As has been well remarked: "Lord Stanhope has turned Gillray to account as a veracious reporter of speeches, as well as a suggestive illustrator of events." His contemporary political influence is borne witness to in a letter from Lord Bateman, dated November 3, 1798. "The Opposition," he writes to Gillray, "are as low as we can wish them. You have been of infinite service in lowering them, and making them ridiculous." Gillray's extraordinary industry may be inferred from the fact that nearly 1000 caricatures have been attributed to him; while some consider him the author of 1600 or 1700. He is invaluable to the student of English manners as well as to the political student. He attacks the social follies of the time with scathing satire; and nothing escapes his notice, not even a trifling change of fashion in dress. The great tact Gillray displays in hitting on the ludicrous side of any subject is only equalled by the exquisite finish of his sketches—the finest of which reach an epic grandeur and Miltonic sublimity of conception.

Gillray's caricatures are divided into two classes, the political series and the social. The political caricatures form really the best history extant of the latter part of the reign of George III. They were circulated not only over Britain but throughout Europe, and exerted a powerful influence. In this series, George III., the Queen, the Prince of Wales, Fox, Pitt, Burke, and Napoleon are the most prominent figures. In 1788 appeared two fine caricatures by Gillray. Blood on Thunder fording the Red Sea represents Lord Thurlow carrying Warren Hastings through a sea of gore; Hastings looks very comfortable, and is carrying two large bags of money. Market-Day pictures the ministerialists of the time as horned cattle for sale. Among Gillray's best satires on the king are—Farmer George and his Wife, two companion plates, in one of which the king is toasting muffins for breakfast, and in the other the queen is frying sprats; The Anti-Saccharites, where the royal pair propose to dispense with sugar, to the great horror of the family; A Connoisseur Examining a Cooper; Temperance enjoying a Frugal Meal; Royal Affability; A Lesson in Apple Dumplings; and The Pigs Possessed. Among his other political caricatures may be mentioned—Britannia between Scylla and Charybdis, a picture in which Pitt, so often Gillray's butt, figures in a favorable light; The Bridal Night; The Apotheosis of Hoche, which concentrates the excesses of the French Revolution in one view; The Nursery with Britannia reposing in Peace; The First Kiss these Ten Years (1803), another satire on the peace, which is said to have greatly amused Napoleon; The Handwriting upon the Wall; The Confederated Coalition, a fling at the coalition which superseded the Addington Ministry; Uncorking Old Sherry; The Plum-Pudding in Danger; Making Decent, *i. e.*, Broad-bottomites getting into the Grand Costume; Comforts of a Bed of Roses; View of the Hustings in Covent Garden; Phaethon Alarmed; and Pandora opening her Box. The miscellaneous series of caricatures, although they have scarcely the historical importance of the political series, are more readily intelligible, and are even more amusing. Among the finest are —Shakespeare Sacrificed; Flemish Characters [two plates]; Twopenny Whist; Oh! that this too solid flesh would melt; Sandwich Carrots; The Gout; Comfort to the Corns; Begone Dull Care; The Cow-Pock, which gives humorous expression to the popular dread of vaccination; Dilletanti Theatricals; and Harmony before Matrimony and Matrimonial Harmonics—two exceedingly good sketches in violent contrast to each other.

A selection of Gillray's works appeared in parts in 1818; but the first good edition was Thomas M'Lean's, which was published with a key, in 1830. A somewhat bitter attack, not only on Gillray's character, but even on his genius, appeared in the *Athenæum* for October 1, 1831, which was successfully refuted by J. Landseer in the *Athenæum* a fortnight later. In 1851 Henry G. Bohn put out an edition, from the original plates, in a handsome folio, the coarser sketches being published in a separate volume. For this edition Thomas Wright and R. H. Evans wrote a valuable commentary, which is a good history of the times embraced by the caricatures. The next edition, entitled *The Works of James Gillray, the Caricaturist: with the Story of his Life and Times* (Chatto and Windus, 1874), was the work of Thomas Wright, and, by its popular exposition and narrative, introduced Gillray to a very large circle formerly ignorant of him. This edition, which is complete in one volume, contains two portraits of Gillray, and upwards of 400 illustrations. Mr. J. J. Cartwright, in a letter to the *Academy* (Feb. 28, 1874), drew attention to the existence of a MS. volume, in the British Museum, containing letters to and from Gillray, and other illustrative documents. The extracts he gave were used in a valuable article in the *Quarterly Review* for April, 1874. See also the *Academy* for Feb. 21 and May 16, 1874.

For a contemporary life of Gillray, see George Stanley's notice in his edition of *Bryan's Dictionary of Painters*. There is a good account of him in Wright's *History of Caricature and Grotesque in Literature and Art*, 1865. See also the article CARICATURE.

GILLYFLOWER, a popular name applied to various flowers, but principally to the clove, *Dianthus Caryophyllus*, of which the carnation is a cultivated variety, and to the stock *Mathiola incana*, a well-known garden favorite. The word is sometimes written gilliflower or gilloflower, and is reputedly a corruption of July-flower, "so called from the month they blow in." Phillips, in his *Flora Historica*, remarks that Turner (1568) "calls it gelouer, to which he adds the word stock, as we would say gelouers that grow on a stem or stock, to distinguish them from the clove-gelouers and the wall-gelouers. Gerard, who succeeded Turner, and after him Parkinson, calls it gilloflower and thus it travelled from its original orthography until it was called July-flower by those who knew not whence it was derived." Dr. Prior, in his useful volume on the *Popular Names of British Plants*, very distinctly shows the origin of the name. He remarks that it was "formerly spelt gyllofer and gilofre with the *o* long, from the French *giroflée*, Italian *garofalo* (M. Lat. *gariofilum*), corrupted from the Latin *Caryophyllum*, and referring to the spicy odor of the flower, which seems to have been used in flavoring wine and other liquors to replace the more costly clove of India. The name was originally given in Italy to plants of the pink tribe, especially the carnation, but has in England been transferred of late years to several cruciferous plants." The gillyflower of Chaucer and Spenser and Shakespeare was, as in Italy, *Dianthus Caryophyllus*; that of later writers and of gardeners, *Mathiola*. Much of the confusion in the names of plants has doubtless arisen from the vague use of the French terms *giroflée*, *oeillet*, and *violette*, which were all applied to flowers of the pink tribe, but in England were subsequently extended and finally restricted to very different plants. The use made of the flowers to impart a spicy flavor to ale and wine is alluded to by Chaucer, who writes—

> "And many a clove gilofre
> To put in ale;"

also by Spenser, who refers to them by the name of sops in wine, which was applied in consequence of their being steeped in the liquor. In both these cases, however, it is the clove-gillyflower which is intended, as it is also in the passage from Gerard, in which he states that the conserve made of the flowers with sugar "is exceeding cordiall, and wonderfully above measure doth comfort the heart, being eaten now and then." The principal other plants which bear the name are the wallflower, *Cheiranthus Cheiri*, called wall-gillyflower in old books; the dame's violet, *Hesperis matronalis*, called variously the queen's, the rogue's, and the winter gillyflower; the ragged robin, *Lychnis flos cuculi*, called marsh-gillyflower; the water-violet, *Hottonia palustris*, called water-gillyflower; and the thrift, *Armeria vulgaris*, called sea-gillyflower. As a separate designation it has in modern times been chiefly applied to the *Mathiola* or stock, but it is now very little used.

GILPIN, BERNARD (1517–1583), rector of Houghton-le-Spring, distinguished by the unusual way in which he carried out his conception of the duties of a Christian pastor, was descended from a Westmoreland family, and was born at Kentmere, in 1517. At Oxford he first adhered to the conservative side, and defended the doctrines of the church against Hooper; but his confidence was somewhat shaken by another public disputation which he had with Peter Martyr. In 1552 he preached before King Edward VI. a sermon on sacrilege, which was duly published, and displays the high ideal which even then he had formed of the clerical office; and about the same time he was presented to the vicarage of Norton, in the diocese of Durham, and obtained a license, through William Cecil, as a general, preacher throughout the kingdom as long as the king lived. Instead of settling down in England, however, he resigned his vicarage, and went abroad to pursue his theological investigations, and if possible satisfy his mind on some disputed matters. He carried out this intention at Louvain, Antwerp, and Paris; and from a letter of his own, dated Louvain, 1554, we get a glimpse of the quiet student rejoicing in an "excellent library belonging to a monastery of Minorites." Returning to England towards the close of Queen Mary's reign, he was invested by his uncle, Dr. Tonstall, bishop of Durham, with the archdeaconry of Durham, to which the rectory of Effington was annexed. The freedom of his attacks on the vices, and especially the clerical vices, of his times excited hostility against him, and he was formally brought before the bishop on a charge consisting of thirteen articles. Tonstall, however, not only dismissed the case, but presented the offender with the rich living of Houghton-le-Spring; and when the accusation was again brought forward, he again protected him. Enraged at this defeat, Gilpin's enemies laid their complaint before Dr. Bonner, bishop of London, and he immediately gave orders for his apprehension. Upon this Gilpin prepared for martyrdom; and, having ordered his house-steward to provide him with a long garment, that he might "goe the more comely to the stake," he set out for London. Providentially, however, he broke his leg on the journey, and his arrival was thus delayed till the news of Queen Mary's death freed him from further danger. He at once returned to Houghton, and there he continued to labor till his death in 1583. When the Roman Catholic bishops were deprived, he was offered the see of Carlisle; but he declined the honor. At Houghton his course of life was a ceaseless round of benevolent activity. His hospitable manner of living was the admiration of all. In his household, he spent "every fortnight 40 bushels of corn, 20 bushels of malt, and an ox, besides a proportional quantity of other kinds of provisions." Strangers and travellers found a ready reception; and even their horses were treated with so much care that it was humorously said that, if one were turned loose in any part of the country, it would immediately make its way to the rector of Houghton. Every Sunday from Michaelmas till Easter was a public day with Gilpin. For the reception of his parishioners he had three tables well covered,—one for gentlemen, the second for husbandmen, the third for day-laborers; and this piece of hospitality he never omitted, even when losses or scarcity made its continuance difficult. He built and endowed a grammar-school at a cost of upwards of £500, educated and maintained a large number of poor children at his own charge, and provided the more promising pupils with means of studying at the universities. So many young people, indeed, flocked to his school that there was not accommodation for them in Houghton, and he had to fit up part of his house as a boarding establishment. Grieved at the ignorance and superstition which the remissness of the clergy permitted to flourish in the neighboring parishes, he used every year to visit the most neglected parts of Northumberland, Yorkshire, Cheshire, Westmoreland, and Cumberland; and that his own flock might not suffer, he was at the expense of a constant assistant. Among his parishioners he was looked up to as a judge, and did great service in preventing law-suits amongst them. If an industrious man suffered a loss, he delighted to make it good; if the harvest was bad, he was liberal in the remission of tithes. And all this he was enabled to do because his frugality was as great as his generosity; for his rectory was worth no more than £400 a year. The boldness which he could display at need is well illustrated by his action in regard to duelling. Finding one day a challenge-glove stuck up on the door of a church where he was to preach, he took it down with his own hand, and proceeded to the pulpit to inveigh against the unchristian custom.

A life of Bernard Gilpin, written by George Carleton bishop of Chichester, who had been a pupil of Gilpin's at Houghton, will be found in Bates's *Vitæ Selectorum aliquot Virorum*, etc., London, 1681. A translation of this sketch by William Freake, minister, was published at London 1629; and in 1852 it was reprinted in Glasgow, with an introductory essay by Edward Irving. It forms one of the lives in Christopher Wordsworth's *Ecclesiastical Biography* (vol. iii., 4th edit.), having been compared with Carleton's Latin text. Another biography of Gilpin, which, however, adds little to Bishop Carleton's, was written by William Gilpin, M.A., prebendary of Ailsbury, London, 1753, and 1854.

GILPIN, William (1724–1804), author of several works on the scenery of Great Britain, was born at Carlisle in 1724. He was educated at Oxford university, and, after holding for some time a small curacy in the north of England, established a school for sons of gentlemen at Cheam in Surrey. Among his pupils were Viscount Sidmouth, Lord Bexley, and Mitford, the author of the *History of Greece*, the last of whom presented him, when he had resolved to retire from teaching, with the living of Boldre, near the New Forest, Hampshire. Gilpin died there, April 5, 1804. He is author of a *Life of Bernard Gilpin*, several miscellaneous religious publications, and lives of a number of the Reformers, but is chiefly known for his works on the scenery of various parts of England and Scotland, illustrated by tasteful engravings in aquatint executed by himself.

The principal of these works are—*The River Wye and Southern Districts of Wales*, 1782; *The Lake Country*, 1789; *Observations on Picturesque Beauty made in the year 1776 in several parts of Great Britain, particularly the Highlands of Scotland*, 1778; two corresponding volumes on the *Lakes of Cumberland and Westmoreland*; *Forest Scenery*, 1791; *Three Essays on Picturesque Beauty, with a Poem on Landscape Painting*, 1782; *Essays on Prints and Early Engravings*; *Western Parts of England and Isle of Wight*, 1798; and *The Coasts of Hampshire, Sussex, and Kent*, published posthumously.

GIL VICENTE. See Vicente, Gil.

GIN, the name commonly given to an aromatized spirit for drinking, varieties of which are also known as Geneva, Hollands, and Schiedam. Gin is an abbreviation of Geneva, both being primarily derived from the French *genièvre* (juniper), from the fact that the characteristic flavoring ingredient of the spirit is juniper berries. Gin was originally and is still largely a Dutch compounded liquor, but it has long been a favorite stimulant beverage with the lower orders in London and other large English towns; and it is manufactured on a great scale by English rectifiers. As each separate distiller varies to some extent the materials and proportions of ingredients used in the preparation of gin, the varieties of the beverage are numerous; but generally a clear distinction exists between Hollands or Dutch gin and English gin. In the manufacture of Hollands a mash is prepared consisting of say 112 ℔ of malted bere or bigg and 228 ℔ of rye meal, with 460 gallons of water, at 162° Fahr. After infusion a proportion of cold water is added; and when the heat is reduced to about 80°, the whole, about 500 gallons, is run into the fermenting vat, to which about half a gallon of yeast is added. Fermentation speedily ensues, and in about two days the attenuation is complete, although at this stage nearly one-third of the saccharine matter in the liquor is undecomposed. The special features of the fermentation are the small proportion of yeast employed and the imperfect attenuation of the worts. The wash so obtained is distilled, and the resulting low wine is redistilled, with the addition of juniper berries and a little salt, sometimes with the addition of hops. Dutch gins vary much one from another, but generally they are much purer and mellower liquors than the more highly flavored and frequently adulterated British gins. Good qualities of the latter have as their basis plain grain spirit from the ordinary whisky distilleries, the following being an example of a mixture for distillation:—

300 gallons of low wines.
650 " rectified spirit.
95 ℔ juniper berries.
95 " corianders.
47 ℔ crushed almond cake.
2 " angelica root.
6 " powdered liquorice.

There is, however, much variation in the ingredients employed, and several other flavoring substances—notably cardamoms and cassia or cinnamon—are freely employed. A kind of gin is also prepared by mixing proportions of essential oils by agitation with plain spirits without any redistillation, and much inferior liquor is said to be made with oil of turpentine and aromatic substances without the use of juniper berries at all. To prevent the cloudiness or turbidity that would arise in these inferior beverages when mixed with water, they are fined with alum, potassium carbonate, acetate of lead, or sulphate of zinc. To give factitious pungency and mellowness to such drinks, grains of paradise and Cayenne pepper are freely used, and the absence of spirit is also covered by the use of sugar. What is known as cordial gin is usually more highly aromatized than the other varieties, and sweetened so that it really ought to be classed as a coarser liqueur. In thirty-eight specimens of gin examined by Dr. Hassall, the alcoholic strength of which ranged from 22·35 to 48·80 degrees, and the sugar present varied between 2·43 and 9·38 per cent., seven were found to contain Cayenne pepper, two had cinnamon or cassia oil, and nearly all contained sulphates. From the fact that the essential oil of juniper is the most powerful of all diuretics, gin is frequently prescribed in diseases of the urinary organs. Its beneficial effects in such cases is most marked; but, on the other hand, the grossly sophisticated liquors which are largely consumed under the name of gin are most detrimental in their effects. In the early part of the 18th century gin-shops multiplied with great rapidity in London, and the use of the beverage increased to an extent so demoralizing that retailers actually exhibited placards in their windows intimating that there people might get drunk for 1d., and that clean straw in comfortable cellars would be provided for customers. The legislature was obliged to interfere in order to try to curb the tide of debauchery, and what is known as the Gin Act was passed in 1736, under the provisions of which, dealers were prohibited from selling gin and other spirits in quantities less than 2 gallons without a license of £50, and an excise duty of 20s. was charged on each gallon. The operation of the Act, however, gave rise to much confusion, to illicit trade, and to gin riots, and after a lapse of seven years the statute was repealed.

GINCKELL, Godart van (1640–1703), first earl of Athlone, general, was born in Guelderland about 1630 or 1640. He was the head of an ancient and noble family, and bore the title of Baron van Reede. In his youth he entered the Dutch army, and in 1688 he followed William prince of Orange in his expedition to England. In the following year he distinguished himself by a memorable exploit—the pursuit, defeat, and capture of the Scottish regiment which had mutinied at Ipswich, and was marching across the fens to their native land. It was the alarm excited by this mutiny that facilitated the passing of the first Mutiny Act. In 1690 Ginckell accompanied William III. to Ireland, and commanded a body of Dutch cavalry at the battle of the Boyne. On the king's return to England, General Ginckell was entrusted with the conduct of the war. He took the field in the spring of 1691, and established his headquarters at Mullingar. Among those who held a command under him was the marquis of Ruvigny, the recognized chief of the Huguenot refugees. Early in June Ginckell took the fortress of Ballymore, capturing the whole garrison of 1000 men. The English lost only 8 men. After reconstructing the fortifications of Ballymore, the army marched to Athlone, then one of the most important of the fortified towns of Ireland. The Irish defenders of the place were commanded by a distinguished French general, Saint-Ruth. The firing began on June 19th, and on the 30th the town was stormed, the Irish army retreating towards Galway, and taking up their position at Aghrim. Having strengthened the fortifications of Athlone and left a garrison there, Ginckell led the English, on July 12th, to Aghrim. An immediate attack was resolved on, and, after a severe and at one time doubtful contest, the crisis was precipitated by the fall of Saint-Ruth, and the disorganized Irish were defeated and fled. A horrible slaughter of the Irish followed the struggle, and 4000 corpses were left unburied on the field, besides a multitude of others that lay along the line of the retreat. Galway next capitulated, its garrison being permitted to retire to Limerick. There the viceroy, Tyrconnel, was in command of a large force, but his sudden death early in August left the command in the hands of General Sarsfield and the Frenchman D'Usson. The English army came in sight of the town on the day of Tyrconnel's death, and the bombardment was immediately begun. Ginckell, by a bold device, crossed the Shannon and captured the camp of the Irish cavalry. A few days later he stormed the fort on Thomond Bridge, and after difficult negotiations a capitulation was signed, the terms of which were divided into a civil and a military treaty. Thus was completed the conquest or pacification of Ireland, and the services of the Dutch general were amply recognized and rewarded. He received the formal thanks of the House of Commons, and was created by the king first earl of Athlone and baron of Aghrim. The immense forfeited estates of the earl of Limerick were given to him, but the grant was a few years later revoked by the English parliament. The earl continued to serve in the English army, and accompanied the king to the Continent in 1693. He fought at Landen, and assisted in destroying the French magazine at Givet. In 1702 he took command of the Dutch serving under the duke of Marlborough. He died at Utrecht, February 10, 1703. On the death of the ninth earl without issue in 1844, the title became extinct.

GINGER (French, *Gingembre;* German, *Ingwer*), the rhizome or underground stem of *Zingiber officinale*, Roscoe, a perennial reed-like plant growing from 3 to 4 feet high. The flowers and leaves are borne on separate stems, those of the former being shorter than those of the latter, and averaging from 6 to 12 inches. The flowers themselves are borne at the apex of the stems in dense ovate oblong cone-like spikes from 2 to 3 inches long, composed of obtuse strongly-imbricated bracts with membranous margins, each bract enclosing a single small sessile flower. The leaves are alternate, bright green, smooth, tapering at both ends, with very short petioles. The plant, though unknown in a wild state, is considered, with very good reason, to be a native of the warmer parts of Asia, over which it has been cultivated from an early period, and the rhizome imported into England. From Asia the plant has spread into the West Indies, South America, western tropical Africa, and Australia.

The use of Ginger as a spice has been known from very early times; it was supposed by the Greeks and Romans to be a product of southern Arabia, and was received by them by way of the Red Sea; in India it has also been known from a very remote period, the Greek and Latin names being derived from the Sanskrit. Flückiger and Hanbury, in their *Pharmacographia*, give the following notes on the history of ginger. On the authority of Vincent's *Commerce and Navigation of the Ancients*, it is stated that in the list of imports from the Red Sea into Alexandria, which in the second century of our era were there liable to the Roman fiscal duty, ginger occurs among other Indian spices. So frequent is the mention of ginger in similar lists during the Middle Ages, that it evidently constituted an important item in the commerce between Europe and the East. It thus appears in the tariff of duties levied at Acre in Palestine about 1173, in that of Barcelona in 1221, Marseilles in 1228, and Paris in 1296. Ginger seems to have been well known in England even before the Norman Conquest, being often referred to in the Anglo-Saxon leech-books of the 11th century. It was very common in the 13th and 14th centuries, ranking next in value to pepper, which was then the commonest of all spices, and costing on an average about 1s. 7d. per ℔. Three kinds of ginger were known among the merchants of Italy about the middle of the 14th century:—(1.) *Belledi* or *Baladi*, an Arabic name, which, as applied to ginger, would signify country or wild, and denotes common ginger; (2.) *Colombino*, which refers to Columbum, Kolam, or Quilon, a port in Travancore, frequently mentioned in the Middle Ages; and (3.) *Micchino*, a name which denoted that the spice had been brought from or by way of Mecca. Marco Polo seems to have seen the ginger plant both in India and China between 1280 and 1290. John of Montecorvino, a missionary friar who visited India about 1292, gives a description of the plant, and refers to the fact of the root being dug up and transported. Nicolo di Conto, a Venetian merchant in the early part of the 15th century, also describes the plant and the collection of the root, as seen by him in India. Though the Venetians received ginger by way of Egypt, some of the superior kinds were taken from India overland by the Black Sea. The spice is said to have been introduced into America by Francisco de Mendoça, who took it from the East Indies to New Spain. It seems to have been shipped for commercial purposes from San Domingo as early as 1585, and from Barbados in 1654; so early as 1547 considerable quantities were sent from the West Indies to Spain.

Ginger is known in commerce in two distinct forms, termed respectively coated and uncoated ginger, as having or wanting the epidermis. For the first, the pieces, which are called "races" or "hands," from their irregular palmate form, are washed and simply dried in the sun. In this form ginger presents a brown, more or less irregularly wrinkled or striated surface, and when broken shows a dark brownish fracture, hard, and sometimes horny and resinous. To produce uncoated ginger the rhizomes are washed, scraped, and sun-dried, and are often subjected to a system of bleaching, either from the fumes of burning sulphur or by immersion for a short time in a solution of chlorinated lime. The whitewashed appearance that much of the ginger has, as seen in the shops, is due to the fact of its being washed in whiting and water, or even coated with sulphate of lime. This artificial coating is supposed by some to give the ginger a better appearance; it often, however, covers an inferior quality, and can readily be detected by the ease with which it rubs off, or by its leaving a white powdery substance at the bottom of the jar in which it is contained. Uncoated ginger, as seen in trade, varies from single joints an inch or less in length to flattish irregularly branched pieces of several joints, the "races" or "hands," and from 3 to 4 inches long; each branch has a depression at its summit showing the former attachment of a leafy stem. The color, when not whitewashed, is a pale buff; it is somewhat rough or fibrous, breaking with a short mealy fracture, and presenting on the surfaces of the broken parts numerous short bristly fibres.

The British market derives its supply of ginger from various parts of the world. The principal sorts, however, or those most commonly found in commerce, are Jamaica, Cochin, Bengal, and African, though each of these in its turn has its several varieties and qualities. The best or most valued kind of all is the Jamaica, and next to it the Cochin. For ordinary purposes uncoated ginger is considered the best; the largest and finest pieces, of a pale buff color both outside and inside, and cutting softly and evenly, are considered the most valuable. The chief sources of supply are the East and West Indies, Sierra Leone, and Egypt.

The principal constituents of ginger are starch, volatile oil (to which the characteristic odor of the spice is due), and resin (to which is attributed its pungency). Its chief use is as a condiment or spice, but as an aromatic and stomachic medicine it is also used internally. "The stimulant, aromatic, and carminative properties render it of much value in atonic dyspepsia, especially if accompanied with much flatulence, and as an adjunct to purgative medicines to correct griping." Externally applied as a rubefacient, it has been found to relieve headache and toothache. The rhizomes, collected in a young green state, washed, scraped, and preserved in syrup, form a delicious preserve, which is largely exported both from the West Indies and from China. Cut up into pieces like lozenges, and preserved in sugar, ginger also forms a very agreeable sweetmeat. (J. R. J.)

GINGHAM is a woven cotton fabric, of a close stoutish texture, the distinguishing characteristics of which are that it is a plain (*i. e.*, untwilled) cloth, woven into yarn-dyed stripes or checks of two or more colors. In some cases as many as seven or eight colors are introduced in the warp and weft of a gingham; but no patterns are made that cannot be woven in a common plain loom. Gingham was originally an Indian product, but its manufacture was early introduced into the Lancashire and Glasgow districts; and during the first half of the present century the trade formed an important feature in the textile industries of the latter locality—the demand for the fabric coming chiefly from the United States and the West Indies. The trade distinction of gingham is now to a large extent superseded by other terms.

GINGUENÉ, Pierre Louis (1748–1815), the author of the *Histoire littéraire d'Italie*, was born on 25th April, 1748, at Rennes in Brittany. He was educated at a Jesuit college in his native town, but he owed most of his literary tastes and accomplishments to his father, who early imbued him with a love of music and the languages of England and Italy. His first literary effort, a poetical piece entitled *Confession de Zulmé*, brought him into notice among the literary coteries of Paris, from the circumstance that, when published at first anonymously, it was claimed by six or seven different authors. Though the value of the piece is not very great, it is Ginguené's poetical *chef d'œuvre*. The part he took as a defender of Piccini against the partisans of Gluck made him still more widely known; and the reputation he acquired as a promising political writer secured employment for him in the public service in 1780. He hailed, however, the first symptoms of the Revolution, joined Rabaut, St. Étienne, and Cerutti in producing the *Feuille Villageoise*, and celebrated in an indifferent ode the opening of the states-general. A more creditable effort was his *Lettres sur les Confessions de J. J. Rousseau*, 1791, in which he defended to the uttermost the life and principles of his author. Refusing to countenance the excesses of the Revolution, he was thrown into prison, whence he only escaped with life by the downfall of Robespierre. Some time after his liberation he assisted, as director-general of the "commission exécutive de l'instruction publique," in reorganizing the system of public instruction. When the Institute was established in 1796, he was elected a member of the division called the academy of moral and political sciences. In 1798 the directory appointed him minister plenipotentiary to the king of Sardinia, whose ruin, begun by force of arms, they had determined to complete by treachery. A less promising tool could not have been found for carrying out their design. After fulfilling his duties for seven months, very little to the satisfaction of his employers, Ginguené retired to his country house of St. Prix, in the valley of Montmorency, and there he prosecuted his literary labors till the Revolution of the 18th Brumaire called him once more before the world. He was appointed a member of the tribunate, which made a show of maintaining democratic opposition to the first consul; but Napoleon, finding that he was not sufficiently tractable, had him expelled at the first "purge," and Ginguené once more joyfully returned to his favorite pursuits. These were now more than ever a necessity of life to him, as his only other source of income was the small endowment attached to his seat in the Institute. Fortunately he was nominated one of the commission charged to continue the literary history of France, which had been brought down by the Benedictines to about the close of the 12th century; and the three volumes of this series which appeared in 1814, 1817, and 1820 are for the most part the result of his labors. But the work by which Ginguené will be longest remembered is his *Histoire littéraire d'Italie* (9 vols. 8vo, 1811–1819), to which he was putting the finishing touches when he was cut off by a painful disease, November 16, 1815. The first six volumes appeared before their author's death; the seventh is entirely his except a few pages; and of the eighth and ninth he wrote about a half, the other half being composed by Salfi, and revised by Daunou. The success of the history in Italy was astonishing: editions were published in various parts of the peninsula, with notes and comments by the best scholars, and three translations appeared respectively at Milan, Naples, and Venice.

Ginguené was originally led to make Italian literature his special study by finding how ill that subject was understood, and how little it was appreciated, by his countrymen. In the composition of his history he was guided for the most part by the great work of the Jesuit Tiraboschi, but he avoids the prejudices and party views of his model. His own style, though occasionally forcible and eloquent, is not unfrequently too tame for the subject, and he often trespasses on his reader's patience by over-minuteness of detail; but these faults are more than atoned for by fine critical discernment, impartiality, and freedom. On the score of accuracy, indeed, Ginguené sometimes offends, but seldom in matters of great moment; and his slips are such as are almost inevitable to a foreigner, who could hardly be said to have even seen the country whose literary history he relates. The Italians felt grateful to him for having placed their literature in its proper light, and readily forgave the excessive eulogies which he passed on many of their writers, whose very names had been forgotten in their own country.

During the latter years of his life Ginguené wrote extensively for the press, and he edited the *Décade philosophique, politique, et littéraire*, till it was suppressed by Napoleon in 1807. He contributed largely to the *Biographie universelle*, the *Mercure de France*, and the *Encyclopédie méthodique*; and he edited the works of Chamfort and of Lebrun. Among his minor productions are an opera, *Pomponin ou le Tuteur mystifié*, 1777; *La Satire des Satires*, 1778; *De l'autorité de Rabelais dans la révolution présente*, 1791; *D. M. Neckar*, 1795; *Fables inédites*, 1814. See "Éloge de Ginguené," by Dacier, in the *Mémoires de l'Institut*, tom. vii.; "Discours" by M. Daunou, prefixed to the 2d edit. of the *Hist. litt. d'Italie*; D. J. Garat, *Notice sur la vie et les ouvrages de P. L. Guingené*, Paris, 1817.

GINSENG, the root of a species of *Panax* (*P. Ginseng*, Meyer), belonging to the natural order *Araliaceæ*, is a very celebrated Chinese medicine. The demand is so great that many other roots are substituted for it, notably that of *Panax quinquefolium*, Linn., distinguished as American ginseng, and imported from the United States. At one time the ginseng obtained from Manchuria was considered to be the finest quality, and in consequence became so scarce that an imperial edict was issued prohibiting its collection. That prepared in Corea is now the most esteemed variety. The root of the wild plant is preferred to that of cultivated ginseng, and the older the plant the better is the quality of the root considered to be. Lockhart states that all the ginseng collected in the Chinese empire is imperial property, and is sold to those who have the privilege of dealing in it at its weight in gold. Great care is taken in the preparation of the drug. The account given by Kœmpfer of the preparation of nindsin, the root of *Sium ninsi*, Thunb., in the Corea, will give a good idea of the preparation of ginseng, ninsi being a similar drug of supposed weaker virtue, obtained from a different plant, and often confounded with ginseng. "In the beginning of winter nearly all the population of Sjansai turn out to collect the root, and make preparations for sleeping in the fields. The root, when collected, is macerated for three days in fresh water, or water in which rice has been boiled twice; it is then suspended in a closed vessel over the fire, and afterwards dried, until from the base to the middle it assumes a hard, resinous, and translucent appearance, which is considered a proof of its good quality."

Ginseng of good quality generally occurs in hard, rather brittle, translucent pieces, about the size of the little finger and varying in length from 2 to 4 inches. The taste is mucilaginous, sweetish, and slightly bitter and aromatic. The root is frequently forked, and it is probably owing to this circumstance that medicinal properties were in the first place attributed to it, its resemblance to the body of a man being supposed to indicate that it could restore virile power to the aged and impotent. In price it varies from 6 or 12 dollars to the enormous sum of 300 or 400 dollars an ounce. Root of this quality can of course only be purchased by the most wealthy, and the greatest care is taken of such pieces by the vendors.

Lockhart gives a graphic description of a visit to a ginseng merchant. Opening the outer box, the merchant removed several paper parcels which appeared to fill the box, but under them was a second box, or perhaps two small boxes, which, when taken out, showed the bottom of the large box and all the intervening space filled with more paper parcels. These parcels, he said, "contained quicklime, for the purpose of absorbing any moisture and keeping the boxes quite dry, the lime being packed in paper for the sake of cleanliness. The smaller box, which held the ginseng, was lined with sheet-lead; the ginseng further enclosed in silk wrappers was kept in little silken-covered boxes. Taking up a piece, he would request his visitor not to breathe upon it, nor handle it; he would dilate upon the many merits of the drug and the cures it had effected. The cover of the root, according to its quality, was silk, either embroidered or plain cotton cloth, or paper." In China the ginseng is often sent to friends as a valuable present; in such cases, "accompanying the medicine is usually given a small, beautifully-finished double kettle, in which the ginseng is prepared as follows. The inner kettle is made of silver, and between this and the outside vessel, which is a copper jacket, is a small space for holding water. The silver kettle, which fits on a ring near the top of the outer covering, has a cup-like cover in which rice is placed with a little water; the ginseng is put in the inner vessel with water, a cover is placed over the whole, and the apparatus is put on the fire. When the rice in the cover is sufficiently cooked, the medicine is ready, and is then eaten by the patient, who drinks the ginseng tea at the same time." The dose of the root is from 60 to 90 grains. During the use of the drug tea-drinking is forbidden for at least a month, but no other change is made in the diet. It is taken in the morning before breakfast, from three to eight days together, and sometimes it is taken in the evening before going to bed.

At one time it was proposed by some Russians to establish ginseng plantations, with the view of growing the root as an important article of trade with China. Ginseng is also cultivated in Japan, having been introduced from Corea; but, although it grows more luxuriantly there than in its native country, the root is considered to be much less active. This may be due to the fact that, while in the mountains of Corea the root is perennial, in Japan the plant runs to seed the first year, and becomes annual. Europeans have hitherto failed to discover any remarkable properties in the drug. Dr. Porter Smith, however, mentions having seen some cases in which life appeared to be prolonged for a time by its use; and M. Maack states that one of the Cossacks of his party, having chopped off a finger accidentally with an axe, applied ointment made from ginseng, and the wound healed rapidly. Its properties, which may be likened to those of the mandrake of Scripture, are perhaps dependent in great measure upon the faith of the patient.

See Porter Smith, *Chinese Materia Medica*, p. 103; *Reports on Trade at the Treaty Ports of China*, 1868, p. 63; Lockhart, *Med. Missionary in China*, 2d ed. p. 107; *Bull. de la Société Impériale de Nat. de Moscow*, 1865, No. 1, pp. 70–76; *Pharmaceutical Journal*, (2), vol. iii. pp. 197, 333, (2), vol. ix. p. 77; Lewis, *Materia Medica*, p. 324; *Journal of Botany*, 1864, p. 320; Geoffroy, *Tract. de Materié Medicale*, t. ii. p. 112; Loureiro, *Flora Cochinchinensis*, p. 656; Kœmpfer, *Amœnitates Exoticæ*, p. 824.

GIOBERTI, VINCENZO (1801–1852), the ablest philosophical writer of modern Italy, and one of the most interesting actors in the recent history of the country, was born in Turin on the 5th April, 1801, the only child of parents in moderate circumstances there, and was educated by the fathers of the Oratory with a view to the priesthood, to which he was ordained in 1825. His study of the ancient philosophers, and the fathers and doctors of the church, occupied him for years, during which he led a very retired life; gradually, however, he took more and more interest in the affairs of his country, as well as in the literature of the day, entering warmly into the new ideas then beginning to be discussed in connection with politics. The freedom of Italy from foreign masters became his ruling motive in life, and this freedom in his conception of it was an emancipation, not only from armed masters, but from modes of thought alien to its genius, and detrimental to its European authority. This authority was in his mind connected with papal supremacy, though in a way quite novel—intellectual rather than political. One must remember this in considering nearly all his writings, and also in estimating his position, both in relation to the ruling clerical party—the Jesuits—and also in relation to the politics of the court of Piedmont after the accession of Charles Albert in 1831. He was now noticed by the king and made one of his chaplains. His popularity and private influence, however, were reasons enough for the court party to mark him for exile; he was not one of them, and could not be depended on. Knowing this, he in 1833 asked permission to resign his chaplaincy, but was suddenly arrested while walking with a friend in the public gardens, and after an imprisonment of four months, sent out of the country in the escort of a carabineer, under decree of banishment. This was done without trial or process—simply, it would appear, by private influence of the clerical party, his name being at the same time struck off the list of theological doctors of the college of Turin. With broken fortunes and ruined plans Gioberti arrived in Paris in the beginning of October, 1833. A year later he went to Brussels, where he spent the best period of his life from that time to 1845, teaching philosophy, and assisting in the work of a college superintended by his friend Gaggia, yet finding time, by rising early and sitting late, to write many works of great importance in philosophical inquiry, but bearing a special relation to his country and its position. His spirits never returned to him, however, as his whole being was bound up with the welfare of his native country. An amnesty having been passed by Charles Albert in 1846, Gioberti had liberty to return to Italy, just as Pius IX. in the beginning of his pontificate manifested strongly liberal sympathies. Gioberti took no step, however, till the end of 1847, and did not return to his native land till after certain negotiations, and the public expression of popular enthusiasm in his favor. On his entrance into Turin, 29th April, 1848, there was a general outburst of this enthusiasm, mainly caused, it appears, by his unjust banishment and by the large circulation of his books, especially the *Gesuita Moderno*. The city was illuminated; deputations waited upon him; the king made him senator, but, having been returned both by Turin and by Genoa as deputy to the assembly of representatives, now first meeting under the new constitution, he elected to sit in the lower chamber, for his native town. Previous to the opening he made a tour in various provinces, beginning at Milan and including Rome, where he had three interviews with the liberal pope, who at that moment seemed to be the representative of his ideal imagined in the work *Del Primato morale e civile*, which Pius had read and admired. While he was engaged in this tour, constantly addressing the people publicly, the chamber met and elected him president. In the same parliament sat Azeglio, Cavour, and other liberals, and Balbo was prime minister. At the close of the same eventful year, a new ministry was formed, headed by Gioberti; but with the accession of Victor Emmanuel in March, 1849, his active life came to an end. For a short time, indeed, he held a seat in the cabinet, though without a portfolio; but an irreconcilable disagreement soon followed, and his removal from

Turin was accomplished by his appointment on a mission to Paris, whence he never returned. There, refusing the pension which had been offered him and all ecclesiastical preferment, he lived frugally, and spent his days and nights as at Brussels in literary labor. Many other exiles gathered about him, and the Marquis Pallavicino became his bosom friend. He died suddenly, of apoplexy, on the 26th October, 1852.

Gioberti's writings are more important than his political career. In the general history of European philosophy they stand apart. As the speculations of Rosmini, against which he wrote, have been called the last link added to mediæval thought, so the system of Gioberti, more especially in his greater and earlier works, is unrelated to other modern schools of thought. It shows a harmony with the Roman Catholic faith which caused Cousin to make the superficial criticism that "Italian philosophy was still in the bonds of theology." Method is with him a synthetic, subjective, and psychological instrument. He reconstructs, as he declares, ontology, and begins with the "ideal formula," "the Ens creates ex nihilo the existent." He is in some respects a Platonist, and transplants certain dogmata from the ancient idealist. He identifies religion with civilization, and arrives in his treatise *Del Primato morale e civile degli Italiani* at the conclusion that the church is the axis on which the well-being of human life revolves. His later works, the *Rinnovamento* and the *Protologia*, are sometimes thought to be less affirmative in this matter, and there is a division in opinion among his critics how far he shifted his ground under the influence of events before he died, His first work, written when he was thirty-seven, had a personal reason for its existence. A young fellow-exile and friend, Paolo Pallia, having many doubts and misgivings as to the reality of revelation and a future life, Gioberti at once set to work with *La Teorica del Sovrannaturale*, which was his first publication (2 vols., 1838). After this the enormous labors of his pen made up for the lateness of his commencement as an author. Philosophical treatises in two or three volumes, which would occupy, generally speaking, half a lifetime, followed in rapid succession, each one being a corollary to the last. The *Teorica* was followed by *Introduzione allo Studio della Filosofia* in three volumes, passing through the press in 1839–40. In this work he states his reasons for requiring a new method and new terminology. Here he brings out the doctrine that religion is the direct expression of the *idea* in this life, and is one with true civilization in history. Civilization is a conditioned mediate tendency to perfection, to which religion is the final completion if carried out; it is the end of the second cycle expressed by the second formula, the Ens redeems existence. Essays on the lighter and more popular subjects, *Del Bello* and *Del Buono*, followed the *Introduction*, but were not published as a volume till 1846, having first appeared in connection with the writings of other authors. *Del Primato morale e civile degli Italiani* and the *Prolegomeni* to the same, and soon afterwards his triumphant exposure of the Jesuits, *Il Gesuita Moderno*, in five successive volumes (eight volumes altogether), began to be issued in 1843, and no doubt hastened the transfer of rule from clerical to civil hands. It was, as has been seen, the popularity of these semi-political works, heightened by other occasional political articles which fill two volumes, and by his *Rinnovamento civile d'Italia*, that caused Gioberti to be welcomed with such enthusiasm on his return to his native country. All these works were perfectly orthodox, and aided in drawing the liberal clergy into the movement which has resulted since his time in the unification of Italy. The Jesuits, however, closed round the pope more firmly after his return to Rome, and in the end Gioberti's writings were placed on the *Index*, although with no unfavorable result as far as their influence is concerned. The remainder of his works need not be particularized, although they give his mature views on many points, especially *La Filosofia della Rivelazione* and the *Protologia*. The entire writings of Gioberti, including those left in manuscript, have been carefully edited by Giuseppe Massari in thirty-six volumes.

See Massari, *Ricordi Biografici e Carteggio* (Naples, 1863); *Lettere di Vincenzo Gioberti e Giorgio Pallavicino* (Milan, 1875); Rev. C. B. Smyth, *Christian Metaphysics* (London, 1851).

GIOJA, Melchior (1767–1828), a distinguished Italian writer on philosophy and political economy, was born at Piacenza in 1767. He was educated at the celebrated college of St. Lazare in his native town, and showed special fondness for the philosophical sciences. Apparently he had been destined for the church, but he seems to have given up at an early period the study of theology, and after completing his course at the college spent some years in retirement. His first work was the philosophical treatise *Il nuovo Galateo* (1802), which was followed by the *Logica Statistica*. The arrival of Napoleon in Italy drew Gioja into public life. He advocated warmly the establishment of a republican government, and under the Cisalpine Republic he was named historiographer and director of statistics. After the fall of Napoleon he retired into private life, and does not appear again to have held office. He died in 1828. Gioja's fundamental idea is the value of statistics or the collection of facts. Philosophy itself is with him classification and consideration of ideas. Logic he regarded as a practical art, and his *Esercizioni Logici* has the further title, *Art of deriving benefit from ill-constructed books*. In ethics Gioja follows Bentham, and his large treatise *Del Merito e delle Recompense*, 1818, is a clear and systematic view of social ethics from the utilitarian principle. In political economy this avidity for facts produced better fruits. The *Nuovo Prospetto delle Scienze Economiche*, 6 vols., 1815–17, although long to excess, and overburdened with classifications and tables, contains much valuable material. In particular, Gioja must be credited with the finest and most original treatment of division of labor since the *Wealth of Nations*. Much of what Babbage taught later on the subject of combined work is anticipated by Gioja. His theory of production is also deserving of attention from the fact that it takes into account and gives due prominence to immaterial goods. Throughout the work there is continuous opposition to Smith. Gioja's latest work *Filosofia della Statistica*, 1828, contains in brief compass the essence of his ideas on human life, and affords the clearest insight into his aim and method in philosophy both theoretical and practical.

A notice of Gioja's life is given in the 2d edition of the *Filosofia della Statistica*, 1829. See Ferri, *Essai sur l'histoire de la Phil. en Italie au* 19^{me} *Siècle*, 1869.

GIORDANO, Luca (1632–1705), a painter of great immediate celebrity, was born in Naples, son of a very indifferent painter, Antonio, who imparted to him the first rudiments of drawing. Nature predestined him for the art, and at the age of eight he painted a cherub into one of his father's pictures, a feat which was at once noised abroad, and which induced the viceroy of Naples to recommend the child to Spagnoletto. His father afterwards took him to Rome, to study under Pietro da Cortona. He acquired the nickname of Luca Fa-presto (Luke Work-fast). One might suppose this nickname to be derived merely from the almost miraculous celerity with which from an early age and throughout his life he handled the brush; but it is said to have had a more express origin. The father, we are told, poverty-stricken and greedy of gain, was perpetually urging his boy to exertion with the phrase, "Luca, fà presto." The youth obeyed his parent to the letter, and would actually not so much as pause to snatch a hasty meal, but received into his mouth, while he still worked on, the food which his father's hand supplied. He copied nearly twenty times the Battle of Constantine by Julio Romano, and with proportionate frequency several of the great works of Raphael and Michelangelo. His rapidity, which belonged as much to invention as to mere handiwork, and his versatility, which enabled him to imitate other painters deceptively, earned for him two other epithets, "The Thunderbolt" (Fulmine), and "The Proteus," of Painting. He shortly visited all the main seats of the Italian school of art, and formed for himself a style combining in a certain measure the ornamental pomp of Paul Veronese and the contrasting compositions and large schemes of chiaroscuro of Pietro da Cortona. He was noted also for lively and showy color. Returning to Naples, and accepting every sort of commission by which money was to be made, he practised his art with so much applause that Charles II. of Spain towards 1687 invited him over to Madrid, where he remained thirteen years. Giordano was very popular at the Spanish court, being a sprightly talker along with his other marvellously facile gifts, and the king created him a cavaliere. One anecdote of his rapidity of work is that the queen of Spain having one day made some inquiry about his wife, he at once showed Her Majesty what the lady was like by painting her portrait into the picture on which he was engaged. After the death of Charles in 1700 Giordano, gorged with wealth, returned to Naples. He spent large sums in acts of munificence, and was particularly liberal to his poorer brethren of the art. He again visited various parts of Italy, and died in Naples on 12th January, 1705, his last words being "O Napoli, sospiro mio" (O Naples, my heart's love!). One of his maxims was that the good painter is the one whom the public like, and that the public are attracted more by color than by design.

At the present day, when the question is not how quickly Giordano could do his work, but what the work itself amounts to, his reputation has run down like the drops of heavy rain off a window, or like one of the figures in his own paintings, in which he was wont to use an excessive quantity of oil. His astonishing readiness and facility must, however, be recognized, spite of the general commonness and superficiality of his performances. He left many works in Rome, and far more in Naples. Of the latter one of the most renowned is Christ expelling the Traders from the Temple, in the church of the Padri Girolamini, a colossal work, full of expressive lazzaroni; also the frescoes of S. Martino, and those in the Tesoro della Certosa, including the subject of Moses and the Brazen Serpent; and the cupola-paintings in the Church of S. Brigida, which contains the artist's own tomb. In Spain he executed a surprising number of works,—continuing in the Escorial the series commenced by Cambiasi, and painting frescoes of the Triumphs of the Church, the Genealogy and Life of the Madonna, the stories of Moses, Gideon, David, and Solomon, and the Celebrated Women of Scripture, all works of large dimensions. His pupils, Aniello Rossi and Matteo Pacelli, assisted him in Spain. In Madrid he worked more in oil-color, a Nativity there being one of his best productions. Another superior example is the Judgment of Paris in the Berlin Museum. In Florence, in his closing days, he painted the Cappella Corsini, the Galleria Riccardi, and other works. In youth he etched with considerable skill some of his own paintings, such as the Slaughter of the Priests of Baal. He also painted much on the crystal borderings of looking-glasses, cabinets, etc., seen in many Italian palaces, and was, in this form of art, the master of Pietro Garofolo. His best pupil, in painting of the ordinary kind, was Paolo de Matteis.

GIORGIONE (1477–1511), the name adopted both by his contemporaries and by posterity for one of the most renowned of Italian painters, signifies George the Big, or Great, and was given him, according to Vasari, "because of the gifts of his person and the greatness of his mind." Like Lionardo da Vinci, Giorgione appears to have been of illegitimate birth. His father belonged certainly to the gentle family of the Barbarella, of Castelfranco in the Trevisan; his mother, it seems probable, was a peasant girl of the neighboring village of Vedelago; and he was born in or shortly before the year 1477. In histories and catalogues he is now commonly styled Giorgio Barbarella of Castelfranco; but it seems clear that he was humbly reared, and only acknowledged by his father's family when his genius had made him famous. Twenty-seven years after his death, the brothers Matteo and Ercole Barbarella were glad to inscribe the name of Giorgione among the members of their family in whose honor they built and dedicated a monument in the church of San Liberale in their native town. Presently this church was demolished and replaced by a new one. In the course of this operation the inscription in question perished. Not so a more important memorial of Giorgione's greatness, in the shape of an altar-piece which he painted for the same church on the commission of Tuzio Costanzo. Tuzio Costanzo was a famous captain of free lances, who had followed his mistress, the Queen Cornaro, from Cyprus to her retirement in the Trevisan, and at the beginning of the 16th century was settled at Castelfranco. The altar-piece with which Giorgione adorned the chapel of this patron in the old church of San Liberale, was afterwards transferred to the new church, where it remains to this day, so that there is something more than the mere memory of the great painter to attract the lover of art on a pilgrimage to his native town. Castelfranco is a hill fort standing in the midst of a rich and broken plain at some distance from the last slopes of the Venetian Alps. Giorgione's ideal of luxuriant pastoral scenery, the country of pleasant copses, glades, and brooks, amid which his personages love to wander or recline with lute and pipe, was derived, no doubt, from these natural surroundings of his childhood. We cannot tell how long he remained in their midst, nor what were the circumstances which led him, while still, it seems, a boy, to Venice. Once there, we do not hear of him until his genius is, so to speak, full-fledged. He appears all at once as a splendid presence, the observed of all observers; an impassioned musician, singer, lover; and, above all, as a painter winning new conquests for his art. His progress from obscurity to fame, probably under the teaching of Giovanni Bellini, must have been extraordinarily rapid, as he was still very young when he was employed to paint the portraits of two successive doges, and of great captains and princesses such as Gonzalvo of Cordova and Catharina Cornaro. Giorgione effected, in the Venetian school, a change analogous to that effected by Lionardo in the school of Florence,—a change, that is, which was less a revolution than a crowning of the edifice. He added the last accomplishments of freedom and science to an art that at his advent only just fell short of both. Venetian painting towards 1495 had reached the height of religious dignity in the great altar-pieces of Bellini, the height of romantic sentiment and picturesque animation in Carpaccio's series from the legend of St. Ursula. The efforts of the school for nearly half a century had been concentrated on the development, with the help of the new medium of oil, of color as the great element of emotional expression in painting. Giorgione came to enrich the art with a more faultless design; with a system of color yet more ardent, melting, and harmonious; with a stronger sense of life and of the glory of the real world as distinguished from the solemn dreamland of the religious imagination. He had a power hitherto unknown of interpreting both the charm of merely human grace and distinction, and the natural joy of life in the golden sunlight among woods and meadows. His active career cannot have extended over more than fifteen years, since we know that he died in 1511—according to one account, of a contagious disorder; according to another, of grief at discovering that his mistress had played false with a pupil. But in that brief career he had both deeply modified the older manner of the Venetian school, as represented even by a master so great and so austere as John Bellini, and had prepared the way for its final manner, as represented by the most complete master of all, Titian. Bellini, who outlived Giorgione, had not been ashamed to learn something from the practice of a teacher fully forty years younger than himself, who was probably in the first instance his own pupil. Titian, only ten years younger than Giorgione, succeeded to his conquests, and enjoyed the length of days which was denied him.

A consecutive biography of Giorgione it is impossible to construct, either from literary records or from extant works. The literary records only furnish us with a few general characteristics, and with the mention of a few of his productions, especially the frescoes with which he adorned the front of the Fondaco dei Tedeschi or hall of the German traders of Venice, after its destruction by fire in 1504; and the frescoes and altar-piece, sometimes attributed to the same year, which he executed for Tuzio Costanzo in his native town. The decorations of the Fondaco dei Tedeschi, which Vasari praises for their design and glowing color, but blames for their too fantastic and enigmatical invention, have unhappily been utterly destroyed by the combined operation of weather and of reckless architectural changes in the building. The frescoes of the chapel of Castelfranco were also sacrificed, while the altar-piece was preserved in the manner we have related. A fragment of a love-madrigal, which was once to be read on the back of the panel, addressed apparently by the painter to his model, is quoted as in character with our traditions of the man. The picture itself represents the Virgin and Child enthroned, with a group of saints, and prominent among them the warrior-saint Liberale, the patron of the church. A small and highly-finished study in armor for this figure is now one of the treasures of the National Gallery in London, to which it was bequeathed by Mr. Rogers. To Giorgione are also attributed pictures in almost all the public and private galleries of Europe, to a number ten times greater than could possibly be consistent with the short duration of his career, and with the fact that no inconsiderable portion of that career must have been occupied with the production of the perished frescoes. These so-called Giorgiones of the galleries may to some extent be recognized and classified as the work of one or another of several groups of painters whose manner was more or less akin to, or influenced by, that of Venice in Giorgione's days. One such group belongs to Bergamo; another to Brescia; another is in alliance with Palma; another with Titian; another, again, consists of the later and looser imitators of the master himself, as Andrea and Schiavone, Pietro della Vecchia and Rocco Marcone. It is probable, indeed, that those distinguished authorities, Messrs. Crowe and Cavalcaselle, have gone too far in excluding from the genuine work of Giorgione several of the most famous pictures which have hitherto passed as standards whereby to judge his manner, as, for instance, the Entombment of Christ at Treviso, and particularly the beautiful Concert of the Louvre. Without, however, entering upon disputed ground, there remains a reasonable number of undoubted pictures of the master, and these, while they possess in common the qualities of feeling and invention which we have above defined, in technical style vary from a minute and painstaking precision, almost like that of Antonello da Messina, or of Bellini in his earlier manner, to a degree of breadth, glow, and softness, which are the qualities more popularly associated with the name of Giorgione, and more commonly attempted by his imitators.

We conclude with a mention of a few of the principal undisputed examples of Giorgione's handiwork, following a chronological order, which, however, it should be understood, is necessarily but approximate and conjectural. Florence, Uffizi: an Ordeal of Moses, and a Judgment of Solomon,—small pictures with rich landscape accessories, and figures of extraordinary grace and delicacy, painted apparently in imitation or in rivalry of the New Testament allegory by Bellini, in the same manner, which is preserved in the same gallery; all three were originally in the summer residence of the Medici at Poggio Imperiale. London, collection of Mr. Wentworth Beaumont: Holy Family, with the angel appearing to the shepherds, in the background,—again a small picture, very delicately finished; formerly in the possession of Cardinal Fesch. London, National Gallery: the Study for San Liberale above mentioned. Castelfranco, Church of San Liberale: the altar-piece,—figures life size, exhibiting much of the manner of Bellini in his altar-pieces. Vienna, Belvidere Gallery: a Group of Astronomers in a Glade, known as the Chaldeans,—rich sunset landscape, with villages in the distance and trees in the foreground; beside the trees on the left, three figures in Oriental costumes, one-third of life size; formerly in the Taddeo Contarini gallery. Venice, Manfrini palace: man, woman, and child, known as the Family of Giorgione, in a landscape recalling the neighborhood of Castelfranco,—one of the most beautiful works of the master, formerly in the house of Gabriel Vendramin at Santa Fosca. England, Kingston Lacy, collection of Mr. Bankes: Judgment of Solomon,—a large unfinished picture of great beauty, of clearer tones and broader treatment than the foregoing, bought, at the suggestion of Lord Byron, from the Marescalchi gallery. Florence, Pitti: Concert,—a monk of the Augustinians, seated at the harpsichord; behind him, a clerk with a viol; on the left a young man with plumed hat and long hair. This is the most perfect of all the works which are assumed to belong to the later time of the master.

See Vasari, *Vite de' più excellenti pittori*, etc., vol. vii. p. 80, ed. Lemonnier; Ridolfi, *Maraviglie dell' Arte*, vol. i. p. 121; Crowe and Cavalcaselle, *History of Painting in North Italy*, vol. ii. p. 119. (S. C.)

GIOTTINO (1324–1357), an early Florentine painter. Vasari is the principal authority in regard to this artist; but it is not by any means easy to bring the details of his narrative into harmony with such facts as can be verified at the present day. It would appear that there was a painter of the name of Tommaso (or Maso) di Stefano, termed Giottino; and the Giottino of Vasari is said to have been born in 1324, and to have died early, of consumption, in 1357—dates which must be regarded as open to considerable doubt. Stefano, the father of Tommaso, was himself a celebrated painter in the early revival of art; his naturalism was indeed so highly appreciated by contemporaries as to earn him the appellation of "Scimia della Natura" (ape of nature). He, it seems, instructed his son, who, however, applied himself with greater predilection to studying the works of the great Giotto, formed his style on these, and hence was called Giottino. It is even said that Giottino was really the son (others say the great-grandson) of Giotto. To this statement little or no importance can be attached. To Maso di Stefano, or Giottino, Vasari and Ghiberti attribute the frescoes in the chapel of S. Silvestro (or of the Bardi family) in the Florentine church of S. Croce; these represent the miracles of Pope St. Sylvester, as narrated in the Golden Legend, one conspicuous subject being the sealing of the lips of a malignant dragon. These works are animated and firm in drawing, with naturalism carried further than by Giotto. From the evidence of style, some modern connoisseurs assign to the same hand the paintings in the funeral vault of the Strozzi family, below the Cappella degli Spagnuoli in the church of S. Maria Novella, representing the crucifixion and other subjects. Vasari ascribes also to his Giottino the frescoes of the life of St. Nicholas in the lower church of Assisi. This series, however, is not really in that part of the church which Vasari designates, but is in the Chapel of the Sacrament; and the works in that chapel are understood to be by Giotto di Stefano, who worked in the second half of the 14th century—very excellent productions of their period. It might hence be inferred that two different men produced the works which are unitedly fathered upon the half-legendary "Giottino," the consumptive youth, solitary and melancholic, but passionately devoted to his art. A large number of other works have been attributed to the same hand; we need only mention an Apparition of the Virgin to St. Bernard, in the Florentine Academy; a lost painting, very popular in its day, commemorating the expulsion, which took place in 1343, of the duke of Athens from Florence; and a marble statue erected on the Florentine campanile. Vasari particularly praises Giottino for well-blended chiaroscuro. He left behind him various scholars in the art.

GIOTTO (1276–1336), relatively to his age one of the greatest and most complete of artists, fills in the history of Italian painting a place analogous to that which seems to have been filled in the history of Greek painting by Polygnotus. That is to say, he lived at a time when the resources of his art were still in their infancy, but considering the limits of those resources, his achievements were the highest possible. At the close of the Middle Age, he laid the foundations upon which all the progress of the Renaissance was afterwards securely based. In the days of Giotto, the knowledge possessed by painters of the human frame and its structure rested only upon general observation, and not upon any minute, prolonged, or scientific study; while to facts other than those of humanity their observation had never been closely directed. Of linear perspective they possessed few ideas, and those elementary and empirical, and scarcely any ideas at all of aerial perspective or the conduct of light and shade. As far as painting could ever be carried under these conditions, so far it was carried by Giotto. In its choice of subjects, his art is entirely subservient to the religious spirit of his age. Even in its mode of conceiving and arranging those subjects, it is in part still trammelled by the rules and consecrated traditions of the past. Thus, it is as far from being a perfectly free as from being a perfectly accomplished form of art. Many of those truths of nature to which the painters of succeeding generations learnt to give accurate and complete expression, Giotto was only able to express by way of imperfect symbol and suggestion. But in spite of these limitations and shortcomings, and although he has often to be content with expressing truths of space and form conventionally or inadequately, and truths of structure and action approximately, and truths of light and shadow not at all, yet among the elements over which he has control he maintains so just a balance that his work produces in the spectator less sense of imperfection than that of many later and more accomplished masters. He is one of the least one-sided of artists, and his art, it has been justly said, resumes and concentrates all the attainments of his time not less truly than all the attainments of the crowning age of Italian art are resumed and concentrated in Raphael. In some particulars the painting of Giotto was never surpassed,—in the judicious division of the field and massing and scattering of groups,—in the union of dignity in the types with appropriateness in the occupations of the personages,—in strength and directness of intellectual grasp and dramatic motive,—in the combination of perfect gravity with perfect frankness in conception, and of a noble severity in design with a great charm of harmony and purity in color. The earlier Byzantine and Roman workers in mosaic had bequeathed to him the high abstract qualities of their practice, their balance, their impressiveness, their grand instinct of decoration; but while they had compassed these qualities at an entire sacrifice of life and animation, it is the glory of Giotto to have been the first among his countrymen to breathe life into art, and to have quickened its stately rigidity with the fire of natural incident and emotion. It was this conquest, this touch of the magician, this striking of the sympathetic notes of life and reality, that chiefly gave Giotto his immense reputation among his contemporaries, and made him the fit exponent of the vivid, penetrating, and practical genius of emancipated Florence. His is one of the few names in history which, having become great while its bearer lived, has sustained no loss of greatness through subsequent generations.

No two men were ever more unlike than the rustic Giotto and the patrician Dante; but among the high places of history, their figures stand side by side on a common eminence. They were contemporaries, Dante being the elder of the two by eleven years, and friends, or, at the least, acquaintances. The poetry of Dante, reporting concerning things unseen with a definiteness not less than that of actual vision, served in many ways, until the days of Michelangelo, not only as an inspiration but as a law to the religious art of Italy. This inspiring and legislating authority of the sacred poet was exercised first of all upon Giotto,—partly, it appears, by means of personal intercourse between the two men. On the other hand, Giotto is celebrated in Dante's verse as the foremost painter of the new age. Nor is this the only tribute to his pre-eminence which we find in contemporary, or almost contemporary, literature. He is from the first a kind of popular hero. He is celebrated by the poet Petrarch and by the historian Villani. He is made the subject of tales and anecdotes by Boccaccio and by Franco Sacchetti. From these notices, as well as from Vasari, we gain a distinct picture of the man, as one whose nature was in keeping with his peasant origin; whose sturdy frame and plain features corresponded to a character rather distinguished for shrewd and genial strength than for sublimer or more ascetic qualities; a master craftsman, to whose strong combining and inventing powers nothing came amiss; conscious of his own deserts, never at a loss either in the things of his art or in the things of life, and equally ready and efficient whether he has to design the scheme of some great spiritual allegory in color or imperishable monument in stone, or whether he has to show his wit in the encounter of practical jest and repartee. From his own hand we have a contribution to literature which helps to substantiate this conception of his character. A large part of Giotto's fame as a painter was won in the service of the Franciscans, and in the pictorial celebration of the life and ordinances of their founder. As is well known, it was a part of the ordinances of Francis that his disciples should follow his own example in worshipping and being wedded to poverty,—poverty idealized and personified as a spiritual bride and mistress. Giotto, having on the commission of the order, given the noblest pictorial embodiment to this and other aspects of the Franciscan doctrine, presently wrote an ode in which his own views on poverty are expressed; and in this he shows that, if on the one hand his genius was at the service of the ideals of his time, and his imagination open to their significance, on the other hand his judgment was very shrewdly aware of their practical dangers and exaggerations.

Giotto di Bondone (a name, as it happens, also borne in the same generation by a distinguished citizen of Siena) was the son of a poor peasant of Vespignano. He was born in 1276, and drew, we are told, by natural instinct with whatever materials he could lay his hands on. He was ten years old when Cimabue, as the story goes, found him by the wayside, drawing a sheep with a piece of charcoal upon a stone or tile. The master, then at the height of his fame, took the peasant boy, with the glad consent of his father, to Florence to be his pupil. Of his early career after this we know no more until we find him at work as the foremost among many scholars employed under Cimabue at the interior decorations of the great memorial church of St. Francis at Assisi. This church consists of two structures, one superimposed on the other; it is of the upper and not of the lower church that we speak at present. On the walls of this, a great series of frescoes, now more than half obliterated, was painted by the primitive masters of the Tuscan school, including some of older and some of younger standing than Cimabue. The series is in three tiers, the uppermost tier containing scenes from the Old Testament; the next, scenes from the New; the lowest, scenes from the life of St. Francis. It is in this last tier that we can discern with certainty the hand of the youthful Giotto. The extent of his participation has been much debated. According to the more probable opinion, it can be traced even in the earlier scenes of the history; but it is in the later scenes only that the hand and promise of the master, the presence of a new and vital spirit, reveal themselves with fulness. Some interval (but the chronology of Giotto's career is at all points obscure) would seem to have elapsed between the execution of these frescoes and of others, better known than these, which adorn the lower story of the same structure. In four lunette-shaped spaces in the vaulting of this lower church, Giotto has painted four vast compositions, of which the scheme was dictated to him, no doubt, by some pious and learned mouthpiece of the wishes of the order. One of these exhibits the mystical wedding of Francis with Poverty; a second is an allegory of Chastity; a third, of Obedience; a fourth shows the saint glorified in heaven among the angels. To describe and explain these famous compositions would be beyond our scope. The ideas they embody cannot but seem strained and cold when we express them in modern language. Strained and cold, indeed, the ideas would have been in any other age of the world; but we must remember that the religious temperament of that age in Italy gave even to pedantry the colors of passion, and an ardent and solemn reality to the most far-drawn fantasies of devotion. And however cool the private judgment of Giotto in such matters may have been, it is not his private judgment which speaks to us from the painted allegories of Assisi; it is the sincere imagination of the men among whom he lived; it is the ardor and solemnity of the devotional spirit of his race. In one of the transepts of the same lower church there are frescoes of the Passion of Christ, and others of the life of St. Francis, which modern authorities hold against ancient, most likely with justice, to be also from the hand of Giotto.

Assuming that the later work of the master at Assisi belongs to the year 1296 or thereabouts, we have good evidence that two years afterwards he was working at Rome for the Cardinal Stefaneschi, nephew of Pope Boniface VIII. The remains of his industry in this employment may be seen in a mosaic of the *Navicella*, or Christ saving St. Peter from the waves, now preserved in the portico of St. Peter's at Rome, and in three panels, kept in the sacristy of the canons of the same church, which originally formed part of a ciborium. It is also recorded that Giotto adorned certain MSS. with miniatures for this patron; and in truth there exists in public libraries a very rare class of MSS., in which the miniatures bear the marks, if scarcely of the hand, at any rate of the immediate influence of Giotto. Lastly, a discolored fragment of a fresco of the church of St. John Lateran shows a figure of Pope Boniface VIII. announcing from a balcony the opening of the famous Jubilee of the year 1300. Soon after this, Giotto was once more in his native city. Recent research has again thrown in doubt the relative shares of the master and of his pupils in the decorations of the chapel, called by Ghiberti the chapel of the Magdalene, in the Bargello or palace of the Podestà at Florence. These were painted to celebrate the pacification between the Black and White parties in the state, effected by the Cardinal d'Acquasparta as delegate of the Pope in 1302, and consisted of a series of Scripture scenes, besides great compositions of Hell and Paradise. It is in the Paradise that the painter has introduced those groups, typical of pacified Florence, in which occur the portraits of Dante, Brunetto Latini, and Corso Donato, and which, amid the emotion of all who care for art or history, were recovered in 1841 from the whitewash that had overlain them.

The whole central period of Giotto's life, from about 1305 to about 1334, is divided between periods of residence at Florence and expeditions, of which we can in very rare instances trace the date or sequence, undertaken in consequence of commissions received from other cities of the peninsula. He was as much or more of a traveller as was Van Eyck a century later; and his travels exercised as much or more of the same fertilizing and stimulating influence on art in Italy as did those of the great Fleming in the north-west of Europe. The familiar story of the O belongs to a journey to France, which was projected by Giotto but never undertaken. Pope Benedict XI., the successor of Boniface VIII., sent a messenger to bring him proofs of the painter's powers. Giotto would give the messenger no other sample of his talent than an O drawn with a free sweep of the brush from the elbow; but the pope was satisfied, and engaged Giotto at a great salary to go and adorn with frescoes the papal residence at Avignon. Benedict, however, dying at this time (1305), nothing came of this commission; and the Italian 14th century frescoes, of which remains are still be seen at Avignon, have been proved to be the work, not, as was long supposed, of Giotto, but of the Sienese master, Simone Martini, called Simone Memmi. Another certain date in Giotto's career belongs to the close of the period we have defined. In 1328 he had painted in the palace of the Signoria at Florence a portrait (now lost) of Charles of Calabria kneeling before the Virgin. Two years later he was invited by the father of this prince, King Robert of Naples, to come and work for him in that city. Some frescoes in the chapel of the Incoronata had been long erroneously supposed, on the authority of Petrarch, to represent a part at any rate of the industry of Giotto during the three years which he spent at Naples. It is the merit of Messrs. Crowe and Cavalcaselle, while conclusively setting aside this tradition, to have called attention to a real and very noble work of the master existing in a hall which formerly belonged to the convent of Sta. Chiara in that city. This is a fresco celebrating the charity of the Franciscan order under the figure of the miracle of the loaves and fishes, with the personages of St. Francis and St. Clare kneeling on either hand.

Between these two dates (1305 and 1330), Giotto is said to have resided and left great works at Padua, Ferrara, Urbino, Ravenna, Rimini, Faenza, Lucca, and other cities; and in several of these paintings are still shown which bear his name with more or less of plausibility But among them it is at Padua only that his authentic and mature powers can really be studied, and that in perhaps the greatest and most complete series of creations of all that he has left. These are the frescoes with which he decorated the chapel built in honor of the Virgin of the Annunciation by a rich citizen of the town, Enrico Scrovegni, and called sometimes the chapel of the Arena, because it is on the site of an ancient amphitheatre. Since it is recorded that Dante was Giotto's guest at Padua, and since we know that it was in 1306 that he came from Bologna to that city, we may conclude that to the same year, 1306, belongs the beginning of Giotto's great undertaking in the Arena chapel. The scheme includes a Saviour in Glory over the altar, a Last Judgment over the entrance door, and on either side a series of subjects from the Old and New Testaments and the apocryphal Life of Christ, painted in three tiers, and lowest of all, a fourth tier with emblematic Virtues and Vices in monochrome, the Virtues being on the side of the chapel which is next the incidents of redemption in the entrance fresco of the Last Judgment, the Vices on that side which is next the incidents of perdition. There is no other single building, or single series of representations, in which the highest powers of the Italian mind and hand at the beginning of the 14th century may be so well studied as here. In the same city, the great Franciscan church of St. Antonio contains also the remains of works by the master. And it was still for the same order, in their renowned church of Santa Croce, that Giotto executed most of the paintings which mark the periods of his residence in Florence. Besides a vast altar-piece or panel for the Baroncelli chapel, he decorated with frescoes the walls of a number of private chapels in this church. The Baroncelli altar-piece still exists; the only chapels of which the frescoes have been uncovered are those of the Bardi and Peruzzi. Nor are these the only walls in Florence which to this day bear record of the powers of Giotto—without taking into account many that are attributed to him, but are really by the hand of pupils like Taddeo Gaddi or Puccio Capanna, or of weaker followers like Giottino, Giovanni da Milano, or Agnolo Gaddi.

Meanwhile, Giotto had been advancing, not only in fame, but in years and in prosperity. He was married young, and had, so far as is recorded, three sons, Francesco, Niccola, and Donato, and three daughters, Bice, Caterina, and Lucia. He had added by successive purchases to the plot of land inherited from his father at Vespignano. His fellow-citizens of all occupations and degrees delighted to honor him. And now, in his fifty-eighth year, on his return from Naples by way of Gaëta, he received the final and official testimony to the esteem in which he was held at Florence. By a solemn decree of the Priori (April 12, 1334), he was appointed master of the works of the cathedral of Sta. Reparata (subsequently and better known as Sta. Maria del Fiore), and architect of the city walls and of the towns within her territory. Dying in 1336, he only enjoyed these dignities for two years. But in the course of these two years he had found time not only to make an excursion to Milan, on the invitation of Azzo Visconti and with the sanction of his own Government, but to plan and in part to superintend the execution of two monuments of architecture, of which the one remaining is among the most exquisite in design and richest in decoration that were ever conceived by man. These were, the west front of the cathedral, and its detached campanile or bell tower. The cathedral front was barbarously stripped of its enrichments in a latter age, and stood naked until the other day, when the city of Florence undertook to restore it in a modern imitation. The campanile remains, except for inconsiderable repairs, as it was left by the pupils of Giotto after their master's death; and in the consummate dignity as well as consummate delicacy of its design, in its fair proportions and in the opulent but lucid invention and apportionment of its details, in the thoughtfulness and pregnant simplicity of its sculptured histories, it is the most fitting crown and monument of a strong and memorable career.

A complete bibliography of the earlier as well as the most recent authorities on Giotto would here be out of place. The main materials and references will be found in the following:—Vasari, ed. Lemonnier, vol. i. pp. 309 *sqq.*; Crowe and Cavalcaselle, *Hist. of Painting in Italy*, vol. i. chaps. 8 to 11; Ernst Förster, *Geschichte der Italienischen Kunst*, vol. ii. pp. 211 *sqq.*, and E. Dobbert in article "Giotto" in Dohme's *Kunst und Künstler*, vol. iii.

(S. C.)

GIOVINAZZO, a town of Italy, in the province of Bari, about 11 miles from Bari, on the railway from Otranto to Bologna. Situated on the coast, it has a small harbor, and carries on an export trade in the olives, almonds, and carobs produced in the vicinity. It is also the seat of a bishop, and possesses a cathedral, a castle, and a famous *ospizio* or poorhouse, which was founded by Ferdinand I. of Naples, and is now used partly for the education of foundlings and orphans, and partly for the reformatory treatment of juvenile criminals. Cloth, carpets, thread, and shoes are among the manufactures of the place, and the children of the ospizio are largely trained in such industries. Whether the identification with the ancient town called Netium or Natiolum be well founded or not, it is certain that Giovinazzo was in existence at a very early date, and some portions of its seawall are supposed to belong to the later Roman period. The population of the town in 1875 was 8902, and of the commune 9108.

GIOVIO, PAUL. See JOVIUS.

GIPSIES, a wandering folk scattered through every European land, over the greater part of Asia and North America, and along the northern coast of Africa. Bell of Antermony speaks in his *Travels* (1763) of meeting at Tobolsk a band of sixty Tzigany on their way to China; Koster describes the Brazilian Ciganos (*Travels in Brazil*, 1816); and at the present day cases of Gipsy emigration to Australia are not unknown. No general estimate can be formed of their numbers outside Europe, but travellers agree that they are very numerous in Persia (3000 families in 1856), Armenia, Asiatic Turkey (67,000 in 1877), and Egypt (one alone of the three chief tribes, the Ghagars, being reckoned at 16,000); whilst in America, besides a multitude of British Gipsies, Gipsies from Spain, France, Germany, and Hungary are not unfrequent. The total, 700,000, at which Miklosich placed (1878) the European Gipsies, fairly agrees with the following fragmentary statistics. Turkey, before its late dismemberment, contained 104,750 (9537 in Bosnia and the Herzegovina in 1874); Servia had 24,691 in 1874, Montenegro 500 in 1873; and in Roumania there are from 200,000 to 300,000, according to the varying estimates of Cretzulesco (1876) and the *Annuaire général officiel de Roumnanie* (1874). In 1876 Austria counted about 1000 (13,500 in Bohemia in 1846?), and Hungary 159,000 (78,923 in Transylvania in 1850, and 36,842 in Hungary proper in 1864); while Spain is credited with 40,000, France with from 2000 to 6000 (700 in the Basque country), Germany and Italy together with 34,000 (?) and Scandinavia with 1500. In Russia their number in 1834 was stated at 48,247, exclusive of Polish Gipsies, in 1844 at 1,427,539, and in 1877 at 11,654.[1]

Names.—Just as in every European land the Gipsy calls "Gentiles" (*i. e.*, non-Gipsies) *gajé*, he calls himself *Rom*, "a man or husband." This word *Rom*, connected by Paspati with the name of the Indian god *Ráma*, is by Miklosich identified with the Sanskrit *ḍoma* or *ḍomba*, "a low-caste musician."[2] Of names conferred by "Gentiles," some point to the fancied cradle of the Gipsy race. Thus *Gipsy* or *Gypsy* itself (*Egyptian* in the 16th century), the Spanish *Gitano*, Albanian *Jevk*, modern Greek Γύφτος, Magyar *Pharao népek* ("Pharaoh's people"), and Turkish *Färäwni*, preserve the belief in its Egyptian origin, a belief which finds no confirmation except in the casual resemblance between *Rom* and the Egyptian *rôme*, "man" (*cf.* Rawlinson's *Herodotus*, vol. ii., p. 225), and which was possibly due to the Gipsies' skill in serpent-charming. The Scandinavian and Low-German *Tatare* identifies Gipsies with the Mongolian hordes, the terror of Europe in the 13th century; and their French name *Bohémiens* was probably due either to a confusion of some such form as *Secani* with *Czech* or to the belief that Gipsies originated in Bohemia. To the same class belong *Walachi, Cilices, Uxii, Saraceni, Agareni, Nubiani*, etc., cited by Fritschius (1660). Other names again denote the character, hue, or callings of the race, as Arabic *Harámí*, "villain;" Dutch *Heydens*, "heathens," Persian *Karáchí*, "swarthy;" and modern Greek Κατζίβελος, by Somavera derived from the Latin *captivus*, by Bataillard connected with βέλος, "a dart," and so with the Gipsies' name in Cyprus, *Kilindjiridès*, from the Turkish *gylidj*, "a sword." Their Scotch name *Tinkler*, which occurs in a charter of William the Lion (1165–1214), is commonly held to be a mere variant of *tinker;* but if its initial *t* correspond to *z* (*cf.* English *ten*, German *zehn*), it comes very near the Italian *Zingaro* or *Zingano*, which, like the German *Zigeuner*, Czech *Cingán* or *Cigán*, and Magyar *Cigány*, is a form of the most widespread of all the Gipsies' appellations—Bulgarian *Atzigan*, modern Greek Ἀτσίγκανος or Ἀθίγγανος. The last was also the title of a separatist sect in Asia Minor, so called, it is supposed, because its members kept themselves from contact with unbelievers (α privative, and θιγγάνω, "to touch"). Miklosich, finding in it the source of all the preceding forms, believes it to have been transferred by the Greeks to Gipsies, either because the latter entered the western parts of the Byzantine empire from Phrygia and Lycaonia, or because they were suspected of being adherents of the sect or simply as a nickname (Mikl., vi. pp. 57–66). Bataillard, on the other hand, identifying the heretic Ἀθίγγανοι with Gipsy Ἀτσίγκανοι, and these with the Σίγυνναι of Herodotus (v. 9), derives the name from σιγύνη, "a javelin;" while others among the countless etymologies proposed are Goeje's from Persian *chang*, "a kind of harp or cither;" Burton's from Persian *zang*, "Ethiopia;" and Newbold's from Persian *zīn*, "a saddle."

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[1] In England the census of 1871 gives the number of "vagrants and Gipsies" as 2280, in Scotland of "vagrants" as 1793. These figures, however, while they include a good many non-Gipsy tramps and show-people, exclude all house-dwelling Gipsies, besides the Gipsy horse-dealers, basket-makers, hawkers, and tinkers, entered under their several headings, and are therefore utterly valueless.

[2] *Sinté*, another appellation current among the Gipsies of Germany, Poland, and Scandinavia, and possibly connected with the *Zincalo* of the Gitanos, has been likewise variously derived from the Sanskrit *Sindhu* (Indus) and from the Romani *sundó*, "famous," whilst Batail-

First Appearance in European History.—From whatever cause, it is certain that a confusion did exist between the Ἀτσίγκανοι and Ἀθίγγανοι, which renders it extremely difficult to determine whether the Byzantine historians are speaking of Gipsies or heretics in seven passages collected by Miklosich. It appears from these that Ἀθίγγανοι, described as magicians, soothsayers, and serpent-charmers, first emerge in Byzantine history under Nicephorus I. (802–11), were banished by Michael I. (811–13), and were restored to favor by Michael II. (820–29); but Miklosich's reasons for absolutely identifying them with Gipsies, and positively asserting the latter to have appeared at Byzantium in 810 under Nicephorus, are hard to recognize. Less dubious seems an extract from the Georgian *Life of Giorgi Mtharsmindel* (11th century), which describes how at Constantinople certain descendants of the race of Simon Magus, *Atsinkan* by name, sorcerers and famous rogues, slew wild beasts by their magic arts in the presence of Bagrat IV. Such passages are open to some doubt; hardly so the following from the *Itinerarium Symonis Simeonis* (ed. by J. Nasmith, Camb. 1778), where Fitz Simeon, a Franciscan friar of Dublin, describing his stay in Crete in 1322, says:—"We there saw a people living outside the city (of Candia), who worship according to the Greek rite, and declare themselves of the race of Ham. They rarely or never stop in one place more than thirty days, but, as though accursed of heaven, wander from field to field with little, oblong, black, low tents, like those of the Arabs, or from cave to cave." The empress Catherine de Valois, again, who died in 1346, granted to the suzerains of Corfu authority to reduce to vassalage certain *homines vageniti* coming from the mainland, who under the Venetians formed in 1386 the nucleus of a *feudum Acinganorum* that lasted down to the present century. About 1378 the Venetian governor of Nauplion confirmed the *Acingani* of that Greek colony in privileges granted by his predecessors; and in 1387 Mircea I., waiwode of Wallachia, renewed a grant made by his uncle Ladislaus to the monastery of St. Anthony at Voditza of forty *salaschi* (tents) of *Acigani*. Other documents might be cited, but these are enough to show that in the 14th century Gipsies existed in the Balkan peninsula and islands of the Levant; that in Wallachia they were reduced to a state of bondage (from which they were only freed in 1856); and that nowhere were they regarded as new-comers, so that by these documents it is impossible to fix the date of the first Gipsy immigration. More than this, a metrical German paraphrase of Genesis, made by an Austrian monk about 1122, preserved at Vienna, and edited by Hoffmann in his *Fundgruben für Geschichte deutscher Sprache* (Breslau, 1837), goes far to prove that Gipsies were known in Austria three centuries before the commonly-accepted date of their appearance in that country. A passage relating to Hagar's descendants (Gen. xvi. 15) runs:—"So she (Hagar) had this son; they named him Ishmael. It is from him the Ishmaelites descend. They journey far through the world; we call them *chaltsmide* (lit. cold-smiths). . . . They have no house nor country; everywhere they are found alike; they wander over the country, abusing people by their knaveries. Thus they deceive men,—robbing no one openly." That here by *chaltsmide, Ishmaelites*, and *descendants of Hagar* Gipsies are meant, scarcely admits of doubt, seeing that the smith's is still the Gipsies' leading handicraft; that Lusignan in 1573 speaks of the Gipsies of Cyprus as "Cinquanes, otherwise called *Agariens;*" and that in German and Danish *Rotwälsch* or thieves' slang *Geschmeilim* and *Smaelem* (*i.e.*, Ishmaelites) signify "Gipsies." The κωμοδρόμοι also of Byzantine writers were possibly Gipsies, being defined by Ducange as "circulatores atque adeo *Fabri ærarii* qui per pagos cursitant: ut hodie passim apud nos, quos *Chaudronniers* dicimus." Theophanes (758–818) speaks under the date 544 of a κωμοδρόμος from Italy.

Later Movements.—Late in 1417 there came to Lüneburg a band of 300 wanderers, "black as Tartars and calling themselves *Secani*." At their head rode a "duke" and "count," splendidly dressed, and leading like nobles dogs of chase; next came a motley crew afoot; and women and children brought up the rear in wagons. They bore among other letters of safe-conduct one granted by the emperor Sigismund, and professed themselves engaged on a seven years' pilgrimage, imposed by their bishops in expiation of apostacy from the Christian faith. From Lüneburg they passed to Hamburg, Lübeck, Wismar, Rostock, Stralsund, and Greifswald, camping by night outside the walls, thieving by day, "wherefore several were taken and slain" (*cf.* the contemporary annals of Korner and Rufus, and Krantz's *Saxonia*, 1520). In 1418 they journeyed southwards through Meissen, Leipsic, and Hesse, and, entering Switzerland, arrived at Zurich on August 31st, visiting also Basel, Bern, and Solothurn, according to Conrad Justinger (died 1426) who speaks of them as "more than 200 baptized heathens from Egypt." They now split up into two bands, the first of which appeared before Augsburg (November 1, 1418), the second before Sisteron in Provence (October 1, 1419), where the terrified citizens bestowed on the "Saracens" a hundred loaves. Next comes a long notice of a troop of fully 100 lean, black, hideous Egyptians in the *Chronica di Bologna* (July 18, 1422), which tells how the sorceress, "Duke" Andrew's wife, could read the past and future of men's lives; but Bologna in fifteen days became too hot for them, so by way of Forli—where "certain said they were from India"—the pilgrims travelled on to Rome. Their object was to procure fresh letters from the Pope; and such they afterwards produced, though of their sojourn in the imperial city no record has yet been published. To the burghers of Ratisbon Gipsies presented themselves in 1424; they pitched their tents again before its walls in 1426; and at Paris in 1427 the fair of Landit was attended by a duke, a count, and ten other mounted pilgrims, late renegades of "Lower Egypt," whose women practised palmistry and cleared everybody's pockets. Later we hear of Gipsies at Arnheim (1429), at Metz (1430), at Erfurt (1432), and in Bavaria (1433)—these and all notices of the seventeen years preceding referring probably to the movements of a single ubiquitous band, sent forward to spy out the lands of promise, and composed of from 600 to 1400 persons. For not until 1438 did the great tide of westward immigration

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lard identifies it with the Σίντιες or Σίντιοι ἄνδρες of Homer, Strabo, etc. (*cf.* Pott, i. 32–35).

begin to flow; then, not in hundreds but thousands, headed no longer by paltry "dukes" and "counts," but by a "king," King Zindl,[1] the Gipsies poured over Germany, Italy, and France, reaching Poland by 1501, Sweden by 1512, and having already appeared in Spain in 1447. We find them in England in 1514 (*A Dyaloge of Syr Thomas More*, 1529), but nothing is known of the date of their landing; and in Scotland the earliest certain record of their presence is an entry in the books of the Lord High-Treasurer: "Apr. 22, 1505. Item, to the Egyptianis, be the kingis command, vij. lib." (Pitcairn's *Criminal Trials*, Edin. 1833, vol. iii. p. 592). In a "King of Rowmais" (? *Rómas*, Gipsies), twice mentioned in entries of July, 1492, as also in the "Erle of Grece" (1502), "King Cristall" (1530), and the "King of Cipre" (1532), one dimly recognizes four Gipsy chiefs; and with Gipsies perhaps the Saracens may be identified, whom a tradition represents as making depredations in Scotland prior to 1460 (Simson, p. 98). In no other country were Gipsies better received than in this, where they "dansit before the king in Halyrudhous" (1530); where James IV. gave (July 5, 1505) Anthonius Gagino, count of Little Egypt, a letter of commendation to the king of Denmark; and where James V. subscribed a writ (February 15, 1540) in favor of "oure louit Johnne Faw, lord and erle of Litill Egipt,"[2] to whose son and successor he granted authority to hang and punish all "Egyptians" within the realm (May 26, 1540). But in 1541 an Act was passed, commanding the "Egyptians to pass forth of the realm" under pain of death, and similar edicts were issued before and afterwards in most of the European states—Germany (1497), Spain (1499), France (1504), England (1531), Denmark (1536), Moravia (1538), Poland (1557), etc. Conveying across the seas was among the milder measures adopted; it is, however, noteworthy as one of the causes of the dispersion of the tribes. Under Henry VIII. Gipsies were shipped from England to Norway (Wright's *History of Ludlow*, pp. 389–92) or France; whilst by the latter power, so lately as 1802, the bands infesting Bayonne and Mauléon were caught by night as in a net, huddled on shipboard, and landed on the coast of Africa (Michel, *Pays Basque*, p. 137). In Scotland four Faas were hanged at Edinburgh in 1611 "for abyding within the kingdome, they being Egiptianis," and in 1636 doom was pronounced on other "Egyptians" at Haddington, the "men to be hangit, and the weomen to be drowned; and suche of the weomen as hes children to be scourgit throw the burgh and brunt in the cheeke." Under the English statute of 1562 (repealed 1783) making it felony without benefit of clergy to be merely seen for a month in the fellowship of Gipsies, five men were hanged at Durham "for being Egyptians," 8th August, 1592. Still greater were the cruelties and injustice suffered by Gipsies on the Continent, since there, to the charge of kidnapping, were added the weightier imputations of being cannibals and emissaries of the Turk. Quiñones recounts how in 1629 four Estremaduran Gitanos owned under torture to having eaten a friar, a pilgrim, and a woman of their tribe; and in 1782 forty-five Hungarian Gipsies were beheaded, quartered, or hanged on a like monstrous charge. First racked till they confessed the crime of murder, they were brought to the spot where their victims were said to be buried, and when no bodies appeared they were racked again. "We ate them," was their despairing cry; and forthwith the journals teemed with accounts of "eighty-five persons roasted by Gipsy cannibals;" straightway the "cannibals" were hurried to the scaffold. Then Joseph II. sent a commission down, whose inquiries showed that no one had been murdered—except the victims of the false accusation. The full, impartial annals of the race have still to be compiled from edicts and law-books, from local histories and a few monographs like Dirk's *Geschiedkundige onderzoekingen aangaande het verblijf der Heidens of Egyptiërs in de Noordelijke Nederlanden* (Utrecht, 1850) or Weber's *Zigeuner in Sachsen*, 1488-1792, in vol. ii. of his *Aus vier Jahrhunderten* (Leip. 1861).

Language.—Until lately the information about the Gipsy language to be gathered from books was meagre in the extreme. The thirteen works published prior to 1840 which furnish specimens of the Anglo-Romani dialect—Boorde (1547), Bryant (1785), Bright (1818), Copsey (1818), Harriot (1830), Roberts (1836), etc.—together contain but 396 genuine stems, besides 69 doubtful words, and furnish scarcely any examples of the grammar. Nor are the Continental works cited by Pott, from Vulcanius (1589) downwards, much more copious. Even to-day there are still great gaps in our knowledge, especially of the dialects outside of Europe; but enough has been done to show that from the Nile to the Arctic Ocean, from the Euphrates to the Atlantic, the Gipsies speak, with dialectal variations, one and the selfsame speech. The Romani names for "water," "fire," "hair," and "eye" are in Persia *páni*, *aik*, *bál*, and *aki*; in Egypt *páni*, *ág*, *bal*, and *ankhi*; in Norway *pani*, *jag*, *bal*, and *jak*; in England *páni*, *yog*, *bal*, and *yok*. And these four instances, which might be multipled indefinitely, serve further to show, by their resemblance to the Hindi *pānī*, *āg*, *bāl*, and *āṇkh*, that in Romani we have an Indian tongue. Rüdiger first compared Romani, so long regarded as a thieves' jargon, with one of the New Indian dialects, and in 1782 published the result of the comparison in his *Neuester Zuwachs der Sprachkunde*. In 1783 Grellmann's *Historischer Versuch* reaped all the fruits of Rüdiger's research; and in the same year Marsden was independently led to a like discovery. The conclusion that the Gipsies wandered forth from India is now almost universally accepted, but when, or from what part of India, are questions on which few have done more than idly speculate. Whether Romani is derived from Hindi, Marathi, etc., can only be determined by minute investigations, which, long neglected, are now being carried on by various Orientalists. They have at least established that Romani stands in the relation of a sister, not a daughter, to the seven principal New Indian dialects. Its forms are often more primitive than theirs, sometimes than those of Pali or the Prakrits, *e. g.*, *vast*, "hand" (Sanskrit *hasta*, Pali *hattha*), *kasht*, "wood" (Sanskrit *kāshtha*, Pali *kattha*), *vusht*, "lip" (Sanskrit *oshṭha*, Pali *ottha*), *trash*, "fear" (Sanskrit *trāsa*, Pali *tas*), *trin*, "three" (Sanskrit *tri*, *trīṇi*; Pali *ti*, *tini*) and *pral*, "brother" (Sanskrit *bhrātā*, Pali *bhāta*). And while the archaisms of Romani forbid us to derive it from Hindi or Marathi, some of its seemingly modern forms are the result of independent development. On the other hand, our knowledge of Romani itself, and of the multitudinous spoken dialects of India, is not at present sufficient to warrant our pronouncing the former more primitive than any of them; and as a fact many of its archaisms may be paralleled in the languages of Dardistan and Kafiristan (*cf.* Miklosich, *Beiträge*, iv. 45–54). Thus there are difficulties on both sides in the way of adjudicating between the opinions of Ascoli and Miklosich. The former maintains (*Saggi Indiani*, vol. ii., 1875) that Romani, preserving certain consonantal *nexus* which had almost entirely disappeared at the epoch of the most ancient Prakrit texts, approaches Sanskrit more nearly even than Pali—conclusions, he observes, that harmonize well with Bataillard's pre-historic theory. Miklosich, on the other hand, opposes that theory in Meyer's *Konversations-Lexikon* (3d ed. 1878), where he infers from the agreement of Romani in its phonetic laws and system of case-endings with the modern Aryan languages of India that the emigration cannot have taken place till these were formed, *i. e.*, until after the Prakrit period.

In Europe Miklosich distinguishes thirteen Romani dialects—the Greek or Turkish, Roumanian, Hungarian, Moravo-Bohemian, German, Polo-Lithuanian, Russian, Finnish, Scandinavian, Anglo-Scottish, Italian, Basque, and Spanish. To these should be added the Welsh, which, generally unintelligible to the English Gipsy, is one of the most perfect, as it has also been the least studied, of all the dialects. As a general rule, the further these dialects remove from Turkey, the more corrupt have they become, so that the Gipsies of Spain, of Scandinavia, and in great measure of England, know no case or verb endings other than those of the lands of their adoption. From Turkish Romani, therefore, and Welsh the following examples will be drawn. The Turkish (marked T.) are taken from Paspati;

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[1] The titles of king, duke, earl, count, and (in south-eastern Europe) waiwode were and are borne by the chiefs of greater or smaller bands, more to impress the vulgar than as denoting real authority. With British Gipsies one is bewildered by the host of *soi-disant* kings and queens, from King John Bucle, laid side by side with Athelstan in Malmesbury Abbey in 1657, down to the Gipsy queen of the United States, Matilda Stanley, royally buried at Dayton, Ohio, in 1878.

[2] This letter has an especial interest, since it presents the earliest specimens of the Gipsy tongue, in the names of three of the Gipsies mentioned in it: Grasta (*grast*, "a horse"), Towla Bailyow (*túlo baúlo*, "fat pig"), and Matskalla (? *matchka*, "cat"). Paspati gives as female Turkish Gipsy names *Tchiriclí*, "bird," and *Sappní*, "viper;" but probably the above were merely assumed by way of a jest, like *Corrie* (Hoyland, p. 165), and *Gallimensch* (Pott, i. 52). See, on Gipsy names, Mr. Crofton in *Notes and Queries* (5th ser., vol. ii. p. 349).

the Welsh (W.) are derived from letters and stories written by John Roberts, the oldest living harper, whose thorough knowledge of his language is probably unique.

The definite article, wanting in Asia, is supplied in every European dialect by the Greek ὁ and ἡ—ὁ for the masculine, ἡ for the feminine and the oblique cases, *e. g.*, W. *Potchdas ow bearengaro e vaver tringengey*, "the sailor asked the other three," *E colley pendas*, "the Gipsy woman said." The indefinite article, in some dialects supplied by *yek*, "one," is still omitted by the Welsh and the "deeper" English Gipsies, *e. g.*, *Yeker porro gougeo ta porrey gougey jivenes undra borrow veshestay*, "once (an) old man and (an) old woman were living in (a) great wood." Romani has no trace of either a dual number or a neuter gender. Excepting monosyllables, most of its nouns terminate in *-o* (masc.) and *-i* (fem.), as *raklo*, "lad," *rakli*, "girl." Masculine nouns ending in a consonant form their feminines in *-ni*, as *rom*, "husband," *romni*, "wife." Inanimate objects are indifferently masculine or feminine: to the former belonging *gav*, "town," and *gad*, "shirt;" to the latter *nok*, "nose," and *bok*, "hunger." *Rom*, "a husband," and *rakli*, "a girl," are thus declined in Turkish Romani:—

	Sing.	Plur.		Sing.	Plur.
Nom.	Rom	Rom-á	Nom.	Rakli	Rakli-á
Acc.	Rom-és	Rom-én	Acc.	Rakli-á	Rakli-én
Gen.	Rom-éskoro	Rom-éngoro	Gen.	Rakli-ákoro	Rakli-éngoro
Dat. i.	Rom-éste	Rom-énde	Dat. i.	Rakli-áte	Rakli-énde
Dat. ii.	Rom-eske	Rom-énghe	Dat. ii.	Rakli-áke	Rakli-énghe
Instr.	Rom-ésa	Rom-éndja	Instr.	Rakli-ása	Rakli-éndja
Abl.	Rom-éstar	Rom-éndar	Abl.	Rakli-átar	Rakli-éndar
Voc.	Róm-a	Rom-ále	Voc.	Raklí-e	Rakl-ále

Here the so-called genitive is in reality an adjective. It precedes and agrees in gender with its noun, *e. g.*, T. *e derviséskeri rakli*, "the dervish's daughter;" W. *sonekaiesko mochto*, "a golden box," and *dakey pen*, "mother's sister." Welsh Gipsies often use the dative where we should look for the genitive, as in *Te pogerel yeck e herrenday ow vodrestay*, "to break one of the legs of the bed." Datives and instrumentals are formed by suffixing to accusatives the separable post-positions *te* or *ke*, "to," and *sar*, "with;" and the *-tar* of the ablative (also occurring in *ká-tar*, "whence" lit. "where from") Pott (i. 188) compares with the Pali adverbial ending *-to* = Sansk. *tas* = Lat. *-tus* in *cœlitus*. In most European Romani dialects considerable confusion has arisen in the use of the oblique cases, but Welsh Gipsies employ the following rightly enough: Sing. acc. *te dickel ow krallises*, "to see the king;" dat. masc. *te dickel pesko jivamuskay*, "to look for his living;" dat. fem. *pendas e gougeackey*, "she said to the woman;" inst. *rokkerdas ow krallisesa*, "he spoke with the king;" voc. *Ria*, "Sir!"—Plur. acc. *te patsell e callen*, "to believe the Gipsies;" dat. *te kerrav les undra chichaw grengey*, "to make it into shoes for horses;" voc. *Chovollay*, "mates!" Nouns ending in *-o* form their plural in Welsh, as in Turkish Romani, in accented *-é*, *e. g.*, *chavay*, "children" (sing. *chávo*), and *chiriklay*, "birds" (sing. *chíriklo*); other nouns form it in *-a* or *-ïa*, as *chaia*, "girls" (sing. *chai*), *tema*, "lands" (sing. *tem*), *penya*, "sisters" (sing. *pen*), etc. Of adjectives it need only be remarked that, with rare exceptions, they end in *-o* (masc.) and *-i* (fem.), and form the plural in *-é*, *e. g.*, W. *Java te kerra esa te rigeren tomentatay*, "I go to make clothes to keep you (plur.) warm." The termination of the comparative is *-der*, *e. g.*, W. *porro*, "old," *poradare*, "older;" and the want of a true superlative is frequently supplied, as in French, by prefixing the definite article to the comparative, *e. g.*, W. *con see ow poradare*, "who is the eldest." Romani pronouns present an interesting study, since everywhere they have been better preserved than any other parts of speech. Turkish Romani gives *me*, "I," *man*, "me," *amén*, "we," etc., and *tu*, "thou," *tut*, "thee," *tumén*, "ye" (lit. thou-we), etc., all of which forms are employed by English and Welsh Gipsies. How strikingly indeed the Turkish and Welsh dialects agree may be seen from the instances following these paradigms, taken from Paspati, of *ov*, "he," *ói*, "she," and *ol* (Bohemian Romani, *jon*) "they:"—

Nom.	ov	ói	ol	Dat. ii.	léske	láke	lénghe
Acc.	les	la	len	Instr.	lésa	lása	léndja
Gen.	léskoro	lákoro	léngoro	Abl.	léstar	látar	léndar
Dat. i.	léste	láte	lénde				

Now in Welsh Romani we find: Sing. Masc. nom. *Pendas yov*, "said he;" gen. *lesko pickoo*, "his shoulder;" acc. *cordas les poley*, "he called him back;" dat. i. *deyas lestay*, "he gave him;" dat. ii. *chotchy ow Rye leskay*, "quoth the gentleman to him;" inst. *bitcherdas vaver yeck lessa*, "he sent another one with him:" Sing. Fem. nom. *yoi comdas les*, "she loved him;" gen. *unrea lacko nogo drom*, "in her own way;" acc. *yov comdas la*, "he loved her;" dat. i. *aney joneles yov chomaney trostel latay*, "whether he knew something about her;" dat. ii. *jalla te dickel lakey*, "he goes to look for her;" inst. *commesa to te jas lasa*, "wilt thou go with her:" Plur. nom. *yon jivenes*, "they were living;" gen. *saw e chava bitcherana lengo camyben*, "all the children send their love;" acc. *commos tokey te bichaves len*, "I should like you to send them;" dat. i. *trosel lenday*, "about them;" dat. ii. *potchdas lengey*, "he asked them;" instr. *potchday leskey so wantines lensa*, "they asked him what he wanted with them;" abl. *te tardel lovo from lenda*, "to extract money from them," where the English "from" is redundant. That nineteen out of the twenty-one forms of the Turkish dialect should be preserved in the Welsh after a separation of four centuries, Romani, moreover, being an unwritten language, is singular; hardly less striking is the similarity in the use of the reflexive pronoun *pes*, "himself" or "herself," *e. g.*, W. *dickel pesko drom glan pestay*, "he sees his way before him;" *ow Jack rivdas pes*, "Jack dressed himself;" *te den pengo lovo*, "to give their money;" *e trin morsh gillay pengay*, "the three men went away" (lit. "went to themselves," a curious use). The third pronoun, *lo*, "he," *li*, "she," and *lé*, "they," commonly only used after the auxiliary verb "to be," is also noteworthy, as playing an important part in the formation of the verb. Instances of its use are—W. *postey seslo kinno*, "till he was tired;" *vasavee chibalengerey ses le*, "she was a foul-tongued woman;" *trashaday seslay*, "they were frightened." The auxiliary verb runs in Turkish Romani: Pres. sing. *isóm*, *isán*, *isí* (*usti* in Asiatic R.); plur. *isám*, *isán*, *isí*: Imperf. sing. *isómas*, *isánas*, *isás*; plur. *isámas*, *isánas*, *isás*. And in Welsh Romani occur the forms, *shom*, "I am;" *shan*, "thou art;" *se*, "he is" or "they are;" *sham*, "we are" (*e. g.*, *sham betcherda te las a kai filushin*, "we are sent to get this mansion"); *shen*, "ye are;" *shomas*, "I was;" *shennes*, "thou wert" or "ye were;" *ses*, "he was" or "they were." The terminations of the present indicative in Turkish Romani are: Sing. *-va*, *-sa*, *-la*; Plur. *-sa*, *-na*, *-na*, which are joined immediately to the verbal stem (identical with the imperative) if it is monosyllabic and ends in a vowel, but otherwise are connected with it by a vowel. For example, *lá-va*, "I take;" *lá-sa* (*lésa*), *lá-la* (*léla*), *lá-sa*, *lé-na*, *lé-na*; and *ker-á-va*, "I make;" *ker-é-sa*, etc. Welsh Romani retains all these forms, *e. g.*, *bitcherava*, "I send;" *shonesa*, "thou hearest;" *penela*, "he says;" *bitcherasa*, "we send;" *vena*, "ye come;" *bitcherena*, "they send." In *-va* (*-mi* in Asiatic R.), *-sa*, and *-la* (*cf.* *lo* above) may be recognized the first, second, and third personal pronouns; the *n* of the second and third persons plural may be compared with the *n* in *romén*, "husbands." The imperfect is formed from the present by the suffix of *-s*, or, in the Hungarian dialect, *-hi*, *e. g.*, T. *keráva-s*, "I was making;" Hung. *kamesa-hi*, "thou wast loving;" W. *salles*, "he was laughing," *jivenes*, "they were living." This *-s* or *-hi* is the third person singular of the auxiliary verb, *isi*, "it is," so that literally *kerávas* means "I make + it is" (? some time ago). Perfects are compounded of participles—ending in *-do* (rarely *-to*), *-lo*, and *-no*—and the auxiliary verb. Thus from T. *piráva*, "I walk," part. *pirdó*, comes *pird-óm*, "I walked," *pird-án*, "thou walkedst," *pird-ás*, "he walked," etc.; and from *dáva*, "I give," part. *dinó*, *dinóm*, "I gave." Here too the Welsh agrees generally with the Turkish dialect, *e. g.*, *kerdom*, "I made," *keddan*, "thou madest," *kerdas*, "he made;" but *kedan*, "we made," should properly be *kerdám*; and for the third person plural Welsh R., like the German and other dialects, simply employs the plural participle, as *dicktta*, "they saw." In Continental dialects a pluperfect is formed from the perfect by adding to it *-a-s* or *-a-hi*, just as the imperfect from the present; and for a future *kama-* (*kamava*, "I love, wish, or will") is prefixed to the present, *e. g.*, *kama-keráva*, "I will do," *kama-kerésa*, "thou wilt do," etc. The sign of the subjunctive, which supplies the place of an infinitive, is the conjunction *te*, "that," prefixed to the indicative, which usually drops its vowel-ending, *e. g.*, T. *teréla dúi lav te pénel túke*, "he has two words to tell (lit. that he tells) you;" W. *trashaday seslay te dicken man*, "they were frightened to see (lit. that they see) me." Enough has been said to show that Romani is not so utterly "degraded in its grammar" as Max Müller has declared it to be; and the following short Welsh Gipsy story (printed literatim from Roberts) will illustrate some of the foregoing remarks:—

Yeker a doi ses bearengaro ta vaver store morsh; yek ses
Once there were (a) sailor and other four men; one was

peltanengero, ta ow vaver ses koramangaro, ta sivamangaro,
(a) blacksmith, and the other was (a) soldier, and (a) tailor,

to pallano ses kirchimackaro. Ow bearengaro potchedas e
and the last was (an) innkeeper. The sailor asked the

peltanengaro te vel apra ow doreav. Ow peltanengaro pendas,
blacksmith to come on the sea. The blacksmith said

"Nau, shom te ja te kerra boottee." "So se tero bootee?" "Te
"No, (I) am to go to do work." "What is thy work?" "To

tasarra sastarn," chotchy ow pelttenengaro, "ta te kerravles
heat iron," quoth the blacksmith, "and to make it

undra chichaw grengey." Potchdas ow bearengaro e vaver
into shoes for horses." Asked the sailor the other

trinengey te ven adra ow bearo. Ow koramangaro pendas ta
three to come in the ship. The soldier said that

jalla te kel moyaben. ta javaben; to sivamangaro pendas,
he goes to make facings and marching; and the tailor said,

"Shom te ja te kerra esa te rigeren tomen tatay." A ow
"(I) am to go to make clothes to keep you warm." And the
kirchimackaro pendas, "Java ma te kerra lovina te kel tomen
innkeeper said, "Go I to make beer to make you
matay, te jan saw to menday kai ow Beng." Okke saw
drunk, that may go all you to the Devil." Here (is) all,
dolestay.
to that (*i. e.*, of that).

The Romani vocabulary reveals positively and negatively the route by which the Gipsies must have entered Europe, and the various ways by which they have since dispersed to their present quarters. The absence, for instance, of Arabic elements from every European dialect disproves a common belief that the earliest immigrants may have landed in the Balkan peninsula from Egypt. On the other hand, the presence of Persian and Armenian words shows that they must have traversed and halted in the lands where those languages are spoken. Among the Persian are *devruál*, "sea," *poshóm*, "wool," *vesh*, "forest," *ambról*, "pear," and *avgin*, "honey;" whilst the Armenian words number twenty-six, according to Miklosich—*grast*, "horse," *chor*, "deep," *kotór*, "a piece," *mortí*, "skin," etc. Again, every dialect presents a large number of Greek words, testifying to the long residence of the Gipsies in a Greek-speaking land. In the German Romani dialect Miklosich reckons forty-two, besides the article, in the English thirty, which latter number might be certainly augmented. Alike in Russia and Spain, England and Hungary, Gipsies call a road *drom* (δρόμος), time *chairos* (καιρός), a horseshoe *petul* (πέταλον), a hat *stadi* (σκιάδι), etc.; in every land of Europe ἑφτά, "seven," ὀχτώ, "eight," and ἐννέα, "nine," have superseded the *haut*, *asch*, and *nau* of Asiatic Gipsies. This identity of their borrowed words disproves the view that the Gipsies of different European countries are the result of successive immigrations. Next to the Greek, and almost more numerous than they, come the Slavonic elements. Miklosich cites 70 from the German dialect, 30 from the English, and from the Spanish 46, among them being *kralis*, "king," *kítchima*, "inn," *mátchka*, "cat," *lovina*, "ale," and *plashta*, "cloak." Similarly English Romani contains Wallachian, Magyar, German, and French words, showing that the Gipsies reached England after wandering among Greeks, Slavs, Magyars, Germans, and French. It must not, however, be inferred from the foregoing that Romani is essentially other than an Indian speech. The Gipsies' linguistic pilferings form but a small percentage in the 2332 articles gathered together by Pott. And though some of these articles, founded on error, must be struck out, their place might be more than filled up by omissions; and the sum total is largely multiplied when one considers how many derivatives are grouped under a single head. Altogether, the entire stock of Romani words probably exceeds 5000, though the number known to any individual Gipsy is often small.

Elements of Literature.—The Gipsies have no literature worthy of the name—nothing but some rude ballads, some love and dance songs, and a considerable mass of folk-tales. Valuable from a linguistic point of view, the songs have little merit of their own, and seem to be mainly echoes of Gentile strains. The folk-tales, however, would possibly repay a keener investigation than they have yet received. Alike in Wales and Turkey they may be identified with those of other Aryan races; scarce one has yet been published but its counterpart may be found in Grimm's, Ralston's, or other collections of European folk-lore. For instance Paspati's third story, taken down at Constantinople from a Gipsy professional *raconteur*, is unquestionably the same as Grimm's *Treuer Johannes.* Similarly in the Bukowina we meet with Romani versions of *Das tapfere Schneiderlein*, *Die zwei Brüder*, etc., whilst *Nazdrivánu* may be matched from Ralston's *Russian Folk-tales*, p. 73, and frequent mention is made of the waters of life and death, of hills that butt together like rams (*cf.* Ralston, p. 236), and of other features common in Slavonic folk-lore. This resemblance of Romani to Gentile stories may be explained (1) by the common origin of the Aryan races, (2) by the Gipsies having borrowed from the nations among whom they wander, or (3) by these nations having received their stories from the Gipsies. Probably all three explanations are true by turns, but the first is sometimes excluded by an identity of details too close to have been preserved through untold ages, and as to the second it is hard to see how a story current at Paderborn should have travelled eastward to Constantinople, especially as Paspati's tales, enshrining words and phrases otherwise obsolete, are plainly of some antiquity. Accordingly the third explanation, that the Gipsies may have carried *Treuer Johannes* and other stories westward with them, deserves consideration. Some of the Gaelic stories collected by Campbell were, it should be remarked, taken down from Tinklers; and from a London Gipsy he obtained a version of *The Master Thief*, which is current also among Roumanian Gipsies. At present our information is far too scanty to warrant a definite conclusion; but could it once be shown that the Asiatic possess the same stories as the European Gipsies, it might be necessary to admit that Europe owes a portion of its folk-lore to the Gipsies.[1]

Religious Beliefs and Observances.—"The Gipsies," says Grellmann, "brought no particular religion with them, but regulate themselves in religious matters according to the country where they live, . . . wherefore most writers place them below the heathens." This author notwithstanding, the Gipsies mix with their beginnings of Christianity or Mahometanism the relics of an older faith. *Devel*, their name for God or sky, is akin to the Sanskrit "God" (*cf. dyaus*, "sky") and the German Romani *Miro baro devel dela berschindo*, "my great God gives rain," *i. e.*, "it rains," preserves the original signification. *Gúriben*, "thunder" (lit. "bellowing of cattle"), is another reminiscence of nature worship; and *trúshul*, "cross" (Sanskrit *trisūla*, "the trident of Siva"), presents a curious instance of the transference of religious ideas. *Beng*, "devil," compared by Miklosich with the Sanskrit *bhēka*, "frog," is possibly a survival of serpent-worship, traces of which may be also found in various phrases, stories, emblems, and customs. Survivals also of phallic worship may probably be seen in the honor paid by the three great German Gipsy clans to the fir-tree, the birch, and the hawthorn (Liebich, p. 38); and in the veneration in which Welsh Gipsies hold the fasciated vegetable growth known as the *broado koro.* There are besides a number of other Gipsy superstitions interesting enough in themselves, but which lose their full significance by being at present isolated or insufficiently authenticated, such as, for instance, the alleged devotion of Norwegian Gipsies to a moon-god, Alako (Sundt, 105–10). In the *People of Turkey* (1878) the Tchinghianés are said to keep a fire continually burning in their camp; on the first of May to go all in a body to the sea-coast or banks of a river, where they thrice throw water on their temples, invoking the invisible *genii loci* to grant their special wishes; and annually to drink some potion, prepared in a way known only to the oldest and wisest of the tribe.

Modes of Life.—In Turkey, according to Paspati, the nomad Tchinghianés far outnumber the sedentary; but how far the same statement is true of Gipsies of other lands is hard to determine. Certain at least it is that in England few house-dwelling Gipsies are to be met with who do not remember that their forefathers followed a wandering life, or who do not themselves go temporarily under canvas as hop-picking or the great race-meetings come round. But though for centuries the tent has been the Gipsy's normal habitation, it would not seem to have been so always, if we look to the evidence of the Gipsy tongue. For had it been, assuredly the Romani name for "tent" would be everywhere the same, whereas the Persian Gipsy calls it *guri*, the nomad Tchinghiané *katúna* (modern Greek κατούνα), the sedentary *tchérga* (Turkish *cherkeh*), the Polish Gipsy *czater*, the German *tattin* (from *tatto*, "hot"), the English *tan*, etc. On the other hand, *ker*, "a house," occurs in every dialect. From the time, however, of Fitz-Simeon onwards Gipsies have everywhere been found dwelling in tents, and his description of these tents as "like those of the Arabs, low, black, and oblong," tallies with Mr. Boswell's:—

> "The tents are made of rough blankets. They are nearly always brown ones, because the white blankets are not so good for the rain. First of all they measure the ground with a ridge-pole, then they take the kettle-prop and make the holes exactly opposite each other. Then they take up the ridge-pole and stick all the rods into it. Then there is a blanket that goes behind, and is pinned on with pin-thorns; next to that come the large ones over the top of all, also pinned with the same pins."

In the matter of dress, Mr. Crofton, in *Papers of the Manchester Literary Club* (1876), infers that "Gipsies formerly had a distinctive costume, consisting of a turban-like head-dress of many colors, together with a large cloak, worn after the fashion of a toga, over a long loose under-skirt." The Gipsies, however, of to-day can hardly be said to have a distinctive garb, though certain minutiæ of dress still render them easily recognizable. In Transylvania, for instance, their women's ear-rings differ in pattern from those of the natives; the Hungarian Gipsy chief wears silver buttons, bearing a serpent crest; and his old-fashioned English brother decks his Newmarket coat with spade-guineas or crown-pieces. The English Gipsy woman may be known by her bright silk handkerchief, her curiously-plaited hair, her massy rings, her coral or bead necklace, and by the *monging-guno*, a tablecloth arranged bagwise over her back. In August, 1878, Queen Victoria was welcomed to Dunbar by a Gipsy "queen," one of the Reynolds family, who was "dressed in a black robe with white silk trimmings, and over her shoulders wore a yellow handkerchief. Behind her stood two other women, one of them noticeable from her rich gown of purple velvet, and two stalwart men, conspicuous by their scarlet coats." On the other hand, the dress of the children upon the Continent is simple, not to say scanty.

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[1] See Paspati (pp. 594–629), Miklosich (part iv.), Professor Friedrich Müller's *Beiträge zur Kenntniss der Rom-Sprache* (2 parts, Vienna, 1869–72), and Dr. Barbu Constantinescu's *Probe de Limba si Literatura Tiganilor din Romania* (Bucharest, 1878).

Everywhere Gipsies ply an endless variety of trades. In Egypt they monopolize the art of serpent-charming; in France and Spain they sit as professional models; in England we meet Gipsy Methodist preachers, actors, quack doctors, chimney-sweeps, carpenters, factory hands, etc. But everywhere the men have three principal callings—workers in metals, musicians, and horse-dealers; everywhere the women are "pleasaunt dauncers" as in the days of Andrew Boorde, and by peddling and fortune-telling contribute their share—often more than their share—to the family purse. Gipsies have long been famous as copper and iron smiths in south-eastern Europe, where their horseshoes are reckoned unrivalled. The *calderari* (coppersmiths) of Hungary and Transylvania at certain intervals make trading tours to Germany, France, England, Norway, and even Spain and Algeria. The workers in iron, on the other hand, seldom or never quit the land of their adoption, as neither naturally do the few remaining *aurari*, or Gipsy gold-washers of Transylvania. Simson describes a primitive Tinkler method of smelting iron, and the caves of Granada still echo to the clink of Gipsy anvils; but in England the surname *Petulengro*, "smith" (from *petul*, "horseshoe"), alone recalls the days when Gipsies surpassed the Gentile in the farrier's craft. Liszt, in his work *Des Bohémiens et de leur Musique en Hongrie* (Paris, 1859), ascribes to the Gipsies the creation of Hungary's national music. Bartalus (1868) contests the theory, but few would hesitate to admit its plausibility who at the Paris Exhibition (1878) or elsewhere have listened to the Gipsies' thrilling performance of a *czardas*, or are familiar with the undoubted compositions of Bihary, Csermak, and other Gipsy *maestri*. The Gipsy's favorite instrument is the violin, but few are the instruments he has not successfully essayed. The Eisteddfods of Wales have witnessed the triumphs of Gipsy harpists; and hundreds have been charmed by the concerts of the Roberts family, not knowing they were hearing a Gipsy band. "The Egyptians," as Krantzius dryly remarked in 1520, "frequently change their horses;" horse-dealing and horse-stealing are too often synonymous terms with them. Fortune-telling is on the wane with Gentiles' waning belief in the fortune-teller's powers. The Gipsy crone can no longer persuade the yeoman's wife to bury her treasure in the earth, and return in a fortnight's time to find it—gone. Those halcyon days of *maáuzin* are passed by; the servants' hall is now the only El Dorado left. Enclosure Acts have struck a deadly blow at English Gipsydom, driving the wanderers from breezy common and turf-edged lane to the smoky suburbs of great towns, or at best the outskirts of some watering place. Here, surrounded by Gentiles, the younger generation forget the wisdom of the Egyptians, relinquish time-honored customs, and, wedding with the sons and daughters of the land, widen the stream of Romani blood, and so diminish its "depth." Several accounts have been furnished of Romani marriages, but they rarely tally, and some (Bright's, Borrow's, and Simson's) do not bear quotation. On the Continent one common feature is the breaking by the chief of a flower-crowned pitcher, from whose fragments, as they are many or few, he argues the fortunes of the bridal pair. There are many curious Gipsy practices relating to death and burial, such as waking the corpse, burning the deceased's effects, the fasting of his kinsfolk, and a species of *tabu*. The earliest record of Gipsies burning the property of their dead occurs in the *Annual Register* for 1773, p. 142: "The clothes of the late Diana Boswell, queen of the Gipsies, value £50, were burnt in the Mint, Southwark, by her principal courtiers, according to ancient custom" (*cf.* Liebich, p. 55). Abstention from flesh or some other delicacy is not always a sign of mourning for the dead (*cf.* Crofton in *Papers of the Man. Lit. Club*, 1877); but its most interesting form is where a Gipsy wife or child for ever renounces the favorite delicacy of the dead husband or parent. Like motives prompt the dropping of the dead Gipsy's name entirely out of use, any survivors who happen to bear the same changing it to another. Much might be written of a kind of ceremonial purity prescribed by Gipsy law, and indicated in the language by the distinction between *chiklo*, "dirty," and *mokado*, "unclean." To wash a tablecloth with clothes is *mokado*, since it is connected with food; and a German Gipsy woman may not cook for four months after childbirth, while a vessel touched by the skirt of a woman's dress is held to be defiled. But with one other widespread practice we must take our leave of Gipsy customs, that, namely, of leaving at a cross-road a handful of grass or leaves, a heap of stones, a stick or some such mark (*patrin*, "leaf") to guide the stragglers of the band. See Liebich, p. 96, and Smart and Crofton, p. 199; and compare "Pola," in Sleeman's *Ramaseeana or a Vocabulary of the Thugs* (Calcutta, 1836).

Character.—The Gipsy character, strange medley of evil and of good, presents itself as black and hateful to the outside world, whilst to the Romani race it is all that is fair and lovable. "There's nothing worse than mumply Gentiles" is a saying often in Gipsy mouths, which affords a clue to much that is puzzling in the Gipsy's nature. He is at war with mankind, for centuries his oppressors, and, all being fair in war, may plunder and beguile at will, so that he be not caught. Gipsies' light-heartedness and courtesy are patent to all men; but only to true or adopted members of the tribe are their inmost hearts revealed. Their principal faults are childish vanity, professional cunning, indolence (caused by the absence of ambition), and a hot passionate temper. But they are as ready to forgive as they are quick to resent a wrong; and before implicit confidence their cunning gives place to inviolate honor, a fact borne strongly out by an incident in the *Life* of the actor Charles Mayne Young (p. 186, ed. 1871). Their family affection is intensely strong, prompting a parent never to chastise a younger child, a grown-up son meekly to take a thrashing from his father; and they are lavishly generous to such as are poorer than themselves, even though Gentiles. Their love of nature reveals itself in a hundred quaint, poetic phrases, in a familiarity with beasts and herbs; their love of dumb creatures in the number of their pets. Quick and versatile, all Gipsies readily adapt themselves to any state of life; they have so wonderful a gift of tongues that formerly it was reckoned against them for a proof of sorcery. That hitherto the race has produced, outside the realm of music, none but mute geniuses, is rather due to lack of education than of ability; but "Zingaro" seems to have only been a nickname of the Quentin Matsys of the South, Antonio Solario (1382–1455), and John Bunyan from parish registers does not appear to have had one drop of Gipsy blood (*cf. Notes and Queries*, 5th ser. vol. ii.).

Physique.—Outwardly as within Gipsies present strong contrasts, some being strangely hideous, others very beautiful, though not with a regular, conventional beauty. Finely proportioned, they are as a race of middle stature, but lithe and sinewy, insensible to cold or wet, capable of supporting great fatigue. They pride themselves on their small hands and feet; corpulence rarely occurs, and only with the older women. The hair, black or dark brown, inclines to coarseness, is often frizzled, and does not soon turn gray; the complexion, a tawny olive, was compared by the Plymouth Pilgrims (1622) to that of the Indians of North America. The teeth are of dazzling whiteness and perfect regularity, the cheekbones high; and the aquiline nose is overhung by a strongly-marked brow, knit often in deep lines of thought. But the most striking feature is the full, dark eye, now lustreless, then changing to an expression of mysterious, childlike sorrow, presently blazing forth with sudden passion. As is the case in other Oriental races, the Gipsies early develop and early fade. See, in the *Archiv für Anthropologie* (1872), M. Isidor Kopernicki's learned and exhaustive treatise on Gipsy craniology.

Theories as to Origin.—Several attempts have been made to identify Gipsies with nomad Indian tribes: Grellmann, for example, discovers them in the Sūdras, Richardson in the Nāts (*Asiatic Researches*, vol. vii. 1784), Leland in the Doms, and B. R. Mitra in the Bediyás (*Memoirs of London Anthrop. Soc.*, vol. iii. 1870). These theories, however, need not detain us long; they rest merely on analogies, real or imagined, between the manners of Gipsies and such Indian vagrants, and not on the evidence of language. Nor, were it even shown that any or all of these pariahs speak Romani among themselves, would such a discovery throw of necessity much light on the origin of our European Gipsies; it might simply prove that India has its Gipsy tribes. It is otherwise with the identification of Gipsies with the Jats, who in the Punjab alone numbered (1871) 1,309,399,—a theory started by Pott, elaborated by Bataillard, and supported by Newbold, Sir H. Rawlinson (*Proceedings of the Geogr. Soc.*, vol. i., 1857), Professor de Goeje (*Bijdrage tot de Geschiedenis der Zigeuners*, Amst., 1875), Captain Burton (*Academy*, March 27, 1875), and a writer in the *Edinburgh Review* (July, 1878). About 420 A.D., says Firdousi (*circa* 1000), the Persian monarch Behram Gur imported 10,000 minstrels from India, assigning them lands and cattle. But they, wasting their substance, angered the king, who bade them take their instruments, and roaming through the land procure by their songs a livelihood, "wherefore the *Lûri* now wander about the world." Hamza, the Arab historian of Ispahan (*c.* 940), had already told how Behram dispersed through the cities of his realm 12,000 Indian musicians, "whose descendants are known as *Zuth*;" and of three writers who repeat the tale Mirkhond (15th century) calls the musicians *Djatt.* Thus *Lûri* (mod. Pers. "Gipsy") appears to be synonymous with *Zuth* or *Jat*, the name on the one hand of Damascus Gipsies (?), on the other of an agricultural and cattle breeding race inhabiting the valley of the Indus. Neither are records lacking of westward migrations of Jats from the Indus, as in 714 to Mopsuestia and Antioch, while in 810 we hear of them in the Tigris valley, in 834 in the marshes of Khuzistan, in 855 in the territory of the Byzantine empire (Goeje). Jat theorists differ as to the date of the great migration that gave Europe its Gipsies, the *Edinburgh Review* writer placing it at 1025, while Sir Henry Rawlinson regards our Gipsies as lineal descendants of Firdousi's Lûri. These writers, however, all agree in making the Gipsies Jats; but none have essayed the necessary comparison of Romani and Játakí (the idiom of the living Indian Jats), though Captain Burton himself has published a grammar of the latter in the *Journal of the Bombay Asiatic Society* (Bombay, 1849). We have seen that the dialect of the Turkish Gipsies has remained unchanged for near five centuries, and the Jats are said to "preserve their vernacular tongue wherever they go." Supposing Gipsies then to have broken off from the main Jat stem so late as the eleventh, or even as early as the fifth century A. D., we should look for a striking resemblance between Játakí and Romani. Compare, however, with the foregoing paradigms the following from Burton's grammar:—SING. nom. *ghorá*, "a horse;" gen. *ghore-dá;* dat. *ghore-nún;* acc. *ghorá;* abl. *ghore-te* or *-ton*, "from a horse;" PLUR. nom. *ghore;* gen. *ghorián* or *ghoren-dá;* dat. *ghorián nún*, etc. The Játakí third personal pronoun, again, runs:—SING. nom. *uha*, "he;" gen. *usadá;* dat. and acc. *usnún;* abl. *uste;* PLUR. nom. *uhe;* gen. *uhindá*, etc.: its verbal formation is almost equally unlike the Romani. In the face of the great unlikeness of Romani and Játakí one may well concur with Bataillard in the rejection of this theory, and proceed to consider the later views of that writer as advanced in *Les Origines des Tsiganes* (Par. 1875), *Les Tsiganes de l'Age du Bronze* (Par. 1876), and *État de la question de l'ancienneté des Tsiganes en Europe* (Par. 1877). He now believes the Gipsies to have existed in Europe from immemorial times,—a conclusion to which he is led by the absence of any record of their passage across the Bosphorus, by their enslaved condition in Wallachia in the 14th century, by the casual notices cited above of their presence at a still earlier date, and by their present monopoly of metallurgical arts in South-Eastern Europe. These mainly negative proofs lose some of their force when we remark that neither is any record known to exist of the passage of Gipsies to England, Scotland, or America; and that at Corfu in 1346 (*i. e.*, in historic times) we read of Gipsies being reduced to vassalage. Assuredly it is a mighty leap from the Athingani of the 9th century A. D. to the Sigynnæ of Herodotus (v. 9), whom Bataillard claims for the ancestors of the Gipsy race. The strength, however, of the theory lies less in attempted identifications than in its explanation of the unsolved problem, What was the race that carried bronze to Northern and Western Europe? Referring for a general survey of the question to the article ARCHÆOLOGY, to E. Chantre's *Age de Bronze* (4 vols., Paris, 1877), and to Lubbock's *Prehistoric Times* (2d ed., London, 1869), we extract from the last-named work the following passages:—"The absence of implements made either of copper or tin seems to indicate that the art of making bronze was introduced into Europe, [a view confirmed by the fact that] wherever we find the bronze swords or celts they are the same, not similar in character, but identical. . . . The discovery of moulds proves that the art of casting in bronze was known and practised in many countries. Hence it appears most probable that the knowledge of metal is one of those great discoveries which Europe owes to the East. . . . The implements of bronze appear to have belonged to a race with smaller hands than those of the present European nation. . . . As regards the smallness of the hands, we must remember that Hindus share this peculiarity with Egyptians. . . . The Phœnicians were well acquainted with the use of iron. . . . We have still very much to learn in regard to the race by whom the knowledge of metal was introduced into our continent." Each passage suggests or is explained by the supposition that this was no other than the small-handed and eastern Gipsy race. The Calderari work exclusively in copper, never in iron; no Gipsy bronze-smith would have spoilt his trade by introducing iron. Traces might perhaps yet be found in Norway of the workings of a band of Calderari, who visited that country in 1874; and certainly the utensils they wrought in France were exactly similar to those that they wrought in Norway. Bataillard's theory is strengthened by the fact that so high an authority as M. de Mortillet—who is followed by Chantre and Burnouf—had been independently led to a like conclusion in 1874. Its strongest confirmation, however, is the important discovery of Dr. Kopernicki that in Eastern Galicia there survive to the present day certain *Zlotars* (Ruth. "goldsmiths"), Gipsy workers in bronze, whose processes Bataillard minutely describes in *Les Zlotars* (Paris, 1878). Difficulties there are in accepting the theory:—the unsettled question of the antiquity of the Romani tongue; the yawning chasm of a thousand years; above all, the unnoticed fact that nearly all the metallurgical terms of Romani seem to be borrowed from Greek—*kalái*, "tin" (καλαίον); *khárkoma*, "copper" (χάλκωμα); *molív*, "lead" (μολύβιον); *kakkarí*, "kettle" (κακκάβη); *amuní*, "anvil" (ἀμόνι); *rin*, "file" (ῥινί); *sirrí*, "hammer" (σφυρί); *ksilávi*, "pincers" (ξυλάβιον); *karfín*, "nail" (καρφί); *klidí*, "key" (κλειδί); *gampána*, "bell" (καμπάνα); and *pétalo*, "horseshoe" (πέταλον). This looks like an insuperable objection, since certainly no Calderari of to-day would borrow from French or German the names for these the most familiar objects of his long-practised calling; and unless Bataillard be prepared to maintain that Greek took the terms from Romani, not *vice versa*, his theory falls.

Bibliography.—The literature on the Gipsies is richer in appearance than in reality. Miklosich (i. 54–59) and Bataillard (*Les derniers Travaux relatifs aux Bohémiens*, Paris, 1872) give the titles of 118 works, a number which might be largely increased. But many of these "works" are articles hidden away in periodicals, as "The English Gipsies," by the Rev. S. James, in *The Church of England Magazine*, 1875; many are mere *rechauffés* of earlier publications. Imperfect though it be, Grellmann's *Historischer Versuch über die Zigeuner* (1783; 2d and enlarged ed., Gött., 1787; Eng. translation by M. Raper, 1787) remains the only attempt at a full history of the Gipsy race; its grave deficiencies are best supplied by Sprengler's *Dissertatio historica-juridica de Cinganis sive Zigeunis* (Leyden, 1839), by Hopf's *Einwanderung der Zigeuner in Europa* (Gotha, 1870), by the historical portions of Miklosich's work, and above all by Bataillard's *De l'Apparition et de la Dispersion des Bohémiens en Europe* (Paris, 1844), *Nouvelles Recherches* (Paris, 1849), and *État de la Question*, etc. (Paris, 1877). On the language viewed as a whole the chief authorities are—*Die Zigeuner in Europa und Asien* (2 vols., Hallè, 1844–45), by A. F. Pott; *Zigeunerisches* (Halle, 1865), by G. H. Ascoli; and *Ueber die Mundarten und die Wanderungen der Zigeuner Europa's* (8 parts, Vienna, 1872–78), and *Beiträge zur Kenntniss der Zigeunermundarten* (4 parts, Vienna, 1874–78), by F. von Miklosich. From works on the Gipsies of different European lands the following may be given as a selection (the more important being marked with an asterisk):—for Turkey, **Études sur les Tchinghianés* (Constan., 1870), by A. G. Paspati; for Roumania, the unsatisfactory *Grammaire, Dialogues, et Vocabulaire de la Langue des Cigains* (Paris, 1868), by J. A. Vaillant; for Hungary, *A' czigány nyelv elemei* (Pesth, 1853), by J. Bornemisza; for Bohemia, **Románi Czib* (Prague, 1821), by A. J. Puchmayer; for Germany, **Die Zigeuner in ihrem Wesen und ihrer Sprache* (Leipsic, 1863), by R. Liebich; for Poland, *Rys historiczny ludu cygánskiego* (Wilna, 1830), by T. Narbutt; for Russia, *Ueber die Sprache der Zigeuner in Russland* (St. Pet., 1853), by O. Böhtlingk; for Norway, *Beretning am Fante- eller Landstrygerfolket i Norge* (5 parts, Christian., 1850–65), by E. Sundt; for Denmark, *Tatere og Natmandsfolk i Danmark* (Copenh., 1872), by F. Dyrlund; for England, **The English Gipsies and their Language* (London, 1873), by C. G. Leland, *Romano Lavo-Lil: Word-book of the English Gipsy Language* (1874), by G. Borrow, and **The Dialect of the English Gipsies* (1875), by B. Smart and H. T. Crofton; for Scotland, *A History of the Gipsies* (London, 1865), by W. Simson; for Italy, *Zigeunerisches* (Halle, 1865), by Ascoli; for the Basque Country, *Vocabulaire de la Langue des Bohémiens habitant les Pays Basques Français* (Bord., 1862); for Spain, *The Zincali* (2 vols., Lond., 1841; new ed. 1873), by Borrow. From works on non-European Gipsies selection is unnecessary, since their sum total is as follows:—"Ueber die Sprache der Zigeuner in Syrien," by

Pott, in *Zeitschrift für die Wissenschaft der Sprache* (Berlin, 1846); *Reisen durch Syrien, Palästina*, etc. (Berlin, 1854), by U. J. Seetzen, containing a Syro-Romani vocabulary; * "The Gipsies of Egypt," in the *Journ. of the Roy. Asiatic Soc.* (Lond., 1856), by Captain Newbold, comprehending vocabularies from Egypt, Syria, and Persia; "Die Zigeuner in Ægypten," in *Petermann's Mittheilungen* (Gotha, 1862), by A. von Kremer; *Notes et Questions sur les Bohémiens en Algerie* (Paris, 1874), by P. Bataillard; and *Travels in the East* (Lond., 1823), by Sir W. Ouseley, vol. iii. of which gives a Karáchi vocabulary. To these may be added the specimens of the Gipsy dialects of Asia Minor, furnished by Paspati, and vocabularies from Armenia and Siberia in Miklosich's *Beiträge* (iv. pp. 38–41).

F. H. G.

Giraffe.

GIRAFFE (*Camelopardalis giraffa*), a mammal belonging to the ruminant group of the Artiodactyle Ungulates, and the single living representative of the family *Camelopardalidæ*. Intermediate between the members of the deer and ox families, the giraffe differs from both in having neither true horns nor antlers. It possesses however two solid, bony, and persistent appendages, attached partly to the frontal and partly to the parietal bones; and not to the former only as in the true horned ruminants, and these, unlike the processes of the latter, are distinct bones, separable, at least in the young animal, from those of the forehead. These horn-like peduncles are completely covered over by the skin of the forehead, and are terminated by a tuft of bristles, while in front of them there is a protuberance caused by a thickening of the bone, sufficiently prominent in the male to have been frequently described as a third horn. The giraffe is the tallest of existing animals, measuring usually from 15 to 16 feet high—the females being somewhat less—but attaining in the largest examples a height of 18 feet. This exceptional elevation is chiefly due to its great length of neck and limb, the cervical vertebræ, although only seven in number as in other mammals, being in this case exceedingly long. Its body is proportionately short, measuring only 7 feet between the breast and rump, and slants rapidly towards the tail—a peculiarity which has given rise to the erroneous impression that the fore legs of the giraffe are longer than the pair behind. Its feet terminate in a divided hoof, which, says Sir Samuel Butler, "is as beautifully proportioned as that of the smallest gazelle;" and the accessory hoofs found in most ruminants are entirely awanting. Its head is small, its eyes large and lustrous; and these, which give to the giraffe its peculiarly gentle appearance, are capable of a certain degree of lateral projection, which enable the creature without turning its head to see around and to a certain extent behind it. The elevated eyes of the giraffe thus enjoy a wider range of vision than those of any other quadruped. Its nostrils are provided with a peculiar mechanism of sphincter muscles, by which they can be opened or closed at will, and the animal is thus enabled to avoid the injurious effects of the sand storms which occasionally pass over its native haunts. Its tongue is remarkable for its great length, measuring about 17 inches in the dead animal, and for its great elasticity and power of muscular contraction while living. It is covered with numerous large *papillæ*, and forms, like the trunk of the elephant, an admirable organ for the examination and prehension of its food. The graceful appearance presented by the giraffe, to which it owes its name through the Arabian *Xirapha*, is greatly heightened by the orange-red color of its hide, mottled as it is all over with darker spots; while in its long tail, ending in a luxurious tuft of dark-colored hair, it possesses an admirable fly-whipper, without which it would probably be impossible for the giraffe to maintain its ground against the seroot fly and other stinging insects of central Africa. It lives on open plains in the neighborhood of low woods, high forest being scrupulously avoided, as depriving it of the extensive prospect which forms its chief defence against the attacks of its two great enemies—the lion and man. It feeds almost exclusively on the foliage of trees, showing a preference for certain varieties of mimosa, and for the young shoots of the prickly acacia, for browsing on which the prehensile tongue and large free lips of the giraffe are specially adapted. It is gregarious in its habits, living in small herds rarely of more than twenty individuals, although Sir S. Baker, who hunted it in Abyssinia, states that he has seen as many as a hundred thus herding together.

There is probably no animal more difficult of approach than the giraffe, owing to that exceeding wariness which prompts it to place sentinels to give the herd timely warning of approaching danger, as well as to its ability, from the elevated position of its eyes, and the openness of the ground it frequents, to see danger, and from its keenness of scent to smell it from afar. It is a fleet though by no means graceful runner, its awkward, shambling gait being due to its moving the fore and hind legs of the same side simultaneously. In hunting it on horseback the rule to be observed, according to the traveller already mentioned, is to press the giraffe the instant he starts; "it is the speed that tells upon him, and the spurs must be at work at the very commencement of the hunt, and the horse pressed along at his best pace; it must be a race at top speed from the very start, but should the giraffe be allowed the slightest advantage for the first five minutes the race will be against the horse." In pursuing it thus on horseback the experienced hunter avoids too close an approach to the creature's heels, a blow from which he has probably learnt to regard, with Dr. Livingstone, as leaving little to choose between it and "a clap from the arm of a windmill." Although trusting for safety to flight, it will, when brought to bay, even turn upon the lion; and not seldom does it defend itself successfully against his attacks by the vigorous blows of its powerful limbs. It is, however, powerless against the "king of beasts" when taken unawares, and with this object the latter lies in wait by the banks of streams, and springs upon the giraffe as it seeks to quench its thirst. In captivity it is said to make use of its skin-covered horns as weapons of defence, giving impetus to the blow, not by depressing and then elevating the head, as in the butting of an ox or sheep, but by a sidelong swing of its muscular neck. The skin of the giraffe is in many parts so thick that the bullet of the hunter often fails to pierce it, the surest method of hunting it being that pursued by the Hamran Arabs of Abyssinia, who run it down, and when galloping at full speed cut the tendons of its legs, or "hamstring" it, as this operation is called, with their broadswords, and thus completely disable it.

The giraffe is only found wild in Africa, where it ranges throughout the open country of Ethiopia as far south as the confines of Cape Colony. Until about fifty years ago it was almost totally unknown in Europe; it is now, however, to be found in most of the European zoological gardens, where it appears to thrive as well on corn and hay as on the mimosas of its native haunts. It also breeds freely in confinement, so that it may now be regarded as acclimatized in Europe. The giraffe family was more largely represented and enjoyed a wider distribution during the Miocene period, fossil remains of extinct species having been found in Greece and the Siwalik Hills; while an allied genus, *Helladotherium*, with less neck and more body than the existing giraffe, extended during the same period from the south of France to north-west India.

The skin of the giraffe forms a valuable leather material, that made from the thicker parts being in special request for sandals; its flesh, according to Sir S. Baker, was, when roasted, the best he had ever tasted; the tendons of its long legs are valued by the Arabs as thread for sewing leather, and as strings for their musical instruments; while its leg bones, which differ from those of other ruminants in being solid, are largely used in England in the manufacture of buttons and other articles of bone.

GIRALDI, Giglio Gregorio (1479–1552), or Lilius Gregorius Gyraldus, one of the scholars and poets of the golden age of Italian literature, was born June 14, 1479, at Ferrara, where he early distinguished himself by his talents and acquirements. On the completion of his literary course he removed to Naples, where he lived on familiar terms with Pontano and Sannazaro; and subsequently to Lombardy, where he enjoyed the favor of the Mirandola family. At Milan in 1507 he studied Greek under Chalcondylas; and shortly afterwards, at Modena, he became tutor to Ercole (afterwards Cardinal) Rangone. About the year 1514 he removed to Rome, where, under Clement VII., he held the office of apostolic protonotary; but having in the sack of that city (1527), which almost coincided with the death of Cardinal Rangone his most powerful patron, lost all his property, he returned in poverty once more to Mirandola, whence again he was driven by the troubles consequent on the assassination of the reigning prince in 1533. The rest of his life was one long struggle with ill health, poverty, and neglect; and he is alluded to with sorrowful regret by Montaigne in one of his *Essais* (i. 34), as having, like Sebastian Castalio, ended his days in utter destitution. He died at Ferrara in February, 1552; and his epitaph makes touching and graceful allusion to the sadness of his end. Giraldi was a man of very extensive erudition; and numerous testimonies to his profundity and accuracy have been given both by contemporary and by later scholars. His *Historia de Diis Gentium* marked a distinctly forward step in the systematic study of classical mythology; and by his treatises *De Annis et Mensibus*, and on the *Calendarium Romanum et Græcum*, he contributed to bring about the reform of the calendar, which was ultimately effected by Pope Gregory XIII. His *Progymnasma adversus Literas et Literatos* deserves mention at least among the curiosities of literature; and among his other works to which reference is still occasionally made are *Historiæ Poetarum Græcorum ac Latinorum; De Poetis suorum temporum;* and *De Sepultura ac vario sepeliendi ritu.* Giraldi was also an elegant Latin poet. His *Opera Omnia* were published at Leyden in 1696.

GIRALDI, Giovanni Battista (1504–1573), surnamed Cynthius, Cinthio, or Cintio, Italian novelist and poet, born at Ferrara in November, 1504, was educated at the university of his native town, where in 1525 he became professor of natural philosophy, and where, twelve years afterwards, he succeeded Celio Calcagnini in the chair of belles-lettres. Between 1542 and 1560 he acted as private secretary, first to Ercole II. and afterwards to Alphonso II. of Este; but having, in connection with a literary quarrel in which he had got involved, lost the favor of his patron in the latter year, he removed to Mondovi, where he remained as a teacher of literature till 1568. Subsequently, on the invitation of the senate of Milan, he occupied the chair of rhetoric at Pavia till 1573, when, in search of health, he returned to his native town, where on the 30th of December he died. Besides an epic entitled *Ercole* (1557), in twenty-six cantos, Giraldi wrote nine tragedies, the best known of which, *Orbecche*, was produced in 1541. The sanguinary and disgusting character of the plot of this play, and the general poverty of its style, are, in the opinion of many of its critics, almost fully redeemed by occasional bursts of genuine and impassioned poetry; of one scene in the third act in particular it has even been affirmed that, if it alone were sufficient to decide the question, the *Orbecche* would be the finest play in the world. Of the prose works of Giraldi the most important is the *Hecatommithi* or *Ecatomiti*, a collection of tales told somewhat after the manner of Boccaccio, but still more closely resembling the novels of Giraldi's contemporary, Bandello, only much inferior in workmanship to the productions of either author in vigor, liveliness and local color. Something, but not much, however, may be said in favor of their professed claim to represent a higher standard of morality. Originally published at Monteregale, Sicily, in 1565, they were frequently reprinted in Italy, while a French translation by Chappuys appeared in 1583, and one in Spanish in 1590. They have a peculiar interest to students of English literature, as having furnished, whether directly or indirectly, the plots of *Measure for Measure* and *Othello*. That of the latter, which is to be found in the *Hecatommithi* (iii. 7), is conjectured to have reached Shakespeare through the French translation; while that of the former (*Hecat.*, viii. 5) is probably to be traced to Wheatstone's *Promos and Cassandra* (1578), an adaptation of Cinthio's story, and to his *Heptamerone* (1582), which contains a direct English translation. To Giraldi also must be attributed the plot of Beaumont and Fletcher's *Custom of the Country*.

GIRALDUS CAMBRENSIS. See Barri.

GIRARD, Philippe Henri de (1775–1845), a celebrated French mechanician, was born at Lourmarin, in the department of Vaucluse, 1st Febuary, 1775. In his early life he manifested a strong aptitude for mechanical invention, and he also at that time devoted his attention to botany, painting, and literature. When at the Revolution his family took refuge in Italy he supported himself there for some time by painting, but afterwards, at the age of eighteen, he established a soap manufactory at Leghorn. Returning to France after the fall of Robespierre, he began to conduct a chemical work at Marseilles, but soon afterwards judged it prudent to go to Nice, where he obtained the professorship of chemistry and of natural history. Returning to Marseilles about 1800, he afterwards went to Paris, where, in company with his brother Frederick, he established a soap manufactory. In 1804 he and his brother took out a patent for what is known as the fountain lamp; and at the "Exposition" of 1806 he was awarded a gold medal for his one-cylindered direct acting steam engine. Napoleon having in 1810 decreed a reward of one million francs to whoever should invent a machine for the spinning of flax, equally successful with those in use for the spinning of hemp, Girard, after a course of experiments, invented and patented a flax-spinning machine. In 1813 he established a flax mill at Paris and another at Charonne, in both of which he made use of his machine; but although he was declared to have earned the reward offered for the invention the fall of Napoleon in 1815 left the decree unfulfilled. Girard, who expected that the expenses connected with his experiments would be met by the promised premium, now got into serious money difficulties, and had to leave France for Austria, where, besides establishing a flax mill at Hirtenberg, he built the first line of steam ships on the Danube. In 1825, at the invitation of the emperor Alexander I. of Russia, he went to Poland, where he erected a flax manufactory, round which grew up a village which received the name of Girardow. He was also appointed chief engineer of the mines of Poland. In 1844 he returned to Paris, and exhibited at the Exposition a large number of inventions, including a machine for combing flax, a machine for making gunlocks, several new improvements in guns, a piano of double octaves, and a new instrument called the *Tremolophone*. For his inventions connected with the manufacture of flax a gold medal was decreed to him by the jury; and in 1845 the Society of Inventions awarded him a sum which raised the pension he received from the Russian Government to 6000 francs. Besides the inventions already mentioned, Girard was the author of a large number of others, many of them of considerable importance in connection with various departments of industrial machinery. He died at Paris, August 26, 1845. A pension of 6000 francs was bestowed in 1857 on his only surviving brother, and another on his niece.

GIRARD, Stephen (1750–1831), American philanthropist, was born at Bordeaux on 21st May, 1750. At the age of thirteen he commenced life as a sailor, and followed his avocation with such assiduity that he was enabled, before the French requisitions of age and service allowed, to become master and captain, in October, 1773. His first mercantile venture was to San Domingo in February, 1774, whence he proceeded in July to the then colony of New York. After trading for three years between New York, New Orleans, and Port au Prince, he went to Philadelphia in May, 1777, and gave up the sea for a mercantile career. While he was engaged most successfully in the prosecution of an extensive trade, the yellow fever in its most malignant type broke out in Philadelphia, sweeping away one-sixth of its population. When, during its height, a hospital was established, for which it seemed almost impossible to secure competent management, Girard devoted himself personally, fearless of all risks, to the care of the sick and the burial of the dead, not only in the hospital, of which he became manager, but throughout the city, supplying the poorer sufferers with money and provisions. Two hundred children, made orphans by the ravages of the fever, were in a great measure thrown upon his care. From this period his success commercially and financially was unexampled. He gave a portion of his time to the management of municipal affairs for several years, and rendered efficient service as warden of the port and as director of many public institutions. On the dissolution of the Bank of the United States he instituted what is known now as the Girard Bank. During the war of 1812 " he rendered valuable services to the Government by placing at its disposal the resources of his bank at a time of difficulty and embarrassment, subscribing to a large loan which the Government had vainly sought to obtain." Girard added to his other avocations that of a practical agriculturist. He died December 26, 1831.

Girard College was founded by him for the education and support of the poor white orphans of his adopted city. His fortune amounted to about seven and a half millions of dollars. After specific legacies of two millions for the erection and endowment of the college, $140,000 to his relatives, $300,000 to the State for internal improvements, $500,000 to the city of Philadelphia to improve its eastern front, $116,000 to public charities, and various annuities and legacies, he bequeathed the residue of his estate to the city of Philadelphia, mainly for the improvement and maintenance of the college. The most minute directions were given by Girard in regard to the buildings to be erected, and the admission and management of the inmates. He specifically requires that the orphans be instructed in the purest principles of morality, so that on their entrance into active life they may evince benevolence towards their fellow creatures, and a love for truth, sobriety, and industry. As for religious belief, they are left to adopt such tenets as their matured reason may lead them to prefer; and to secure this he interdicts the employment, and even the admission into the grounds, of any ecclesiastic whatever.

GIRARDIN, Madame Émile de, a French authoress, was born at Aix-la-Chapelle, January 26, 1804, and died at Paris June 29, 1855. Her maiden name was Delphine Gay, and her mother, the well-known Madame Sophie Gay, brought her up in the midst of that brilliant literary society of which she was afterwards a conspicuous ornament. In 1822 she obtained peculiarly honorable mention from the Academy for a poem on the *Devotion of the Sisters of Sainte Camille at the Siege of Barcelona;* and not long after she published two volumes of miscellaneous pieces, *Essais poétiques* (1824) and *Nouveaux essais poétiques* (1825). A visit to Italy in 1827, during which she was enthusiastically welcomed by the literati of Rome and even crowned in the capitol, was productive of various poems, of which the most ambitious was *Napoline* (1833). Her marriage in 1831 to M. Émile Girardin opened up a new literary career. The contemporary sketches which she contributed from 1836 to 1839 to the feuilleton of *La Presse*, under the *nom de plume* of Charles Delaunay, were collected under the title of *Lettres Parisiennes* (1843), and obtained a success which has proved as permanent as it was brilliant. But it was to more elaborate efforts that the authoress would have preferred to entrust her reputation, and she indeed confesses, in a half serious half mocking mood, that it was almost a disappointment to find herself famous for so slight a thing. To the close of her life she continued to appear both as a novelist and as a writer for the stage, and in both departments she reaped a wide popularity through the wit and emotional force of her productions. *Contes d'une vieille fille à ses neveux* (1832), *La canne de Monsieur de Balzac* (1836), and *Il ne faut pas jouer avec la douleur* (1853) are among the best known of her romances; and her dramatic pieces include *L'École des journalistes* (1840), *Judith* (1843), *Cléopatre* (1847), *C'est la faute du mari* (1851), *Lady Tartufe* (1853), *La joie fait puer* (1854), *Le chapeau d'un horloger* (1854), and *Une femme qui déteste son mari*, which did not appear till after the author's death. In the literary society of her time Madame Girardin exercised no small personal influence, and among the frequenters of her drawing-room were Gautier and Balzac, Alfred de Musset and Victor Hugo. During the latter years of her life a pensive melancholy gathered round her; for long years she had prayed the prayer of Hannah, and her woman's heart had not been comforted. Her collected works were published in six volumes, 1860–1861.

See Sainte-Beuve, *Causeries du lundi*, t. iii.; G. D. Molenès, "Les femmes poètes," in *Revue des Deux Mondes*, July, 1842; Taxile Delord, *Les Matinées littéraires*, 1860; *L'esprit de Madame Girardin, avec une préface par M. Lamartine*, 1862; G. d'Heilly, *Madame de Girardin, sa vie et ses œuvres*, 1868.

GIRARDIN, Saint-Marc (1801–1873), a politician and man of letters whose real name was Marc Girardin simply, was born at Paris in 1801, and died at Morsang-sur-Seine on the 11th of April, 1873. His school career at the Lycée Henri IV. was a distinguished one, and he afterwards took university honors both in literature and law, but he never practised at the bar. During the reign of Charles X. he obtained several Academy prizes, and a mastership at the Lycée Louis le Grand, though his liberal principles stood a little in his way. In 1828 he began to contribute to the *Journal des Débats*, on the staff of which he remained for nearly half a century. At the accession of Louis Philippe he was appointed professor of history at the Sorbonne and master of requests. Soon afterwards he exchanged his chair of history for one of literature, continuing to contribute political articles to the *Débats*, and sitting as deputy in the chamber from 1835 to 1848. As a professor he directed his efforts chiefly against the clerical reaction. In 1844 he was elected a member of the Academy. During the revolution of February, 1848, Girardin was for a moment a minister, but after the establishment of the republic he was not re-elected deputy, nor did he take any prominent part in politics during the second empire save with his pen. In the capacity of journalist he continued to be active, and interested himself not merely in moderate opposition to the Government at home but also in foreign politics, especially in the affairs of Syria, Greece, and Turkey. After the war of 1870 he was returned to the Bordeaux assembly by his old department—the Haute Vienne. His Orleanist tendencies and his objections to the republic were strong, and though he at first supported Thiers, he afterwards became a leader of the opposition to the president. He died, however, before Thiers was actually driven from power. Saint-Marc Girardin was one of the most distinguished of the many writers whose political and literary activities combined have raised them to distinction in France during this century, but to whom there cannot be assigned the highest rank either as politicians or as littérateurs. His political claims were not above those of a vigorous and intelligent journalist. His professorial lectures were popular and well attended; his literary knowledge was wide, and included German and Italian; his criticisms, on which his claims as a man of letters rest, were acute and well expressed, but not remarkable for great subtlety or novelty of thought or style.

His chief work is his *Cours de littérature dramatique* (1843–1863), a series of lectures the delivery and publication of which lasted for over twenty years. This work has for second title *De l'Usage des Passions dans le Drame*, which describes it more accurately. The author goes through the list of the various passions, and of the chief situations which call them out, discussing at the same time the mode in which they are treated in the most celebrated dramas of ancient and modern times. The source of these illustrations is not indeed limited to drama, and the lecturer takes a wide range over the fields of poetry and romance. The result was doubtless as a course of lectures interesting and stimulating; as a book it is somewhat desultory. Among his other works may be noticed *Essais de Littérature* (1844, 2 vols.), made up chiefly of contributions to the *Débats*, his

Notices sur l'Allemagne (1834), and many volumes of collected *Souvenirs*, *Reflexions*, etc., on foreign countries and passing events. His latest works of literary importance were *La Fontaine et les Fabulistes* (1867) and an *Étude sur J. J. Rousseau* (1870) which had appeared in the *Revue des Deux Mondes*.

GIRARDON, FRANÇOIS (1628–1715), a sculptor whose works are typically characteristic of the epoch of Louis XIV., was born at Troyes in 1628, and died in the Louvre in 1715. As a boy he had for master a joiner and wood-carver of his native town, Baudesson by name (*Arch. de l'Art Français*, v. 4), under whom he is said to have worked at the château of Liébault, where he attracted the notice of Chancellor Séguier. By the chancellor's influence Girardon was first removed to Paris and placed in the studio of François Anguier, and afterwards sent to Rome. In 1650 he returned to France, and seems at once to have addressed himself with something like ignoble subserviency to the task of conciliating Le Brun, who owed his start in life to the same patron. Girardon is reported to have declared himself incapable of composing a group, whether with truth or from motives of policy it is impossible to say. This much is certain, that a very large proportion of his work was carried out from designs by Le Brun, and shows the merits and defects of Le Brun's manner—a great command of ceremonial pomp in presenting his subject, coupled with a large treatment of forms which if it were more expressive might be imposing. The court which Girardon paid to the "premier peintre du roi" was rewarded. An immense quantity of work at Versailles was entrusted to him, and in recognition of the successful execution of four figures for the Bains d'Apollon, Le Brun induced the king to present his protegé personally with a purse of 300 louis, as a distinguishing mark of royal favor. In 1650 Girardon was made member of the Academy, in 1659 professor, in 1674 "adjoint au recteur," and finally in 1695 chancellor. Five years before (1690), on the death of Le Brun, he had also been appointed "inspecteur général des ouvrages de sculpture"—a place of power and profit. In 1699 he completed the bronze equestrian statue of Louis XIV., erected by the town of Paris on the Place Louis le Grand. This statue was melted down during the Revolution, and is known to us only by a small bronze model (Louvre) finished by Girardon himself. His Tomb of Richelieu (church of the Sorbonne) was saved from destruction by M. Alexandre Lenoir, who received a bayonet thrust in protecting the head of the cardinal from mutilation. It is a capital example of Girardon's work; but amongst other important specimens yet remaining may also be cited the Tomb of Louvois (St. Eustache), that of Bignon (St. Nicolas du Chardonneret), and decorative sculptures in the Galerie d'Apollon and Chambre du roi, in the Louvre. Although chiefly occupied at Paris, Girardon never forgot his native Troyes. In the Hôtel de Ville is still shown a medallion of Louis XIV., and in the church of St. Rémy a bronze crucifix of some importance,—both works by his hand. In 1850 M. Corrard de Breban, who has given much time to researches concerning artists native to the town of Troyes, published a *Notice sur la vie et les œuvres de Girardon*.

GIRDLE, a band of leather or other material worn round the waist, either to confine the loose and flowing outer robes so as to allow freedom of movement, or to fasten and support the garments of the wearer. In southern Europe and in all Eastern countries the girdle was and still is an important article of dress. Among the Romans it was used to confine the *tunica;* and so general was the custom that the want of a girdle was regarded as strongly presumptive of idle and dissolute propensities. It also formed a part of the dress of the Greek and Roman soldier; the phrase *cingulum deponere*, to lay aside the girdle, was as equivalent to quitting the service. It was used as now in the East to carry money in; hence *zonam perdere*, to lose one's purse.

Girdles and girdle-buckles are not found in early Celtic interments, nor are they frequent in Gallo-Roman graves. But in Frankish and Burgundian graves they are almost constantly present, often ornamented with plaques of bronze or silver, and the clasps and mountings chased or inlaid with various ornamental designs, occasionally including figures of the cross, and rude representations of Scripture subjects. In later times girdles are frequently represented on brasses and monumental effigies from the 12th to the 16th century. They were either of leather or of woven materials, often of silk and adorned with gold and gems. The mode in which they were worn is shown on the effigies; usually fastened by a buckle in front, the long free end of the girdle was passed up underneath and then down over the cincture, and through the loop thus formed the ornamented end hung down in front. Among the sumptuary regulations of Edward III. there were prohibitions against wearing girdles of gold and silver unless the wearer were of knightly rank or worth £200 a year. Similar regulations against extravagance in girdles are occasionally found to the 16th century. The brasses of the 15th century present many beautiful examples of ladies' girdles, which were often worn like that of the knight with the ornamental end hanging down in front, sometimes with both ends depending from a large clasp or ornamental fastening in the centre. Allusions to the girdle are common in the poetry of the 16th and 17th centuries. The purse, the dagger, the rosary, the pen and inkhorn and the bunch of keys were carried suspended from it, and hence it was an ancient custom for bankrupts or insolvent persons to put off and surrender their girdles in open court. It is recorded that the widow of Philip I., duke of Burgundy, renounced her right of succession by putting off her girdle upon the duke's tomb. The girdle, which was a very important element in the dress of the Levitical priesthood, does not appear as an ecclesiastical vestment in the Christian Church until the 8th century. Germanus, who died in 740, mentions the girdle worn by deacons; and Hrabanus Maurus in the succeeding century speaks of the girdle as one of the regular vestments, and refers to its symbolism. Some centuries later the church had to discountenance extravagance in this article of attire, and splendor in the decoration of girdles was denounced as secular and unbefitting the ecclesiastical character.

GIRGEH, GIRGA, or JIRJEH, a town of Upper Egypt, situated on the left bank of the Nile, about 9 miles northwest of the ancient city of Abydus. It owes its name to the Coptic monastery of St. George or Girgis, and is the seat of a Coptic bishop, possesses eight mosques and a Roman Catholic monastery which ranks as the oldest in Egypt, and numbers from 8000 to 10,000 inhabitants, of whom about 500 are Christians. For a long time it was the capital of the Sa'id, but this rank is now held by Soohag. The worst enemy of Girgeh is the river, which was a quarter of a mile to the east at the time of Pococke's visit, about 1740, but has gradually crept nearer, and is now slowly undermining the very site of the town.

GIRGENTI, a city in the south of Sicily, at the head of a province of its own name, occupies a fine position about 3 miles from the coast on a platform of Mount Camicus, more than 1100 feet above the level of the sea. It lies about 60 miles S. S. E. of Palermo, with which it is connected by a railway 90 miles long. As seen from the lower ground Girgenti presents a grandiose but sombre appearance, with its buildings rising in close array from ancient substructions and the steep rocks of the mountain; but within it is for the most part mean, monotonous, and melancholy, the streets with few exceptions being confined, irregular, steep, and ill-paved, and the houses all presenting the same grey-brown walls, the same reddish roofs, and the same narrow doors and narrow windows. The cathedral, begun in the 14th century, has still an impressive effect, in spite of the incongruous mixture of styles; but the interior is a typical specimen of modern rococo. The acoustic conditions are sufficiently peculiar: a word spoken in the softest whisper at the entrance can be distinctly heard behind the choir, 100 paces off. One of the chapels contains the shrine and bears the name of St. Gerlando, the first bishop of Girgenti; the altar-piece is a Virgin and Child, by Guido Reni; and in the north aisle there stands a marble sarcophagus now used as a font, with fine rilievos, probably of Roman workmanship after a Greek original, representing the story of Hippolytus and Phædra. Not only are the archives of the cathedral rich in historic documents of the Norman period, but they profess to contain an autograph letter of the devil himself. Among the other churches, upwards of forty in number, S. Maria dei Greci is worthy of note as preserving two Doric pillars which had belonged to the temple of Zeus Polieus, founded in 570 B. C. by Phalaris, and are thus the oldest architectural remains in Girgenti. As the chief town of a province, Girgenti is the residence of a prefect and the military headquarters of the district. It is also the seat of the wealthiest bishopric in Sicily, dating from the pontificate of Urban II.; and it possesses a chamber of commerce and art, an industrial institute, a lyceum, a gymnasium, a technical school, and an episcopal seminary. Its principal library, Bibliotheca Lucchesiana, was presented to the town by Don Andrea Lucchese, of the family of Campo Franco; the Casino Empedocleo, with well-appointed library and reading-rooms, was founded by a number of the wealthier citizens. In the early part of the century Girgenti was a poverty-stricken town, but it has attained a considerable degree of prosperity since 1850. It lies in the centre of the sulphur district of Sicily, and its port, formerly Molo di Girgenti, now Porto Empedocle, is the principal place of shipment. The harbor has been largely improved since 1870: the pier, originally constructed in the 17th century, in part at least from the ruins of the temple of the Olympian Jupiter, has been extended to a length of 4800 feet, so as to include an area of 330,000 square yards, and the depth, which was only 10 feet on the bar and 16 within, has been greatly increased by dredging. Around the port, which is 3 miles from the city proper, has gathered a cluster of houses and stores, and the spot is defended by a small fort. Almonds and grain are the only important articles of export besides sulphur; but, though the grain-pits hewn out of the rock are of large extent, the actual shipments of grain are not very great. The average value of the annual export of sulphur amounted, between 1868 and 1870, to £411,700, while that of the other articles was less than £15,000 each. The population of Girgenti was 18,802 in 1871, and that of Porto Empedocle 6691. In the history of Girgenti there is little of note; the historical interest of the district gathers round the splendid ruins of the older Agrigentum, which lie between Girgenti and the sea.

See Piccone, *Memorie storiche Agrigentine;* De La Salle's *Voyage pittoresque en Sicile;* Häckel's "Reiseskizzen aus Sicilien," in *Zeitschrift für Erdk. zu Berlin*, 1860; Renan, "Voyage in Sicile," in *Revue des Deux Mondes*, Nov., 1875.

GIRODET DE ROUSSY, Anne Louis (1767–1824), better known as Girodet-Trioson, was born at Montargis, January 5, 1767. He lost his parents in early youth, and the care of his fortune and education fell to the lot of his guardian, M. Trioson, "médecin de mesdames," by whom he was in later life adopted. After some preliminary studies under a painter named Luquin, Girodet entered the school of David, and at the age of twenty-two he successfully competed for the Prix de Rome. At Rome he executed his Hippocrate refusant les présents d'Artaxerxes, and Endymion dormant (Louvre), a work which was hailed with acclamation at the Salon of 1792. The peculiarities which mark Girodet's position as the herald of the romantic movement are already evident in his Endymion. The firm-set forms, the grey cold color, the hardness of the execution, are proper to one trained in the school of David, but these characteristics harmonize ill with the literary, sentimental, and picturesque suggestions which the painter has sought to render. The same incongruity marks Girodet's Danae, and his Quatre Saisons, executed for the king of Spain (repeated for Compiègne), and shows itself to a ludicrous extent in his Fingal (St. Petersburg, Leuchtenberg collection), executed for Napoleon I. in 1802. This work unites the defects of the classic and romantic schools, for Girodet's imagination ardently and exclusively pursued the ideas excited by varied reading both of classic and modern literature, and the impressions which he received from the external world afforded him little stimulus or check; he consequently retained the mannerisms of his master's practice whilst rejecting all restraint on choice of subject. The credit lost by Fingal Girodet regained in 1806, when he exhibited Scène de Deluge (Louvre), to which (in competition with the Sabines of David) was awarded the decennial prize. This success was followed up in 1808 by the production of the Reddition de Vienne, and Atala au Tombeau—a work which went far to deserve its immense popularity, by a happy choice of subject, and remarkable freedom from the theatricality of Girodet's usual manner, which, however, soon came to the front again in his Révolte de Caire (1810). His powers now began to fail, and his habit of working at night and other excesses told upon his constitution; in the Salon of 1812 he exhibited only a Tête de Vierge; in 1819 Pygmalion et Galatée showed a still further decline of strength; and in 1824—the year in which he produced his portraits of Cathelineau and Bonchamps—Girodet died on 9th December, aged fifty-seven.

The number of his paintings is inconsiderable; but he executed a vast quantity of illustrations. amongst which may be cited those to the Didot *Virgil* (1798) and to the Louvre *Racine* (1801–1805). Fifty-four of his designs for *Anacreon* were engraved by M. Chatillon. Girodet wasted much time on literary composition, his poem *Le Peintre* (a string of commonplaces), together with poor imitations of classical poets, and Essays on *Le Génie* and *La Grace*, were published after his death (1829), with a biographical notice by his friend M. Coupin de la Couperie; and M. Delécluze, in his *Louis David et son temps*, has also a brief life of Girodet.

GIRONDE, a maritime department in the S. W. of France, formed from four divisions of the old province of Guyenne, viz., Bordelais, Bazadais, and parts of Périgord and Agénois. It is bounded on the N. by the department of Charente-Inférieure, E. by those of Dordogne and Lot-et-Garonne, S. by that of Landes, and W. by the Bay of Biscay. It lies between 44° 12′ and 45° 35′ N. lat., and between 0° 18′ E. and 1° 16′ W. long., being 106 miles in length from N. W. to S. E., and 80 in breadth from N. E. to S. W. It takes its name from the river or estuary of the Gironde formed by the union of the Garonne and Dordogne. The department divides itself naturally into a western and an eastern portion. The former, which is termed *Les Landes*, occupies more than a third of the department, and consists chiefly of morasses, or of sandy and unfruitful downs. The downs stretching along the sea-coast have, however, been now planted with pines, which, binding the sand together by means of their roots, afford an efficacious protection against the encroachments of the sea. Near the coast are two extensive lakes, Carcans and Lacanau, communicating with each other, and with the bay of Arcachon, near the southern extremity of the department. The Bay of Arcachon contains numerous islands, and on the land side forms a vast shallow lagoon, a considerable portion of which, however, has been drained and converted into arable land. The eastern portion of the department consists chiefly of a succession of hill and dale, and, especially in the valley of the Gironde, is very fertile. The estuary of the Gironde is about 45 miles in length, and varies in breadth from 2 to 6 miles. The principal affluent of the Dordogne in this department is the Isle. The feeders of the Garonne are, with the exception of the Dropt, all small. West of the Garonne the only river of importance is the Leyre, which flows into the bay of Arcachon. The climate is humid and temperate. Wheat, rye, maize, millet, and hemp are grown to a considerable extent. The corn produced, however, does not more than half meet the wants of the inhabitants. The culture of the vine is by far the most important branch of industry carried on, the vineyards occupying about one-seventh of the surface of the department. The wine-growing districts are the Médoc, Graves, Côtes, Palus, and Entre-deux-Mers. The Médoc country grows the three *grands crus*. The Graves country forms a zone 30 miles in extent, and is situated in the vicinity of the Garonne and Dordogne, extending from Châtillon-sur-Gironde to Langon. This is the Sauterne country. The wines of the Côtes district are St. Émilion, Pommerol, St. Laurent, St. Hippolyte, St. Christophe, and St. George. The Palus and Entre-deux-Mers produce is inferior. Fruits and vegetables are increasingly cultivated, strawberries, cherries, apricots, prunes, artichokes, and peas being largely exported. Tobacco is also cultivated to a considerable extent. Large supplies of resin, pitch, and turpentine are obtained from the pine wood. There are stone quarries and smelting works, but few mines. The manufactures are various, and, with the general trade, are chiefly carried on at Bordeaux. Gironde is divided into the arrondissements of Bordeaux, Blaye, Lesparre, Libourne, Bazas, and La Réole, with 48 cantons, and 547 communes. The chief town is Bordeaux. The total area is 3761 square miles; and the population in 1866 was 701,855, and in 1876, 735,242. For a graphic description of the scenery of *Les Landes* in Gironde see the novel *Maître Pierre* of Edmund About.

GIRONDISTS. See France.

GIRVAN, a burgh of barony and market-town, in the county of Ayr, Scotland, is situated at the mouth of the river Girvan, 21 miles S. W. of Ayr, and nearly opposite Ailsa Craig, a rocky island 10 miles distant. The principal industry was formerly hand-loom weaving, but the number of persons so employed has decreased from 3000 to 300. Of late years the herring-fishing has been greatly developed; in the spring of 1879, 304 boats were engaged in it, the "take" exceeding 20,000 crans. The harbor is a tidal one, with a depth at high-water of only 9 feet. The public buildings are very superior; and of late many handsome villas have been erected. The situation of the town is one of the finest in the west of Scotland, and the shore affords excellent facilities for sea-bathing. The population, which was 7319 in 1851, had fallen to 4776 in 1871, but it is now increasing.

GISORS, a town in France, department of Eure, is situated in a pleasant valley on the Epte, 45 miles E. N. E. of Paris. Of its ancient castle, which dates from the 12th century, and was at one time one of the principal strongholds in the kingdom, the octagonal keep, built by Henry II. of England, remains entire, and the rest of the ruins still present an imposing appearance. Its ancient ramparts have been converted into promenades. There is a fine old church, the choir of which was built in 1240, and contains windows with portraits of Blanche of Castile and Louis VIII. The north portal is a good specimen of the florid style of the Renaissance. The church contains some fine sculptures and paintings. The principal other buildings are the communal college, the convent, and the hospital. The industries include tanning, brewing, cotton-spinning, and bleaching. The population in 1876 was 3590.

GITSCHIN, the chief town of a circle in Bohemia, is situated on the Cydlina and on the North West Austrian railway, 50 miles N. E. of Prague. The principal buildings are the parish church, erected after the model of the pilgrim's church of Santiago de Compostella in Spain; the prison, formerly a Jesuit college; the castle, built by Wallenstein in 1630; the gymnasium, the normal school, and the real school. There is a considerable trade in corn. Gitschin was made the capital of the duchy of Friedland by Wallenstein in 1627, at which time it contained only 200 houses. Wallenstein was interred at the neighboring Carthusian monastery, but in 1639 the head and right hand were taken by General Banér to Sweden, and in 1702 the other remains were removed by Count Vincent of Waldstein to his hereditary burying ground at Münchengrätz. At Gitschin the Prusians gained a great victory over the Austrians, June 29, 1866. The population in 1869 was 6750.

GIULIO ROMANO. See Pippi.

GIUNTA PISANO, the earliest Italian painter whose name is found inscribed on an extant work, exercised his art from 1202 to 1236; he may perhaps have been born towards 1180 in Pisa, and died in or soon after 1236. There is some ground for thinking that his family-name was Capiteno. In recent times some efforts have been made to uphold his deservings as an artist, thereby detracting so far from the credit due to the initiative of Cimabue; but it cannot be said that these efforts rest on a very solid basis. To most eyes the performances of Giunta merely represent a continuing stage of the long period of pictorial inaptitude. The inscribed work above referred to, one of his earliest, is a Crucifix now or lately in the kitchen of the convent of St. Anne, in Pisa. Other Pisan works of like date are very barbarous, and some of them may be also from the hand of Giunta. It is said that he painted in the upper church of Assisi,—in especial a Crucifixion, dated 1236, with a figure of Father Elias, the general of the Franciscans, embracing the foot of the cross. In the sacristy is a portrait of St. Francis, also ascribed to Giunta; but it more probably belongs to the close of the 13th century. This artist was in the practice of painting upon cloth stretched on wood, and prepared with plaster.

GIURGEVO, in Roumanian *Giurgiu* or *Shursha*, a town of Roumania (formerly of Lower Wallachia), at the head of the district of Vlashka, lies on the left or northern bank of the Danube, over against Rustchuk in Bulgaria, and is distant about 40 miles from Bucharest, with which it has been connected by railway since 1869. It presents on the whole rather a mean appearance, rising out of the mud embankments of the river, but its population is increasing, its commercial advantages, as the port of Bucharest, are becoming more generally recognized, and improvements are consequently being effected in the town itself. It is the seat of a court of primary instance, and has a normal school and a gymnasium. The fortifications to which it was formerly indebted for no small part of its importance were destroyed in 1829, and its only defence is a castle on the island of Slobosia, with which it communicates by a bridge. Giurgevo, or, as it was called by its founders, San Zorzo, that is, San Giorgio, or St. George's, owes its origin to the Genoese of the 14th century. It has frequently figured in the wars whereby the lower Danube has so often been laid waste. The population in 1875 was about 15,000.

GIUSTI, Giuseppe (1809-1850), Tuscan satirical poet, was born at Monsummano, a small village of the Valdinievole, on May 12, 1809. His father, a cultivated and rich man, accustomed his son from childhood to study, and himself taught him, among other subjects, the first rudiments of music. Afterwards, in order to curb his too vivacious disposition, he placed the boy under the charge of a priest near the village, whose severity did perhaps more evil than good. At twelve Giusti was sent to school at Florence, and afterwards to Pistoia and to Lucca; and during those years he wrote his first verses. In 1826 he went to study law at Pisa; but, disliking the study, he spent eight years in the course, instead of the customary four. He lived gaily, however, though his father kept him short of money, and learned to know the world, seeing the vices of society, and the folly of certain laws and customs from which his country was suffering. The experience thus gained he turned to good account in the use he made of it in his satire.

His father had in the mean time changed his place of abode to Pescia; but Giuseppe did worse there, and in November, 1832, his father having paid his debts, he returned to study at Pisa, seriously enamored of a woman whom he could not marry, but now commencing to write in real earnest in behalf of his country. With the poem called *La Ghigliottina* (the guillotine), Giusti began to strike out a path for himself, and thus revealed his great genius. From this time he showed himself the Italian Béranger, and even surpassed the Frenchman in richness of language, refinement of humor, and depth of satirical conception. In Béranger there is more feeling for what is needed for popular poetry. His poetry is less studied, its vivacity perhaps more boisterous, more spontaneous; but Giusti, in both manner and conception, is perhaps more elegant, more refined, more penetrating. In 1834 Giusti, having at last entered the legal profession, left Pisa to go to Florence, nominally to practise with the advocate Capoquadri, but really to enjoy life in the capital of Tuscany. He fell seriously in love a second time, and, as before, was abandoned by his love. It was then he wrote his finest verses, by means of which, although his poetry was not yet collected in a volume, but for some years passed from hand to hand, his name gradually became famous. The greater part of his poems were published clandestinely at Lugano, at no little risk, as the work was destined to undermine the Austrian rule in Italy. After the publication of a volume of verses at Bastia, Giusti thoroughly established his fame by his *Gingillino*, the best in moral tone as well as the most vigorous and effective of his poems. The poet sets himself to represent the vileness of the treasury officials, and the base means they used to conceal the necessities of the state. The *Gingillino* has all the character of a classic satire. When first issued in Tuscany, it struck all as too impassioned and personal. Giusti entered heart and soul into the political movements of 1847 and 1848, served in the national guard, sat in the parliament for Tuscany; but finding that there was more talk than action, that to the tyranny of princes had succeeded the tyranny of demagogues, he began to fear, and to express the fear, that for Italy evil rather than good had resulted. He fell, in consequence, from the high position he had held in public estimation, and in 1848 was regarded as a reactionary. His friendship for the marquis Gino Capponi, who had taken him into his house during the last years of his life, and who published after Giusti's death a volume of illustrated proverbs, was enough to compromise him in the eyes of such men as Guerrazzi, Montanelli, and Niccolini. On May 31, 1850, he died at Florence in the palace of his friend.

The poetry of Giusti, under a light trivial aspect, has a lofty civilizing significance. The type of his satire is entirely original, and it had also the great merit of appearing at the right moment, of wounding judiciously, of sustaining the part of the comedy that "castigat ridendo mores." Hence his verse, apparently jovial, was received by the scholars and politicians of Italy in all seriousness. Alexander Manzoni in some of his letters showed a hearty admiration of the genius of Giusti; and the weak Austrian and Bourbon Governments regarded them as of the gravest importance.

His poems have been often reprinted, the best editions being those of Le Monnier of Florence, and also that published in Verona, with valuable annotations, by Professor Giovanni Fioretti in 1876. Besides the poems, and the proverbs already mentioned, we have a volume of select letters, full of vigor and written in the best Tuscan language, and a fine critical discourse on Giuseppe Parini, the satirical poet of the last century, whose poetical works are published in a volume by Le Monnier. In some of his compositions the elegiac rather than the satirical poet is seen. Many of his verses have been excellently translated into German by Paul Heyse. Good English translations were published in the *Athenæum* by the late Mrs. T. A. Trollope.

GIUSTINIANI, the name of a prominent Italian family which originally belonged to Venice, but established itself subsequently in Genoa also, and at various times had representatives in Naples, Corsica, and several of the islands of the Archipelago.

In the Venetian line the following are most worthy of mention. I. Lorenzo (1380–1465), the Laurentius Justinianus of the Roman Calendar, at an early age entered the congregation of the canons of Saint George in Alga, and in 1433 became general of that order. About the same time he was made by Eugenius IV. bishop of Venice; and his episcopate was marked by considerable activity in church extension and reform. On the removal of the patriarchate from Grado to Venice by Nicholas V. in 1451, Giustiniani was promoted to that dignity, which he held for fourteen years. He died on January 8, 1465, was canonized by Pope Alexander VIII., his festival (semi-duplex) being fixed by Innocent XII. for September 5th, the anniversary of his elevation to the bishopric. His works, consisting of sermons, letters, and ascetic treatises, have been frequently reprinted—the best edition being that of the Benedictine P. N. A. Giustiniani, published at Venice in 2 vols. folio, 1751. They are wholly devoid of literary merit. His life has been written by Bernard Giustiniani, by Maffei, and also by the Bollandists. (2.) Leonardo (1388–1446), brother of the preceding, was for some years a senator of Venice, and in 1443 was chosen procurator of St. Mark. He translated into Italian Plutarch's *Lives of Cinna and Lucullus*, and was the author of some poetical pieces, amatory and religious, as well as of rhetorical prose compositions. (3.) Bernardo (1408–1489), son of Leonardo, was a pupil of Guarino and of George of Trebizond, and entered the Venetian senate at an early age. He served on several important diplomatic missions both to France and Rome, and about 1485 became one of the council of ten. His orations and letters were published in 1492; but his title to any measure of fame he possesses rests upon his history of Venice, *De Origine Urbis Venetiarum rebusque ab ipsa gestis historia* (1492), which was translated into Italian by Domenichi in 1545, and which at the time of its appearance was undoubtedly the best work upon the subject of which it treated. It is to be found in vol. i. of the *Thesaurus* of Grævius. (4.) Pietro, also a senator, lived in the 16th century, and wrote an *Historia rerum Venetarum* in continuation of that of Bernardo. He was also the author of chronicles *De Gestis Petri Mocenigi* and *De Bello Venetorum cum Carolo VIII.* The latter has been reprinted in the *Script. Rer. Ital.*, vol. xxi.

Of the Genoese branch of the family the most prominent members were the following. (1.) Paolo, di Moniglia (1444–1502), a member of the order of Dominicans, was, from a comparatively early age, prior of their convent at Genoa. As a preacher he was very successful, and his talents were fully recognized by successive popes, by whom he was made master of the sacred palace, inquisitor-general for all the Genoese dominions, and ultimately bishop of Scio and Hungarian legate. He was the author of a number of Biblical commentaries (no longer extant), which are said to have been characterized by great erudition. (2.) Agostino (1470–1536), was born at Genoa, and spent some wild years in Valencia, Spain. Having in 1487 joined the Dominican order, he gave himself with great energy to the study of Greek, Hebrew, Chaldee, and Arabic, and in 1514 commenced the preparation of a polyglot edition of the Bible. As bishop of Nebbio in Corsica, he took part in some of the earlier sittings of the Lateran council (1516–17), but in consequence of party complications, withdrew to his diocese, and ultimately to France, where he became a pensioner of Francis I., and was the first to occupy a chair of Hebrew and Arabic in the university of Paris. After an absence from Corsica for a period of five years, during which he visited England and the Low Countries, and became acquainted with Erasmus and More, he returned to Nebbio about 1522, and there remained, with comparatively little intermission, till in 1536, when, while returning from a visit to Genoa, he perished in a storm at sea. He was the possessor of a very fine library, which he bequeathed to the republic of Genoa. Of his projected polyglot only the Psalter was published (*Psalterium Hebræum, Græcum, Arabicum, et Chaldaicum*, Genoa, 1616). Besides the Hebrew text, the LXX. translation, the Chaldee paraphrase, and an Arabic version, it contains the Vulgate translation, a new Latin translation by the editor, a Latin translation of the Chaldee, and a collection of scholia. Giustiniani printed 2000 copies at his own expense, including fifty in vellum for presentation to the sovereigns of Europe and Asia; but the sale of the work did not encourage him to proceed with the New Testament, which he had also prepared for the press. Besides an edition of the book of Job, containing the original text, the Vulgate, and a new translation, he published a Latin version of the *Moreh Nevochim* of Maimonides (*Director Dubitantium aut Perplexorum*, 1520), and also edited in Latin the *Aureus Libellus* of Æneas Platonicus, and the *Timæus* of Chalcidius. His annals of Genoa (*Castigatissimi annali di Genova*) were published posthumously in 1537.

The name Giustiniani has also been borne by the following:—(1.) Pompeio (1569–1616), a native of Corsica, who served under Alessandro Farnese and the marquis of Spinola in the Low Countries, where he lost an arm, and, from the artificial substitute which he wore, came to be known by the soubriquet Bras de Fer. He also defended Crete against the Turks; and subsequently was killed in a reconnaissance at Friuli. He left in Italian a personal narrative of the war in Flanders, which has been repeatedly published in a Latin translation (*Bellum Belgicum*, Antwerp, 1609). (2.) Giovanni (1513–1556), born in Candia, translator of Terence's *Andria* and *Eunuchus*, of Cicero's *In Verrem*, and of Virgil's *Æneid*, l. viii. (3.) Orsatto (1538–1603), Venetian senator, translator of the *Œdipus Tyrannus* of Sophocles, and author of a collection of *Rime*, in imitation of Petrarch. He is regarded as one of the latest representatives of the classic Italian school. (4.) Geronimo, a Genoese, flourished during the latter half of the 16th century. He translated the *Alcestis* of Euripides and three of the plays of Sophocles; and wrote two original tragedies, *Jephte* and *Christo in Passione.* (5.) Vincenzo, who in the beginning of the 17th century built the Roman palace and made the art-collection which are still associated with his name (see *Galleria Giustiniana*, Rome, 1631). The collection was removed in 1807 to Paris, where it was to some extent broken up. In 1815 all that remained of it, about 170 pictures, was purchased by the king of Prussia and removed to Berlin, where it forms a portion of the royal museum.

GIVET, one of the strongest fortified towns of France, on the Belgian frontier, situated in the department of Ardennes, on the river Meuse, 40 miles N.N.E. of Mezières. The Eastern French railway connects it with Rheims, and the Belgian railways connect it with Namur and Charleroi. It is divided into three portions—the citadel called Charlemont, and Grand Givet on the left bank of the river, and on the opposite bank Petit Givet, connected with Grand Givet by a stone bridge of five arches. The citadel of Charlemont, built by the emperor Charles V. in 1555, is situated at the top of a precipitous rock 705 feet high, and on the east side, by which alone it is accessible, is fortified by six bastions and several other works. Grand Givet has four bastions and three ravelins, and Petit Givet three bastions. The fortress has accommodation for 25,000 men, but can be held by 3000 or 4000. The town is famed for its clay tobacco-pipes. There are also manufactures of nails, lead pencils, sealing wax, white lead, glue, earthenware, and leather, and the town has some trade. The population in 1876 was 5275.

GIVORS, a town of France, department of Rhône, is situated on the Rhone and the canal of Rive-de-Gier, near the railway between Lyons and St. Étienne, 14 miles south of Lyons. It has glass and tile works, potteries, tanneries, foundries, silk factories, and dyeworks, and is the principal entrepôt for the coal and coke of the Gier valley. Near it are the ruins of the château of St. Gerald and of the convent of St. Ferréol. Population (1876), 10,855.

GLACIER,[1] a name given to a mass of ice, having its origin in the hollows of mountains where perpetual snow accumulates, but which makes its way down towards the lower valleys, where it gradually melts, until it terminates exactly where the melting, due to the contact of the warmer air, earth, and rain of the valley, compensates for the bodily descent of the ice from the snow reservoirs of the higher mountains.

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[1] The following are synonyms in different languages and dialects:—French, *glacier;* German, *gletscher;* Italian, *ghiacciaja;* Tyrolese, *fern;* in Carinthia, *käss;* in the Valais, *biegno;* in part of Italy, *vedretto;* in Piedmont, *ruize;* in the Pyrenees, *serneille;* in Norway,

The diminution of temperature as we ascend the slopes of mountains, is indicated by successive zones of vegetation, and finally by the occurrence of perpetual snow (see Geology, p. 249). It was first shown by Baron Humboldt and Von Buch that the limit of perpetual snow depends principally on the temperature of the summer, and not upon that of the whole year.

A glacier usually protrudes into a valley far below the limit of perpetual snow, and terminates amidst a wilderness of stones borne down upon its surface and deposited by its fusion. This earthy and rocky rubbish is termed moraine matter, and has already been described (Geology, p. 249). Lying in front of the lower end of a glacier, it marks in a characteristic and certain manner the greatest limit of extension which the glacier has at any one time attained. Sometimes a glacier is seen to have withdrawn very far within its old limits, leaving a prodigious barren waste of stones in advance of it, which, being devoid of soil, nourishes not one blade of grass. At other times the glacier pushes forward its margin beyond the limit which it has ever reached (at least within the memory of man), tears up the ground with its icy ploughshare, and shoves forward the yielding turf in wrinkled folds, uprooting trees, moving vast rocks, and scattering the walls of dwelling-houses in fragments before its irresistible onward march.[1]

The lower end of a glacier is usually steep,—sometimes with a dome-shaped unbroken outline, more frequently broken up by intersecting cracks into prismatic masses which the continued action of the sun and rain sharpen into pyramids, often assuming (as in the glacier of Bossons at Chamouni) grotesque or beautiful forms. From a vault in the green-blue ice, more or less perfectly formed each summer, the torrent issues which represents the natural drainage of the valley, derived partly from land springs, partly from the fusion of the ice. The united or crevassed condition of the glacier generally depends almost entirely on the slope of its bed. If it incline rapidly, numerous transverse fissures are formed from the imperfect yielding of the ice during its forced descent along its uneven channel. These cracks often extend for hundreds of yards, and may be hundreds of feet in depth; but their greatest depth is not accurately known, since they are rarely quite vertical. In many cases, however, the crevasses are comparatively few in number, and the glacier may be readily traversed in all directions. This is especially the case if a glacier of considerable dimensions meets with any contraction in its course. The ice is embayed and compressed, and its slope lessens, just as in the case of a river when it nears a similar contraction preceding a fall. Such level and generally traversable spaces may be found about the middle regions of the Mer de Glace, the lower glacier of Grindelwald, the lower glacier of the Aar, and in many other cases. The last-named glacier is perhaps the most remarkably even and accessible of any in Switzerland. The slope of its surface is in many places only 3°. The Pasterzen glacier in Carinthia is even less inclined. It is in such portions of a glacier that we commonly find internal cascades, or "moulins." These arise from the surface water being collected into a considerable mass by a long course over its unbroken surface, and then precipitated with violence into the first fissure it meets with. The descending cascade keeps open its channel, which finally loses the form of a fissure, presenting that of an open shaft, often of immense depth.

Nearly connected in their origin with the internal cascades are the "gravel cones," occasionally seen on the surface of glaciers, which appear to be formed in this way. A considerable amount of earthy matter derived by the superficial water-runs from the moraine accumulates in heaps in the inequalities of the ice, or at the bottom of the "moulins." As the glacier surface wastes by the action of the sun and rain, these heaps are brought to the surface, or rather the general surface is depressed to their level. If the earthy mass be considerable, the ice beneath is protected from the radiation of the sun and from the violent washing of the rain; it at length protrudes above the general level of the glacier, and finally forms a cone which appears to be entirely composed of gravel, but is in fact ice at the heart, with merely a protecting cover of earthy matter. These singular cones are very well seen on the glacier of the Aar, but on most others they are comparatively rare. The similar protective action of large stones detached from the moraines and lying on the surface of the ice often produces the striking phenomenon of "glacier tables." Stones of any considerable size almost invariably stand upon a slightly elevated pillar of ice; but when they are broad and flat they occasionally attain a height of 6 and even of 12 feet above the general level.

The superficial waste of a glacier is thus a very important phenomenon. Owing to it the body of the ice has its vertical thickness rapidly diminished during the heats of summer, and, as we have already intimated, the lower end of a glacier has its position determined by the amount of this waste. Suppose a glacier to move along its bed at the rate of 300 feet per annum, and imagine (merely for the sake of illustration) its yearly superficial waste to be 20 feet; then the thickness of the glacier will diminish by 20 feet for every 300 feet of its length, or at the rate of 360 feet per mile, so that the longitudinal section of a glacier has the form of a wedge; and however enormous its original thickness, after a certain course we must at length come to the thin end of the wedge, and that the more rapidly as the causes of melting increase towards the lower extremity. These causes are indeed so various that it is difficult to estimate them with accuracy. We have (1) the direct solar heat, (2) the contact of warm air, and (3) the washing of rain. All these causes act on the surface and produce the "ablation" of the surface. Besides these, the ice of the glacier wastes somewhat beneath by the contact of the soil and the washing of the inferior streams. This may be called its "subsidence." Further, the natural slope of the rocky bed of the glacier causes any point of the surface to stand absolutely lower each day in consequence of the progressive motion. These three causes united produce the "geometrical depression" of the surface. Principal J. D. Forbes showed how the several effects may usually be distinguished by observation. During the height of summer, near the Montanvert, he found the daily average ablation to be 3·62 inches, the daily subsidence to be 1·63 inches. Seven-tenths of the geometrical depression are due therefore to the former cause, and three-tenths to the latter. This is a very large amount, and it is certain that during the colder period of the year, and whilst the glacier is covered with snow, the subsidence is not only suspended, but the glacier recruits in thickness a portion of its waste during the seasons of summer and autumn. To this subject we shall again return.

The middle region of the great glaciers of the Alps extends from the level of about 6000 to 8000 feet above the sea. The inclination is usually there most moderate—say from 2½° to 6°. But this is not invariably the case. Beyond 8000 feet we reach the snow-line. The snow-line is a fact as definite on the surface of a glacier as on that of a mountain, only in the former case it occurs at a somewhat lower level. It cannot be too distinctly understood that the fresh snow annually disappears from the glacier proper. Where it ceases entirely to melt, it of course becomes incorporated with the glacier. We have therefore arrived at the region where the glacier *forms;* everywhere below it only *wastes.* This snowy region of the glacier is called in French *névé*, in German *firn.* As we ascend the glacier it passes gradually from the state of ice to the state of snow. The superficial layers are more snowy and white, in fact nearly pure snow; the deeper ones have more color and consistence, and break on the large scale into vast fragments, which at Chamouni are called *seracs.* The *névé* moves, as the glacier proper does, and it is fissured by the inequalities of the ground over which it passes. These fissures are less regular than those of the lower glacier. They are often much wider, in fact, of stupendous dimensions, and, being often covered with treacherous snowy roofs, constitute one of the chief dangers of glacier travelling. The constitution of the *névé* may be well studied on the Glacier du Géant,

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iisbræ or *iisbrede;* in Lapland, *geikna* or *jegna;* in Iceland, *jökull* or *fall-jökull.*

[1] Such a sudden and disastrous increase took place in many of the glaciers of Switzerland and Savoy in 1818 (occasioning the catastrophe of the Val de Bagnes), and in those of the Bergenstift in Norway about 1740. The retreat of a glacier far within its old moraines is well exemplified in most of the glaciers of the latter country, and especially in that of Nygaard.

a tributary of the Mer de Glace. The mountain-clefts in which large glaciers lie usually expand in their higher portions (in conformity with the ordinary structure of valleys) into extensive basins in which snow is perpetual, and which therefore contain the *névé*, the true origin and material of the glacier, which is literally the overflow of these snowy reservoirs. The amount of overflow, or the discharge of the glacier—upon which depends the extent of its prolongation into the lower valleys—depends in its turn on the extent of the *névé* or collecting reservoir. Glaciers with small reservoirs of necessity perish soon. Their thickness being small, the wedge of the glacier soon thins out. They are common in confined *cirques* of the higher mountains. Such are the glaciers of the second order described by De Saussure. Their slope is often very great—from 20° to 40°.

The ice of the glacier proper has a very peculiar structure, quite distinct from the stratification of the snow on the *névé* (the relics of its mode of deposit), and one which requires special notice. When we examine the appearance of the ice in the wall of an ordinary crevasse (especially if it be tolerably near the side of the glacier) we are struck with the beautiful vertically laminated structure (first observed by Principal Forbes) which it commonly presents, resembling delicately veined marble (especially the variety called in Italy *cipollino*), in shades varying from bluish-green, through green, to white. When we trace the direction of the planes constituting the laminated structure, by observing them on the surface of the glacier (where they are usually well seen after rain, or in the channels of superficial water-runs), we find that where best developed (or not very far from the sides of the glacier) these laminæ are nearly parallel to the sides, but rather incline from the shore to the centre of the ice stream as we follow the declivity of the glacier.

Forbes found that certain superficial discolorations in the form of excessively elongated hyperbolas are due to the recurrence (at intervals of some hundred feet along the course of the glacier) of portions of ice in which the veined structure is more energetically developed than elsewhere, and where, by the decomposition of the softer laminæ, portions of sand and dirt become entangled in the superficial ice, and give rise to the phenomena of "dirt bands," which thus at a distance display (though in a manner requiring some attention to discover) the exact course of this singular structure on the surface of the glacier. Fig. 1 displays the superficial form of the dirt bands, and the course of the structural laminæ projected horizontally. Fig. 2 shows an ideal transverse section of the glacier, and fig. 3 another vertical section parallel to its length. These three sections in rectangular planes will serve to give a correct idea of the course of this remarkable structure within the ice, but a more popular conception will be formed of it from the imaginary sections of a canal-shaped glacier in fig. 4. The structure of the compound glacier, originally double, becomes gradually single; and the "frontal dip" of the laminæ at the loop of the horizontal curves, which in the upper region is nearly vertical, gradually slopes forwards until at the lower termination it has a very slight dip inwards, or indeed may be reversed and fall outwards and forwards. The general form of a structural lamina of a glacier rudely resembles that of a spoon.

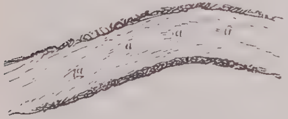
Fig. 1.

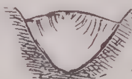
Fig. 2.

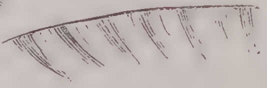
Fig. 3.

This structure and the accompanying dirt bands have been recognized by different observers in almost all glaciers, including those of Norway and of India. The interval between the dirt bands has been shown in the case of the Mer de Glace (and therefore probably in other cases) to coincide with annual rate of progression, and in the higher parts of the glacier (towards the *névé*) to be accompanied by wrinkles or inequalities of the surface which are well marked by the snow lying in them during the period of its partial disappearance.

The Motion of Glaciers and its Causes.—There is something about a glacier which almost inevitably conveys to the mind the idea of a stream. This may be traced in the descriptions of unscientific tourists, of poets, and of some of those who have addressed themselves more seriously to the question of the real nature of these bodies. To the latter class of observers belong Captain Basil Hall and Monseigneur Rendu, bishop of Annecy, who had much more than hinted at the possibility of a true mechanical connection between the descent of a glacier and that of a mountain torrent, or of a stream of lava. But until the actual conditions of motion were reduced to rule, it was impossible to know how far the analogy was real.

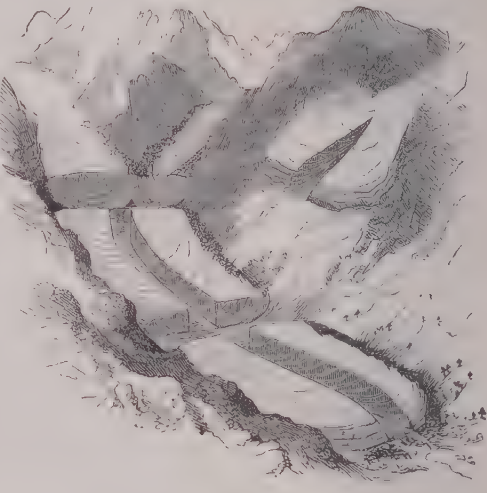
Fig. 4.

The most characteristic and remarkable feature of glaciers is their motion downwards from the *névé* towards the lower valley. The explanation of it is by far the most important application of mechanical physics connected with the subject. The principal theories to account for the progressive motion of glaciers which were prevalent previous to 1842 may be briefly characterized as De Saussure's and De Charpentier's, though each had been maintained long before by the earlier Swiss writers. The first may be called the *gravitation* theory, the latter the *dilatation* theory. Both suppose that the motion of the ice takes place by its sliding bodily over its rocky bed, but they differ as to the force which urges it over the obstacles opposed by friction and the irregularities of the surface on which it moves.

The following quotation from De Saussure explains his views with his usual precision:—"These frozen masses, carried along by the slope of the bed on which they rest, disengaged by the water (arising from their fusion owing to the natural heat of the earth) from the adhesion which they might otherwise contract to the bottom—sometimes even elevated by the water—must gradually slide and descend along the declivity of the valleys or mountain slopes (*croupes*) which they cover. It is this slow but continual sliding of the icy masses (*des glaces*) on their inclined bases which carries them down into the lower valleys, and which replenishes continually the stock of ice in valleys warm enough to produce large trees and rich harvests." Very sufficient objections have been urged against this theory. It is evident that De Saussure considered a glacier as an accumulation of icy fragments, instead of a great and continuous mass, throughout which the fissures and "crevasses" bear a small proportion to the solid portion; and that he has attributed to the subglacial water a kind and amount of action for which there exists no sufficient or even probable evidence. The main objection, however, is this, that a sliding motion of the kind supposed, if it commence, must be accelerated by gravity, and the glacier must slide from its bed in an avalanche. The small slope of most glacier-valleys, and the extreme irregularity of their bounding walls, are also great objections to this hypothesis.

The dilatation theory ingeniously meets the difficulty of the want of a sufficient moving power to drag or shove a glacier over its bed, by calling in the well-known force with which water expands on its conversion into ice. The glacier being traversed by innumerable capillary fissures, and being in summer saturated with water in all its parts, it was natural to invoke the freezing action of the night to convert this water into ice, and by the amount of its expansion to urge the glacier onwards in the direction of its greatest slope. In answer to this, it is sufficient to observe, in the first place, that during the height of summer the portions of those glaciers which move fastest are never reduced below the freezing point, and that, even in the most favorable cases of nocturnal radiation producing congelation at the surface, it cannot (by well-known laws of conduction) penetrate above a few inches into the interior of the glacier. Again, the ascertained laws of glacier-motion are (as will be immediately seen) entirely adverse to this theory, as it is always accelerated by hot weather and retarded by cold, yet does not cease even in the depths of winter.

It is singular how slow observers were to perceive the importance to the solution of the problem of glacier-motion of ascertaining with geometrical precision the amount of motion of the ice, not only from year to year, but from day to day, in summer and winter, whether constant or variable at the same point, whether continuous or by starts; if variable, on what circumstances it depended, and in what manner it was affected at different points of the length and breadth of a glacier.

This method of studying the question was taken up by Forbes. His observations were commenced on the Mer de Glace of Chamouni, in June, 1842. Between the 26th and 27th of that month the motion of the ice opposite a point called the "Angle" was found, by means of a theodolite, to be 16·5 inches in 26 hours; between the 27th and 28th, 17·4 inches in 25½ hours; and from about 6 A. M. to 6 P. M. on the 28th the motion was 9·5 inches, or 17·5 inches in 24 hours; whilst the proportional motion during even an hour and a half was observed. No doubt could therefore remain that the motion of the ice is continuous and tolerably uniform—in short, that it does not move by jerks. He also ascertained about the same time that the motion of the ice is greatest towards the centre of a glacier and slower at the sides, contrary to an opinion then maintained on high authority. He next found that the rate of motion varied at different points of the length of the same glacier, being on the whole greatest where the inclination of its surface is greatest. As the season advanced, he observed notable changes in the rate of motion of the same part of the ice, and connected it by a very striking direct relation with the temperature of the air. These facts were established during the summer of 1842, and promptly published. By means of occasional observations during the following winter and spring by his guide, Auguste Balmat of Chamouni, and by a more full comparison of the entire motion of a glacier for twelve months with its motion during the hot season of the year, another generally received error was rectified: the motion of the glacier continues even in winter, and it has a very perceptible ratio to the summer motion. Last of all, it was found that the surface of a glacier moves faster than the ice nearer the bottom or bed.

These, and some minor laws of motion, being undoubted expressions of the way in which glaciers move, were formulated by Forbes in an approximate theory: "A glacier is an imperfect fluid or a viscous body, which is urged down slopes of a certain inclination by the mutual pressure of its parts." The analogy subsisting between the motion of a glacier and that of a river (which is a viscous fluid,—were it not so, its motion would be widely different) will be best perceived by stating more precisely its laws of motion.

1. Each portion of a glacier moves, not indeed with a constant velocity, but in a continuous manner, and not by sudden subsidences with intervals of repose. This, of course, is characteristic also of a river.

2. The ice in the middle part of the glacier moves much faster than that near the sides or banks; also the surface moves faster than the bottom. Both these facts obtain in the motion of a river in consequence of the friction of the fluid on its banks, and in consequence also of that internal friction of the fluid which constitutes its viscosity..

Thus, at four stations of the Mer de Glace, distant respectively
from the west shore of the glacier......100 230 405 365 yds.,
the relative velocities were............1·000 1.332 1·356 1·367.

3. The variation of velocity (as in a river) is most rapid near the sides, whilst the middle parts move nearly uniformly. This and the preceding laws are also fully brought out by the subsequent experiments of M. Agassiz on the glacier of the Aar, and of MM. Schlagintweit on the Pasterzen glacier.

4. The variation of velocity of a glacier from the sides to the middle is nearly in proportion to the absolute velocity of the glacier,—whether that absolute velocity change in the same place in consequence of change of season, or between one point and another of the length of the same glacier, depending on its declivity. See (5) and (6) below.

5. The glacier, like a stream, has its pools and its rapids. Where it is embayed by rocks it accumulates, its declivity increases, and its velocity at the same time. When it passes down a steep, issuing by a narrow outlet, its velocity increases. Thus the approximate declivities of the inferior, middle, and superior regions of the Mer de Glace (taken in the direction of its
length) are................ ....15° 4½° 8°,
and the relative velocities are as the numbers..1·398 ·574 ·925.

6. A fact not less important than any of the preceding is that increased temperature of the air favors the motion of the ice, and generally whatever tends to increase the proportion of the watery to the solid constituents of a glacier, as mild rains, and especially the thawing of the superficial snow in spring. The velocity does not, however, descend to zero even in the depth of winter. Indeed, in the lower and most accessible portions of the Mer de Glace (or Glacier des Bois) and the Glacier des Bossons, the ratio of the winter to the summer motion is almost exactly 1 : 2. On endeavoring to establish a relation between the velocity of the glacier and the temperature of the ambient air, we find that these diminish together almost regularly down to the freezing point, below which the velocity seems to remain constant.

Any mechanical theory of glaciers must be more or less imperfect which does not explain the remarkable veined or ribboned structure of the ice, with its peculiar course through the interior of the glacier, as above described. According to Forbes the fundamental idea is that the veined or ribboned structure of the ice is the result of internal forces by which one portion of ice is dragged past another in a manner so gradual as not necessarily to produce large fissures in the ice, and the consequent sliding of one detached part over another, but rather the effect of a general bruise over a considerable space of the yielding body. According to this view, the delicate veins seen in the glacier, often less than a quarter of an inch wide, have their course parallel to the direction of the sliding effort of one portion of the ice over another. Amongst other proofs of this fundamental conception that the veined structure is the external symbol of this forced internal motion of a body comparatively solid, Forbes cited a striking instance from the glacier of La Brenva, on the south side of Mount Blanc. In this case the ice of the glacier, forcibly pressed against the naked rocky face of an opposing hill is turned into a new direction; and in thus shoving and squeezing past a prominence of rock, he observed developed in the ice a "veined structure" so beautiful that "it was impossible to resist the wish to carry off slabs, and to perpetuate it by hand specimens." This perfectly developed structure was visible opposite the promontory which held the glacier in check, and past which it struggled, leaving a portion of its ice completely embayed in a recess of the shore behind it. Starting from this point as an origin, the veined laminæ extended backwards and upwards into the glacier, but did not spread laterally into the embayed ice. They could, however, be traced from the shore to some distance from the promontory into the icy mass. The direction of lamination exactly coincided with that in which the ice must have moved if it was shoved past the promontory at all. That it did so move was made the subject of direct proof, by fixing two marks on the ice opposite the promontory, one on the nearer, the other on the farther side of the belt of ice which had the lamination best developed. The first mark was 50 feet from the shore, and moved at the rate of 4·9 inches daily; the other mark was 170 feet further off, and moved almost three times faster, or 14·2 inches daily. Throughout this breadth of 170 feet there was not a single longitudinal crevasse which might have facilitated the differential motion. A parallelogram of compact ice, only 170 feet wide, was therefore moving in such a manner that, whilst one of its sides advanced only a foot, the other advanced a yard. No solid body, at least no rigid solid body, can advance in such a manner; Forbes therefore concluded that glacier-ice is plastic, that the veined structure is unquestionably the result of the struggle between the rigidity of the ice and the quasi-fluid character of the motion impressed upon it, and that this follows, not only from the direction of the laminæ, but from their becoming distinct exactly in proportion to their nearness to the point where the bruise is necessarily strongest. The subsequent experiments of Sorby on the cleavage structure of rocks proved that it has arisen as the result of intense lateral compression, and could be imitated in many artificial substances. Tyndall obtained it even in beeswax, the analogy between which and the veined structure of ice is very close.

Though Forbes termed his expression of the laws of glacier motion the "viscous" or "plastic theory," it was rather a statement of fact than an explanation of the physical processes concerned in the descent of glaciers. Against his views it was of course objected that ice is by its nature a brittle solid, and not sensibly possessed of any viscous or plastic quality. But he cogently replied that the qualities of solid bodies of vast size, and acted on by stupendous and long-continued forces, cannot be estimated from experiments on a small scale, especially if short and violent; that sealing-wax, pitch, and other similar bodies mould themselves, with time, to the surfaces on which they lie, even at atmospheric temperatures, and whilst they maintain, at the same time, the quality of excessive brittleness under a blow or a a rapid change of form; that even ice does not pass at once, and *per saltum*, from the solid to the liquid state, but absorbs its latent heat throughout a certain small range of temperature (between 28°·4 and 32° of Fahrenheit), which is precisely that to which the ice of glaciers is actually exposed; that, after all, a glacier is not a crystalline solid, like ice tranquilly frozen in a mould, but possesses a peculiar fissured and laminated structure, through which water enters (at least for a great part of the year) into its intrinsic composition. He insisted that the quasi-fluid or viscous motion of the ice of glaciers is not a theory but a fact. A substance which is seen to pour itself out of a large basin through a narrow outlet without losing its continuity; the different parts of which, from top to bottom, and from side to centre, possess distinct though related velocities; which moves over slopes inconsistent with the friction between its surface and the ground on which it rests; which surmounts obstacles, and even if cleft into two streams by a projecting rock, instead of being thereby anchored as a solid would necessarily be, reunites its stream below, and retains no trace of the fissure, leaving the rock an islet in the icy flood,—a substance which moves in such a fashion cannot, Forbes maintained, in any true sense of the word, be termed a rigid solid, but must be granted to be ductile, viscous, plastic, or semifluid, or to possess qualities represented by any of these terms which we may choose to adopt as least shocking to our ordinary conception of the brittleness of ice.

The problem of the cause of glacier-motion cannot yet be considered to be satisfactorily solved. One of the most important contributions to the solution of this question was made by Professor James Thomson when he predicted that the freezing point of ice must be lowered by pressure, and when he sought by means of this property to explain the plastic or viscous behavior of glaciers contended for by Forbes. This prediction was experimentally verified by his brother, Sir W. Thomson. Tyndall subsequently to Forbes's work brought forward an explanation termed the "pressure or fracture and regelation theory." Some experiments of Faraday in 1850 had shown that two pieces of ice with moistened surfaces would if in contact adhere, owing to the freezing of the thin film of water between them, while at a lower temperature than 32°, and with consequently dry surfaces, no adhesion took place. The freezing was obtained even under warm water. Starting from those observations Tyndall was led to make experiments on the effects of compression upon ice, and found that a quantity of pounded ice could be moulded into a compact homogeneous mass. This property possessed by ice of reuniting by pressure after fracture was termed regelation, and was applied by Tyndall in explanation of the motion of glaciers. He maintained that the ice of a glacier is a solid brittle substance, and that its descent down a valley is due to constant rupture produced by the effects of gravitation and to the consequent sliding forward of the mass in which the surfaces of fracture speedily reunite. He pointed more particularly to the ice-falls of glaciers where the ice in passing over a steep descent and undergoing great tension does not yield as a viscous body, but is fractured as a solid. More recently Canon Mosely investigated the physics of glaciers, especially by determining the shearing force of the ice. He found that in a glacier of such a uniform section and slope, moving at such a uniform rate, as the Mer de Glace at Les Ponts, the aggregate resistance offered by the ice to its descent is about 34 times greater than the force of gravitation. He therefore concluded it to be physically impossible that a glacier could slide down its valley by its own weight, and consequently that the gravitation or fracture and regelation theory could not be maintained. The slow descent of sheet lead on a roof of moderate inclination, and its ability even to draw out from the rafters the nails with which it had been fastened, led him to propound another theory of glacier-motion, viz., that it is due to expansion and contraction caused by changes of solar heat. He contended that the ice, like the lead, is expanded by heat, and that, as it cannot on expansion move up the valley without overcoming the resistance of gravitation as well as of friction, it necessarily moves chiefly downward, in which direction gravitation co-operates. Contraction on the other hand must also tend to send the ice downward, for a larger part will move with the force of gravitation than against it. Dr. Croll, objecting to Canon Mosely's views that no observed alternations of glacier temperature warrant the conclusion that the ice can be impelled downward by that cause, has proposed yet another explanation. He regards the motion of the ice of a glacier as molecular, resulting from the very conduction of heat through the mass of the glacier. He contends that from the thermal conditions of glacier-ice its molecules will melt before their temperature can be raised. Any given molecule on melting will transmit its extra heat or part of it to the next molecule, which in turn may melt, and thus a wave of thaw will travel through the ice. But as each molecule loses its heat again it freezes, and in the act of solidification exerts an enormous pressure on the walls of the interstice into which while fluid it entered. Hence in proportion to the amount of heat received by it the ice is subjected to great molecular pressure. As the glacier cannot expand laterally on account of the walls of its channel, and as gravitation opposes its expansion up the valley, it necessarily finds relief by a downward movement—the direction in which gravitation co-operates.

See De Saussure's *Voyages dans les Alpes*, § 535; De Charpentier, *Essai sur les Glaciers*, 1841; Agassiz, *Études sur les Glaciers*, 1840, *Système Glaciaire*, 1847; L'Abbé Rendu, "Théorie des Glaciers de la Savoie," in *Mém. Acad. Savoie*, x., 1841, translated by G. Forbes and published 1875; J. D. Forbes, *Travels in the Alps*, 1843, *Norway and its Glaciers*, 1853, and *Occasional Papers on Glaciers*, 1859; Tyndall's *Glaciers of the Alps*, 1857; Mousson's *Gletscher der Jetztzeit*, 1854; Mosely, *Proc. Roy. Soc.*, 1869; Croll, *Climate and Time*, 1875; J. Thomson, *Proc. Roy. Soc.*, 1856–7.

GLADBACH, usually called **Bergisch-Gladbach**, a town of Prussia, circle of Mülheim, government district of Cologne, is situated 8 miles N. E. of the latter town. It possesses an iron foundry, and manufactories of paper, pasteboard, powder, percussion caps, nets, and machinery. Ironstone, peat, and lime are found in the vicinity. The population in 1875 was 7030.

GLADBACH, or **München-Gladbach**, a flourishing and rapidly increasing manufacturing town of Rhenish Prussia, capital of a circle in the government district of Düsseldorf, is situated 16 miles W. S. W. of the town of that name. It is one of the chief manufacturing seats of Rhenish Prussia, its principal industries being the spinning and weaving of cotton, the manufacture of silks, velvets, ribbons, and damasks, and dyeing and bleaching. There are also tanneries, tobacco manufactories, machine works, and foundries. The town possesses a chamber of commerce, a gymnasium, and a female school of the higher grade. There are an Evangelical and three Catholic churches, one of which possesses a choir of 1250, a nave dating from the beginning of the twelfth century, and a crypt of the 8th century. Gladbach existed before the time of Charlemagne, and a Benedictine monastery was founded near it in 972 by Archbishop Gero of Cologne. The population in 1855 was only 4398; but it had increased in 1858 to 13,965, in 1861 to 17,074, in 1871 to 26,354, and in 1875 to 31,962.

GLADIATORS, professional combatants with men or beasts in the Roman arena. That this form of spectacle, which is almost peculiar to Rome and the Roman provinces, was originally borrowed from Etruria is shown by various indications. On an Etruscan tomb discovered at Tarquinii there is a representation of gladiatorial games; the slaves employed to carry off the dead bodies from the arena wore masks representing the Etruscan Charon; and we learn from Isidore of Seville that the name for a trainer of gladiators, *lanista*, is an Etruscan word meaning butcher or executioner. These games are evidently a survival of the practice of immolating slaves and prisoners on the tomb of illustrious chieftains, a practice recorded in Greek, Roman, and Scandinavian legends, and traceable even as late as this century in the Indian suttee. Even at Rome they were for a long time confined to funerals, and hence the older name for gladiators was *bustuarii;* but in the later days of the republic their original significance was forgotten, and they formed as indispensable a part of the public amusements as the theatre or the circus.

The first gladiators are said, on the authority of Valerius Maximus, to have been exhibited at Rome in the Forum Boarium 264 B. C., by Marcus and Decimus Brutus at the funeral of their father. On this occasion only three pairs fought, but the taste for these games spread rapidly, and the number of combatants grew apace. In 174 B. C. Titus Flamininus celebrated his father's obsequies by a three days' fight, in which 74 gladiators took part. Julius Cæsar engaged such extravagant numbers for his ædileship, that his political opponents took fright, and carried a decree of the senate imposing a certain limit of numbers; but notwithstanding this restriction he was able to exhibit no less than 300 couples. During the later days of the republic the gladiators were a constant element of danger to the public peace. The more turbulent spirits among the nobility had each his band of gladiators to act as a body guard, and the armed troops of Clodius, Milo, and Catiline played the same part in Roman history as the armed retainers of the feudal barons or the condottieri of the Italian republics.

Under the empire, notwithstanding sumptuary enactments, the passion for the arena steadily increased. Augustus, indeed, limited the shows to two a year, and forbade a prætor to exhibit more than 120 gladiators, yet allusions in Horace and Persius show that 100 pairs was the fashionable number for private entertainments; and in the Marmor Ancyranum the emperor states that more than 10,000 men had fought during his reign. The imbecile Claudius was devoted to this pastime, and would sit from morning till night in his chair of state, descending now and then to the arena to coax or force the reluctant gladiators to resume their bloody work. Under Nero senators and even well-born women appeared as combatants; and Juvenal has handed down to eternal infamy the descendant of the Gracchi that appeared without disguise as a *retiarius*, and begged his life from the *secutor*, who blushed to conquer one so noble and so vile. Titus, whom his countrymen surnamed the Clement, ordered a show which lasted 100 days; and Trajan, in celebration of his triumph over Decebalus, exhibited 5000 pairs of gladiators. Domitian instituted *venationes* by torchlight, and at the Saturnalia of 90 A. D. arranged a battle between dwarfs and women. Even as late as 200 A. D. an edict was passed forbidding women to fight. How widely the taste for these sanguinary spectacles extended throughout the Roman provinces is attested by monuments, inscriptions, and the remains of vast amphitheatres. From Britain to Syria there was not a town of any size that could not boast its arena and annual games. The following inscription copied from the pedestal of a statue shows the important part they played in provincial life:—"In four days, at Minturnæ, he showed eleven pairs of gladiators, who did not cease fighting till one-half, all the most valiant men in Campania, had fallen. You remember it well, noble fellow citizens." After Italy, Gaul, North Africa, and Spain were most famous for their amphitheatres; and Greece was the only Roman province where the institution never took root.

Gladiators were commonly drawn either from prisoners of war, or slaves, or criminals condemned to death. Thus in the first class we read of tatooed Britons in their war chariots, Thracians with their peculiar bucklers and scimitars, Moors from the villages round Atlas, and negroes from central Africa, exhibited in the Colosseum. Down to the time of the empire only greater malefactors, such as brigands and incendiaries, were condemned to the arena; but by Caligula, Claudius, and Nero this punishment was extended to minor offences, such as fraud and peculation, in order to supply the growing demand for victims. For the first century of the empire it was lawful for masters to sell their slaves as gladiators, but this was forbidden by Hadrian and Marcus Aurelius. Besides these three regular classes, the ranks were recruited by a considerable number of freedmen and Roman citizens who had squandered their estates, and voluntarily took the *auctoramentum gladiatorum*, by which for a stated time they bound themselves to the *lanista*. Even men of birth and fortune not seldom entered the lists, either for the pure love of fighting, or to gratify the whim of some dissolute emperor; and one emperor, Commodus, actually appeared in person in the arena.

Gladiators were trained in schools (*ludi*) owned either by the state or by private citizens; and though the trade of a lanista was considered disgraceful, to own gladiators and let them out for hire was reckoned a legitimate branch of commerce. Thus Cicero, in his letters to Atticus, congratulates his friend on the good bargain he had made in purchasing a band, and urges that he might easily recoup himself by consenting to let them out twice. Men recruited mainly from slaves and criminals, whose lives hung on a thread, must have been more dangerous characters than modern galley slaves or convicts; and, though highly fed and carefully tended, they were of necessity subject to an iron discipline. In the school of gladiators discovered at Pompeii, of the sixty-three skeletons buried in the cells many were in irons. But hard as was the gladiator's lot,—so hard that special precautions had to be taken to prevent suicide,—it had its consolations. A successful gladiator enjoyed far greater fame than any modern prize-fighter or athlete. He was presented with broad pieces, chains, and jewelled helmets, such as may be seen in the museum at Naples; poets like Martial sang his prowess; his portrait was multiplied on vases, lamps, and gems; and high-born ladies contended for his favors. Mixed, too, with the lowest dregs of the city, there must have been many noble barbarians condemned to the vile trade by the hard fate of war. There are few finer characters in Roman history than the Thracian Spartacus, who, escaping with seventy of his comrades from the school of Lentulus at Capua, for three years defied the legions of Rome; and after Antony's defeat at Actium, the only part of his army that remained faithful to his cause were the gladiators whom he had enrolled at Cyzicus to grace his anticipated victory.

There were various classes of gladiators, distinguished by their arms or modes of fighting. The Samnites fought with the national weapons—a large oblong shield, a vizard, a plumed helmet, and a short sword. The Thraces had a small round buckler and a dagger carved like a scythe; they were generally pitted against the Mirmillones, so called from the fish (μορμύλος) which served as the crest of their helmet. In like manner the Retiarius was matched with the Secutor; the former had nothing on but a short tunic or apron, and sought to entangle his pursuer, who was fully armed, with the cast-net (*jaculum*) that he carried in his right hand; and if successful, he despatched him with the trident (*tridens, fuscina*) that he carried in his left. We may also mention the Andabatæ, who wore helmets with closed vizors; the Dimachæri of the later empire; the Essedarii, who fought from chariots like the ancient Britons; the Hoplomachi, armed like a Greek hoplite; and the Laqueatores, who tried to lasso their antagonists.

The estimation in which gladiatorial games were held by Roman moralists deserves notice, and the influence that they exercised upon the morals and genius of the nation. The Roman was essentially cruel, not so much from spite or vindictiveness, as from callousness and defective sympathies. This element of inhumanity and brutality must have been deeply ingrained in the national character to have allowed the games to become popular, but there can be no doubt that it was fed and fostered by the savage form which their amusements took. That the sight of bloodshed provokes a love of bloodshed and cruelty is a commonplace of morals. To the horrors of the arena we may attribute in part, not only the brutal treatment of their slaves and prisoners, but the frequency of suicide among the Romans. On the other hand, we should be careful not to exaggerate the effects or draw too sweeping inferences from the prevalence of this degrading amusement. Human nature is happily illogical; and we know that many of the Roman statesmen who gave these games and themselves enjoyed these sights of blood, were in every other department of life irreproachable,—indulgent fathers, humane generals, and mild rulers of provinces. In the present state of society it is difficult to conceive how a man of taste can have endured to gaze upon a scene of human butchery. Yet we should remember that it is less than half a century since bear-baiting was prohibited in England, and we are only now attaining that stage of morality in respect of cruelty to animals that was reached in the 5th century, by the help of Christianity, in respect of cruelty to men. We shall not then be greatly surprised if hardly one of the Roman moralists is found to raise his voice against this amusement, except on the score of extravagance. Cicero, in a well-known passage, commends the gladiatorial games as the best discipline against the fear of death and suffering that can be presented to the eye. The younger Pliny, who perhaps of all Romans approaches nearest to our ideal of a cultured gentleman, speaks approvingly of them. Marcus Aurelius, though he did much to mitigate their horrors, yet in his writings condemns the monotony rather than the cruelty. Seneca is indeed a splendid exception, and his letter to Lentulus is an eloquent protest against this inhuman sport. But it is without a parallel till we come to the writings of the Christian fathers, Tertullian, Lactantius, Cyprian, and Augustine In the *Confessions* of the last there occurs a narrative which is worth quoting as a proof of the strange fascination which the games exercised even on a religious man and a Christian. He tell us how his friend Alipius was dragged against his will to the amphitheatre, how he strove to quiet his conscience by closing his eyes, how at some exciting crisis the shouts of the whole assembly aroused his curiosity, how he looked and was lost, grew drunk with the sight of blood, and returned again and again, knowing his guilt yet unable to abstain. The first Christian emperor was persuaded to issue an edict abolishing gladiatorial games (325), yet in 404 we read of an exhibition of gladiators to celebrate the triumph of Honorius over the Goths, and it is said that they were not totally extinct in the West till the time of Theodoric (see GAMES).

Gladiators formed admirable models for the sculptor. One of the finest pieces of ancient sculpture that has come down to us is the Wounded Gladiator of the National Museum at Naples. The so-called Fighting Gladiator of the Borghese collection, now in the Museum of the Louvre, and the Dying Gladiator of the Capitoline Museum, which inspired the famous stanza of *Childe Harold*, have been pronounced by modern antiquaries to represent, not gladiators, but warriors. In this connection we may mention the admirable picture of Gérôme which bears the title, Ave, Cæsar, morituri te salutant.

The attention of archæologists has been recently directed to the *tesseræ* of gladiators. These tesseræ, of which about sixty exist in various museums, are small oblong tablets of ivory or bone, with an inscription on each of the four sides. The first line contains a name in the nominative case, presumably that of the gladiator; the second line a name in the genitive, that of the *patronus* or *dominus;* the third line begins with the letters SP, for *spectatus* or approved, which shows that the gladiator had passed his preliminary trials; this is followed by a day of a Roman month; and in the fourth line are the names of the consuls of a particular year.

Lipsius, *Saturnalia*, Wesel, 1675; Friedländer, *Darstellungen aus der Sittengeschichte Roms*, Leipsic, 1869; H. Goell, *Kulturbilder aus Hellas und Rom*, Leipsic, 1863; Charles Magnin, *Les Origines du théâtre moderne*, Paris, 1838; H. Wallon, *Histoire de l'esclavage*, Paris, 1847; Guhl and Koner, *The Life of the Greeks and Romans;* Lecky, *History of European Morals.* (F. S.)

GLADIOLUS, a genus of monocotyledonous or endogenous plants, belonging to the natural order *Iridaceæ*, and representative of the tribe *Gladioleæ*, a group of bulbous plants in which the perianth is irregular, and the stamens unilateral and arched, with the filaments free. It belongs to a subdivision of the *Gladioleæ*, in which the segments of the limb of the perianth are very unequal, and is specially distinguished by having the perianth tube curved, funnel-shaped, and widening upwards, and by the segment equalling or exceeding the tube in length. About ninety species are described, of which number upwards of fifty are from the Cape, and the rest from tropical Africa, the central and southern regions of Europe, Persia, the Caucasus, and the Levant. One species, *G. illyricus*, is found apparently wild in England, in the New Forest, Hampshire. Some of the species have been cultivated for a long period in our flower-gardens, where both the introduced species and the modern varieties bred from them are very ornamental and popular. *G. segetum* has been cultivated since 1596, and *G. byzantinus* since 1629, while many additional species were introduced during the latter half of the 18th century. One of the earlier of the hybrids originated in gardens was the beautiful *G. Colvillii*, raised in the nursery of Mr. Colvill of Chelsea in 1823 from *G. concolor* fertilized by *G. cardinalis*. In the first decade of the century, however, the Hon. and Rev. W. Herbert had successfully crossed the showy *G. cardinalis* with the smaller but more free-flowering *G. blandus*, and the result was the production of a race of great beauty and fertility. Other crosses were made with *G. tristis*, *G. oppositiflorus*, *G. hirsutus*, *G. alatus*, and *G. natalensis;* but it was not till after the production of *G. gandavensis* about 1843, by the crossing of *G. natalensis* with *G. oppositiflorus* (sometimes erroneously attributed to *natalensis* and *cardinalis*), that the gladiolus may be said to have become a general favorite in gardens. Since that time the varieties have been greatly multiplied in number, and improved in size and quality, as well as marvellously varied in color and marking, so that they have now become exceedingly popular. A few years since large numbers of novel varieties were annually introduced by the French florists, but the English-raised varieties are now in great measure superseding them. One cultivator, Mr. Kelway, of Langport, devotes a space of not less than 8 acres to gladioli, and cultivates annually from 10,000 to 60,000 each of some of the more popular kinds, while seedlings are raised to the extent of half a million a year. The seeds are sown in the open ground about April, glass culture with so large a number being out of the question; and in the first season the young plants make bulbs averaging the size of peas. The time occupied from the sowing of the seed until the plant attains its full strength is from three to four years. The approved sorts, which are identified by name, are multiplied by means of bulblets or offsets which form around the principal bulb or corm; but in this they vary greatly, some kinds furnishing abundant increase and soon becoming plentiful, while others persistently refuse to yield offsets. The stately habit and rich glowing colors of the modern gladioli render them exceedingly valuable as decorative plants during the late summer months. They are, moreover, very desirable and useful flowers for cutting for the purpose of room decoration, for while the blossoms themselves last fresh for some days, the undeveloped buds open in succession, if the stalks are kept in water, so that a cut spike will go on blooming for a considerable period.

GLAMORGAN (Welsh, *Gwlad Morgan*), a maritime county of South Wales, bounded on the N. by Brecknock and Carmarthen, on the W. by Carmarthen and its bay, on the S. by the Bristol Channel, and on the E. by Monmouth, the boundary line of which is the Rhymney. Its greatest length from E. to W. is about 53 miles, its greatest breadth from N. to S. about 29; its coast-line is about 60 miles, and its area 547,070 acres.

Glamorgan, with the exception of some flat tracts on the borders of the Bristol Channel, consists of a succession of hills and valleys, the country inland growing more and more mountainous, after a broad tract of plain on the south coast, until on the borders of Brecknock its surface is a sea of hills. None of the mountains rise to a great height, the most lofty, Mynydd Llangeinor, being but 1859 feet, and the escarpment of Craig y Llyn about the same height or a little higher. Yet their bold forms add grandeur to the scenery of the county, and their lower slopes are clothed with picturesque though not large timber.

The valleys of Glamorgan have been long famous for great beauty of scenery. The vale of Glamorgan, some 8 miles in breadth, has been truly called the "Garden of Wales," and its climate is so mild that myrtles and other tender plants flourish in the open air. The vale of Neath is known to tourists as the waterfall district of South Wales, the finest falls being betwixt Hirwain and Neath, near the Vale of Neath Railway, viz., Cilhepstè fall, the three Clwngwyns, the falls of the Pyrddin, Scwd-Einon Gam, Scwd-Gladys, and Scwd Hen Rhydd on the Llech, with Melincourt and Abergarwedd still nearer Neath. The highest of these falls are above 80 feet. Swansea valley has also fine scenery. Other valleys are those of the Rhymney, the Taff, the Rhondda, and the Llwchwr, the first two giving their names to important railways.

The rivers of Glamorgan are not large. The chief are the Rhymney, forming the county's eastern boundary; the Ogwr or Ogmore, which flows into the Bristol Channel near Porth-Cawl harbor; the Taff, which rises in the Brecon Beacon, flows southward through the county, and forms the important harbor of Cardiff; the Neath and Tawe, flowing south into Swansea Bay; and the Llwchwr, which is the boundary of the county on the west, and, falling into Carmarthen Bay, forms the estuary of the Burry river.

The chief geological feature of Glamorgan is the Coal-measures, which are of the greatest thickness near Neath, but extend nearly over the whole county, and are bounded by a narrow band of Millstone Grit and Mountain Limestone, nearly coincident with the county boundary on the north. In the extreme south and south-west the Devonian, Magnesian Limestone, and the Lias show themselves.

The climate is mild, and the plains on the coast as well as inland are very fertile. The soil is a deep rich loam, improved by lime. Agriculture is as yet not so forward as it might be with such a soil and climate; but the farms are seldom large, and the buildings are not suited to high farming. The crops chiefly raised are wheat, beans, pease, oats, barley, vetches, turnips, and potatoes. The cattle are of good useful breeds; and good sheep and ponies are reared in the hill-country. According to the agricultural statistics for 1878, the extent under the different crops (the total area being 547,070 acres), and the numbers of live-stock, were as follows:—

Corn crops (two-thirds wheat and oats, and nearly one-third barley)	37,139	acres.
Green crops (two-thirds turnips and swedes)	15,054	"
Grass under rotation	26,468	"
Permanent pasture	186,697	"
Bare, fallow, and uncropped arable land	33,359	"
Total under crops, bare fallow, and grass	268,707	"

Live Stock:—	Horses, including ponies	13,727
	Cattle	46,545
	Sheep	283,389
	Pigs	15,572

According to the Owners and Heritages Return 1872–73, the county was divided among 8426 proprietors, holding 428,386 acres, with a gross estimated annual rental of £1,609,379. The estimated amount of commons and waste lands was 47,018 acres. Of the owners, 78·8 per cent. possessed less than one acre, and the average value per acre was £3, 1s. 8½d. There were 16 proprietors holding 5000 acres and upwards, viz., C. R. M. Talbot, 33,920; Earl of Dunraven, 23,706; Marquis of Bute, 21,402; Lord Windsor, 12,016; Earl of Jersey, 7110; Edward Rees Wingfield, 6463; Lord Tredegar, 6157; Major Vaughan Lee, 6128; Mrs. Blandy Jenkins, 6082; Col. K. Lynte, 5933; Sir Iver B. Guest, 5640; T. Penrice, 5411; Mrs. Chetwode, 5399; R. F. L. Jenner, 5381; C. Bailey, 5343; John D. Llewellyn, 5000.

The industry of Glamorgan is chiefly applied to its coal and iron mines, which practically underlie the whole superficies of the county, and give it its pre-eminence among Welsh counties. In 1872 there were no less than 420 coal pits in Monmouthshire and South Wales, and the yield of some 15 million tons a year came in very large proportion from the Glamorganshire vales of Neath, Taff, Rhondda, Ely, etc. Within the last twenty years the iron works were carried on at an enormous scale of labor and enterprise, there being near Merthyr-Tydvil alone upwards of 60 blast furnaces; but in 1873 it appeared that of 57 furnaces in Glamorganshire 27 were out of blast, and at present (1879) the industry is, from various causes, in a backward state. Excellent means of export for coal and iron are afforded by the unrivalled docks at Cardiff, the enterprise of the late and present marquis of Bute, and by those also at Penarth at the mouth of the Ely. These have within considerably less than a century transformed an insignificant Welsh town into a leading port and emporium with a first rate harbor and anchorage; whilst another dock at Swansea serves a like purpose for the export of the copper ore smelted at Swansea, Neath, Aberavon, and Treforest, and chiefly sold at public ticketings in the first-named town. Cardiff and Swansea, especially the latter, also have a very large export trade in patent compressed fuel prepared from culm and tar.

Glamorgan can boast historic ruins, such as Caerphilly, and Castle Coch near Llandaff, the former a Norman fortress held for Edward II. by the younger De Spencer, the latter an early English fortress on an escarpment of mountain limestone. Other ruined castles are Oystermouth and Pennard in Gower, and Coity near Bridgend; while as restored castles, resided in by their present owners, are Cardiff, the residence of the marquis of Bute, St. Fagan's, near Ely station, and St. Donat's and Dunraven, both on the verge of the Bristol Channel. The county has some fine cromlechs at St. Nicholas and St. Lythan's on the Dyffrin estate, at Cotterell near Peterston, and at Arthur's Stone in Gower. The Sarn Helen, an ancient road, traverses the county. At Llantwit Major, near Cowbridge, was the once famous divinity school founded by St. Germanus, and presided over for an incredible term of years by St. Iltyd. Every stone in this old-world town is "of old memorial." Coity, Coychurch, and Ewenny, near Bridgend, present a fine trio of cross churches, with fortified or embattled towers, characteristic of the county.

South of Swansea lies the promontory of Gower, famed for the beauty of its coast scenery, its people of Flemish descent, planted here by Henry I., and its bone-caves. The last, in the limestone cliffs, accessible only at low water, are at Bacon Hole, Paviland, and Rhosilly Bay.

Besides its ports, Glamorgan has abundant means of transit in four railways and a canal, beside numerous tramways. The county is divided into 128 parishes and 10 hundreds, and is situated in the diocese of Llandaff. The cathedral, 2 miles from the county town of Cardiff, having fallen into decay through the neglect of ages previous to 1844, owed its restoration to a beauty befitting the prestige of the earliest Christian see to the energetic endeavors of Dean Thomas Williams. It was completed in 1869.

The great changes of recent years in elementary education have curiously affected the statistics of schools in Glamorgan. Whereas in 1847 there were 327 day schools in all, with 15,674 scholars, in 1877 the parliamentary return shows a great reduction in the number of schools, though these have probably a much larger aggregate of scholars. This return exhibits 226 public elementary schools in Glamorgan, of which 56 were board-schools, 30 British and foreign, 12 Roman Catholic, 1 Wesleyan, and the remainder national, parochial, and Church of England schools. Of these schools 41 had each in average attendance upwards of 300 scholars, and 2 had upwards of 1000. Fourteen only had night schools in operation. As in other south-west counties, the Welsh language is losing ground, except in remote agricultural districts.

In 1851 the population of the county was 231,849, 120,748 males and 111,101 females; and in 1871 it was 397,859, 205,660 males and 192,199 females. The population has increased since the first census in 1801 by 326,980 persons, or 451 per cent. The county returns two members to parliament, the borough of Merthyr one, and the Cardiff and Swansea districts of boroughs one each, a total of five in all. In the year ending April, 1871, the amount of real property assessed to income and property tax was £1,219,922. The principal towns with the populations in 1871 were—

Aberavon[1]	3,574	Llantrisaint[2]	2,039
Aberdare	36,112	Lloughor[1]	1,220
Bridgend	3,539	Merthyr Tydvil	51,949
Cardiff[2]	39,536	Neath[1]	9,319
Cowbridge[2]	1,134	Swansea[1]	51,702
Kenfig[1]	591		

The bibliography of the county is stronger in such old chronicles as the *Brut y Tywysogion* than in modern researches. Among its important contributions to the *Archæologia Cambrensis* may be mentioned the Rev. H. H. Knight's *Account of Newton Nottage in 1853*; and Dr. Thomas Nicholas's *History of the Annals and Antiquities of Glamorganshire* is the foundation of his *Counties and County Families of Wales*. (J. DA.)

GLANDERS, or Equinia, a specific infectious disease to which certain animals, chiefly those possessing an undivided hoof, are liable, and which is communicable from them to man. The term farcy is also employed to designate a variety of this affection, but there is no pathological distinction between the two. The disease as it affects animals belongs to the subject of Veterinary Medicine.

Glanders is happily a rare form of disease in man, there being evidently less affinity for its development in the human subject than in the equine species. It occurs chiefly among those who from their occupation are frequently in contact with horses, such as grooms, coachmen, cavalry soldiers, veterinary surgeons, etc., and seems always produced either by direct inoculation of the virus from a diseased animal into the broken skin, or by the respiration of air containing the poison. It is said to have occasionally been transmitted from man to man, but such an occurrence is extremely rare.

A period of incubation, lasting from three to five days, generally follows the introduction of the virus into the system. This period, however, appears sometimes to be of much longer duration, especially where there has been no direct inoculation of the poison. The first symptoms are a general feeling of illness, accompanied with pains in the limbs and joints resembling those of acute rheumatism. If the disease has been introduced by means of an abraded surface, pain is felt at that point, and inflammatory swelling takes place there, and extends along the neighboring lymphatics. An ulcer is formed at the point of inoculation which discharges an offensive ichor, and blebs appear in the inflamed skin, along with diffuse abscesses, as in phlegmonous erysipelas. Sometimes the disease stops short with these local manifestations, but more commonly goes on rapidly accompanied with symptoms of grave constitutional disturbance. Over the whole surface of the body there appear numerous red spots or pustules, which break and discharge a thick mucous or sanguineous fluid. Besides these there are larger swellings lying deeper in the subcutaneous tissue, which at first are extremely hard and painful, and to which the term farcy "buds" or "buttons" is applied. These ultimately open and become extensive sloughing ulcers.

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[1] Contributory to Swansea parliamentary district of boroughs.
[2] Contributory to Cardiff parliamentary district of boroughs.

The mucous membranes participate in the same lesions as are present in the skin, and this is particularly the case with the interior of the nose, where indeed, in many instances, the disease first of all shows itself. This organ becomes greatly swollen and inflamed, while from one or both nostrils there exudes a copious discharge of highly offensive purulent or sanguineous matter. The lining membrane of the nostrils is covered with papules similar in character to those on the skin, which form ulcers, and may lead to the destruction of the cartilaginous and bony textures of the nose. The diseased action extends into the throat, mouth, and eyes, while the whole face becomes swollen and erysipelatous, and the lymphatic glands under the jaws inflame and suppurate. Not unfrequently the bronchial tubes become affected, and cough attended with expectoration of matter similar to that discharged from the nose is the consequence. The general constitutional symptoms are exceedingly severe, and advance with great rapidity, the patient passing into a state of extreme prostration. In the acute form of the disease recovery rarely if ever occurs, and the case generally terminates fatally in a period varying from two or three days to as many weeks.

A chronic form of glanders and farcy is occasionally met with, in which the symptoms, although essentially the same as those above described, advance much more slowly, and are attended with relatively less urgent constitutional disturbance. Cases of recovery from this form are on record; but in general the disease ultimately proves fatal by exhaustion of the patient, or by a sudden supervention, which is apt to occur, of the acute form. On the other hand, acute glanders is never observed to become chronic.

In the treatment of this malady the main reliance is to be placed on the maintenance of the patient's strength by strong nourishment and tonic remedies. If the point of inoculation of the virus can be early made out, its active cauterization, as in the case of any poisoned wound, should be resorted to. The opening of abscesses antiseptically, as well as the use of antiseptic lotions for the affected mucous membranes, is recommended. In all cases of the outbreak of glanders it is of the utmost consequence to prevent the spread of the disease by the destruction of affected animals, and the cleansing and disinfection of infected localities.

GLANVIL, GLANVILL, or GLANVILLE, RANULPH DE (died 1190), the oldest writer on English jurisprudence and chief justiciary of England in the reign of Henry II., was born at Stratford in Suffolk, but in what year is unknown. There is also almost no information regarding his early life. Butterley Abbey was founded by him in 1171. In 1174, along with other barons of Yorkshire, he raised a body of knights to oppose William the Lion, king of Scotland, who had invaded the north of England, and it was he who took the king prisoner at Alnwick. In 1175 he was appointed sheriff of Yorkshire, in 1176 justice of the king's court and a justice itinerant in the northern circuit, and in 1180 chief justiciary of all England. It was under his direction that Henry II. completed his judicial reforms, but the principal of them had been carried out before he came into office. After the death of Henry in 1189 Glanvil was removed from his office by Richard I., and imprisoned till he had paid a ransom, according to one authority, of £15,000. Shortly after obtaining his freedom he joined the order of the cross, and he died at the siege of Acre in 1190. At the instance, it is supposed, of Henry II., Glanvil wrote or superintended the writing of the *Tractatus de legibus et consuetudinibus regni Angliæ*, which is divided into 14 books, and is chiefly a practical treatise on the forms of procedure in the *curia regis* or king's court, the principles of law involved in these forms being only incidentally referred to. As the source of our knowledge regarding the earliest form of the *curia regis*, and for the information it affords regarding ancient customs and laws, it is of great value to the student of English history. It is now generally agreed that the work of Glanvil is of earlier date than the *Regiam Majestatem*, a work which bears a close resemblance to his. To him is also ascribed the recension of English laws made in the reign of Henry II.

The treatise of Glanvil was first printed in 1554. An English translation, with notes and introduction by John Beames, was published at London in 1812. A MS. copy of a Norman-French translation, made apparently in the reign of King John, is contained in the library of the duke of Northumberland at Alnwick Castle.

GLANVILL, or GLANVIL, JOSEPH (1636–1680), was born at Plymouth in 1636, and was educated at Oxford university, where he graduated as M.A. in 1658. In 1666 he obtained the cure of Abbey Church at Bath; in 1678 he became prebendary of the church of Worcester, and acted as chaplain in ordinary to Charles II. He died at Bath, November 16, 1680, in the forty-fourth year of his age. Glanvill's first work, *The Vanity of Dogmatizing, or Confidence in Opinions, manifested in a Discourse of the shortness and uncertainty of our Knowledge, and its Causes, with Reflections on Peripateticism, and an Apology for Philosophy*, 1661, is interesting as showing one special direction in which the new method of the Cartesian philosophy might be developed. Pascal had already shown how philosophical scepticism might be employed as a bulwark for faith, and Glanvill follows in the same track. The philosophic endeavor to cognize the whole system of things by referring all events to their causes appears to him to be from the outset doomed to failure. For if we inquire into this causal relation we find that though we know isolated facts, we cannot perceive any such connection between them as that the one should give rise to the other. In the words of Hume, "they seem conjoined but never connected." All causes then are but secondary, are merely the occasions on which the one first cause operates. It is singular enough that Glanvill, who had not only shown, but even exaggerated, the infirmity of human reason, himself paid a strange tribute to its weakness; for, after having combated scientific dogmatism, he not only yielded to vulgar superstitions, but actually endeavored to accredit them both in his *Scepsis Scientifica*, 1665, and in his *Philosophical Considerations concerning the existence of Sorcerers and Sorcery*, published in 1666, in 4to. The story of the pretended drum, which was said to have been heard every night in the house of an inhabitant of Wiltshire (Mr. Mompesson), a story which made much noise in the year 1663, and which is supposed to have furnished Addison with the idea of his comedy of the *Drummer*, appears to have given occasion to the latter work. At his death Glanvill left a piece entitled *Sadducismus Triumphatus*, which was printed in 1681, reprinted with some additions in 1682, and translated into German in 1701. He had there collected twenty-six relations or stories of the same description as that of the drum, in order to establish, by a series of facts, the opinion which he had expressed in his *Philosophical Considerations*. Glanvill supported a much more honorable cause when he undertook the defence of the Royal Society of London, under the title of *Plus Ultra, or the Progress and Advancement of Science since the time of Aristotle*, 1658, a work which shows how thoroughly he was imbued with the ideas of the empirical method as in Bacon. The style of Glanvill is clear, easy, and animated; and to the student of philosophy his words are of considerable interest.

Besides the works already noticed, Glanvill wrote *Lux Orientalis*, 1662; *Philosophia Pia, or Discourse on the Religious Character, and the Tendency of Experimental Philosophy; Essays on Several Important Subjects in Philosophy and Religion*, 1676; *An Essay concerning Preaching*; and *Sermons*. After his death in 1681, there were published other sermons, etc., in one volume, 4to. See Rémusat, *Hist. de la Phil. en Angleterre*, bk. iii. ch. xi.

GLARUS, or GLARIS, a canton of Switzerland, is bounded on the N. and N. E. by St. Gall, on the E. and S. by the Grisons, and on the W. by Uri and Schwyz. Its area is 266 or 267 square miles, its greatest length about 33 miles, and its greatest breadth about 16. A thoroughly Alpine district, sloping northwards from the lofty range which comprises the Tödi (11,887 feet), the Biferten Stock (11,237), and the Scheibe (9587), and including within its limits the Glärnisch (9584) and the Mürtschen Stock (8012), Glarus is almost completely cut off from the neighboring cantons, except towards the south. Of the three passes, the Segnes, the Kisten, and the Panix, which communicate with the Grisons, the first and second are over the snow, and the third has only a bridle-path; and the Klausen pass and the Pragel pass, which conduct respectively to Schwyz and Uri, have also mere bridle-paths. As far as it is a habitable country it may be said to consist of the valley of the Linth, which extends from the Tödi southward to the Wallenstadt Lake along with the lesser valleys of the Sernf (or Sernft) and the Klön, which branch off to the east and the west. The climate, it need hardly be said, is a severe one, the snow generally remaining, even in the lowlands, till near the beginning of May. The föhn at times blows with terrific violence; and, by a law enforced in the town of Glarus, every fire in the place must be extinguished as soon as it sets in. The chief sources of wealth in the canton are the pastures and the manufacturing industries. Though copper, silver, and iron mines were formerly wrought, the only mineral production now of commercial importance is slate, which is extensively quarried in the Plattenberg. Not more than a fifth of the soil is capable of cultivation by the plough, and the agricultural produce has consequently to be supplemented by foreign supplies. About 9000 or 10,000 head of cattle are pastured in the canton, and according to the census of 1876 there are 2000 sheep, 6900 goats, and 3000 swine. Neither butter nor ordinary cheese is made in sufficient quantities for the local consumption, but the *Schabzeiger*, *Schotter Käse*, *Kräuterkäse*, or "green cheese," made of skim milk, whether of goats or cows, mixed with buttermilk and colored with powdered *steinklee* (*Melilotus cærulea*), is still largely manufactured. The curd is brought down from the mountain chalets in sacks, which contain about 200 ℔ each. After being ground for about 2½ hours in a mill along with the *klee* powder, which is added in the proportion of 3 ℔ to the 100, the curd is put into shapes, and pressed in the usual way. It grows ripe in about a year and keeps a long time. Large quantities are exported to America. The cotton manufacture is the staple of the canton, and gives support to about a fourth of the population. Formerly distributed through the country as a domestic industry, it is now concentrated in a few factory towns and villages, which in the aggregate keep about 250,000 spindles going. The cotton goods are sent to the East, America, and Africa. It is not only in their own little country that the people of Glarus find a field for their energies; they have contributed to the industries of many parts of Europe, and their poorer emigrants have founded three flourishing settlements in Wisconsin—New Glarus, Vilten, and New Elm. The population, which in 1851 was 30,213, had increased by 1870 to 35,150, and was estimated in 1876 at 36,179. The vast majority are Protestants, only 6888 being Catholics, according to the census of 1870. The constitution of Glarus is of the simplest kind, and extremely democratic. According to the law of 1842, revised and sanctioned by the federal council in 1851, the government rests in the hands of a Landesgemeinde or assembly of the whole male population above the age of eighteen, which usually meets on the first Sunday in May, and elects the cantonal officials, votes the income and poll-taxes, and passes or rejects any laws that may be presented by the cantonal council or Landesrath. The cantonal council consists of 117 members. A council of 45 members, and a committee of 9 members have control of the executive. The landamman is president of the committee, the executive council, the cantonal council, and the assembly. Justice is administered by five courts completely independent of the Government. Freedom of the press, freedom of religious worship, and freedom of trade and industry are all guaranteed. Aliens are readily naturalized and admitted to the rights of citizens. The canton is divided into 25 communes, only one of which, that of Glarus, has more than 5000 inhabitants, while 16 have less than 1000, and the smallest has only 231.

Glarus, the capital of the canton, is a flourishing little town on the left bank of the Linth, about 1495 feet above the sea-level. Its environment is a remarkable one: to the S. the Glärnisch rises 6153 feet; to the N. W. the Wiggis, 6033; and to the E. the Schild, 6010. The fire of 1861 devastated the greater part of the town, destroying its Gothic church of the 10th century, the casino, the Government houses, and all its principal buildings; 2000 of the inhabitants were rendered houseless, and property to the value of 8,000,000 francs was destroyed. Contributions, however, were sent in from far and near to the amount of 2,754,606 francs, the federal authorities of Switzerland voted a loan of 1,000,000 at two per cent., and the canton furnished a subsidy at three per cent.; the town was rapidly rebuilt in a substantial and regular style, and the public edifices restored. The church is used in common by the Protestants and the Roman Catholics. The high school accommodates 700 pupils. Most of the population, which in 1870 numbered 5516, are supported by the cotton manufacture carried on in the town and the vicinity. A certain trace of rustic life is still maintained, as the operatives have each a bit of ground in the "almend." On the opposite side of the river lies the industrial village of Enneda.

In the end of the 5th century an Irish monk, Fridolin, the founder of the convent of Seckingen on the Rhine, built a church on the site of the present town, and the name of St. Hilarius, which he gave it in honor of his patron the bishop of Poitiers, in course of time became corrupted to Glarus or Glaris. The whole valley was reckoned to the estates of the abbey of Seckingen, and it was governed by a mayor or bailiff whose nomination was vested ultimately in the Hapsburg family. The tyranny of these officers constrained the people of Glarus to join the Helvetic confederation in 1352, and in 1388 they secured their independence by a victory over the Austrians at Näfels, the anniversary of which is still celebrated on the second Thursday of April. Zwingli the Reformer was curate of Glarus from 1506 to 1516, and by 1530 the new doctrines had been accepted by five-sixths of the population of the canton. The two religious parties, though they were happily prevented from appealing to arms, continued long in a state of mutual alienation and suspicion; the Protestants, for example, would have nothing to do with the Gregorian calendar because it was introduced by the papal party. At length a settlement of a peculiar kind was effected in 1683. Each confession was allowed to have a cantonal assembly, a cantonal council, and officials of its own; while for all matters in which both parties were interested there was a cantonal assembly and a cantonal council for discussion and administration in common. It was in the beginning of the 18th century that the present prosperity of the canton received its original impulse. Cotton-spinning was introduced in 1712 by Heidegger of Zurich, and weaving and calico-printing followed before 1750. The population of the canton increased from 15,000 to 20,000 during the century. The effects of the great Revolution were beneficially experienced, and the early part of the 19th century was marked by numerous improvements, political and social. Till 1811 the lower course of the Linth was extremely irregular, and its inundations had gradually turned a large stretch of country into a swamp; but, under the patronage and direction mainly of Escher (von der Linth, as he came afterwards to be called), there was constructed a magnificent system of canals which completely remedied the evils, and the desolate region soon became one of the finest parts of the canton. The whole cost of the works up till 1823 was 974,553 francs. When the new constitution of 1836 was introduced, the Roman Catholic minority, whose influence it greatly diminished, were urged on by Bossi, the bishop of Chur (Coire), to break off from their Protestant countrymen; but the Government expelled the few priests who refused to take the oath, and separated the canton from its connection with the diocese of Chur. After Bossi's death the decree of separation was revoked. In the Sonderbund war of 1847 Glarus was true to the federation; and the same spirit was shown in the voting about the constitution in 1872–5.

See Valentin Tschudi, *Kurze historische Beschreib- oder Erzellung, der in Kriegsund Fridenszeiten verloffenen Sachen und Händlen zu Glarus*, a 16th-century chronicle, printed by J. J. Blumer, *in Archiv für Schweizerische Geschichte*, Zurich, vol. ix., 1853; Johann Heinrich Tschudi, *Beschreibung des Lobl. Orths und Lands Glarus*, Zurich, 1714; Christoph Trümpi, *Neuere Glarner-Chronik*, Wintherthur, 1774; J. M. Schuler, *Die Linththäler*, Zurich, 1814; *Rėsultat moral du desseche des marais de la Linth*, Geneva, 1825; Melchior Schuler, *Geschichte des Landes Glarus*, Zurich, 1834; J. J. Bäbler, *Geschichte u. Inhalt der alten Verträge zwischen den Reformirten u. Katholiken im Kanton Glarus*, Glarus, 1836; J. J. Blumer, "Das Thal Glarus unter Seckingen und Oesterreich und seine Befreiung," in *Archiv für Schweizerische Geschichte*, Bd. iii. Zurich, 1844; Dr. Oswald Heer and J. J. Blumen-Heer, *Der Kanton Glarus, historisch-geographisch-statistisch geschildert*, St. Gall, 1846, forming part of *Gemälde der Schweiz*; Oswald Heer, *Escher von der Linth, Ein Lebensbild*, Zurich, 1873; Egli, *Taschenbuch Schweizer. Geographie*, Zurich, 1875.

GLAS, John (1695–1773), the founder of the sect generally known as Glassites or Sandemanians, was born at Auchtermuchty, Fife, where his father was parish minister, on the 5th of October, 1695. On completion of his education for the ministry at the universities of St. Andrews and Edinburgh, he was licensed as a preacher by the presbytery of Perth, and soon afterwards ordained by that of Dundee as minister of the parish of Tealing (1719). During his ministry there he gradually formed peculiar opinions, which as early as 1725 found expression in the formation of a society "separate from the multitude," numbering nearly a hundred, and drawn from his own and neighboring parishes. The members of this *ecclesiola in ecclesia* pledged themselves "to join together in the Christian profession, to follow Christ the Lord as the righteousness of his people, to walk together in brotherly love, and in the duties of it in subjection to Mr. Glas as their overseer in the Lord, to observe the ordinance of the Lord's Supper once every month, to submit themselves to the Lord's law for removing offences" (Matth. xviii.), and so on. From the scriptural doctrine of the essentially spiritual and heavenly nature of the kingdom of Christ, Glas in his public teaching drew the conclusions, not only that the church, as being identical with that kingdom, ought to consist of none but truly spiritual Christian men, but also that the civil establishment of the church was unlawful and utterly inconsistent with the spirit of Christianity.[1] For the promulgation of these views, which were confessedly at variance with the doctrines of the standards of the national Church of Scotland, he was summoned (1726) before his presbytery, where, in the course of the investigations which followed, he affirmed with still more explicitness than formerly his belief that "every national church established by the laws of earthly kingdoms is antichristian in its constitution and persecuting in its spirit," and further declared opinions upon the subject of church government which amounted to an entire repudiation of Presbyterianism and an acceptance of Independency. For these opinions he was in 1728 suspended from the discharge of ministerial functions, and finally in 1730 deposed; the members of the society already referred to, however, for the most part continued to adhere to him, thus constituting the first "Glassite" or "Glasite" church. The seat of this congregation was shortly afterwards transferred to Dundee, whence Glas subsequently removed to Edinburgh, where he officiated for some time as an "elder." He next labored in Perth for a few years, but ultimately returned to Dundee, where the remainder of his life was spent. In 1739 the General Assembly, without any application either from him or from his friends, removed the sentence of deposition which had been passed against him, and restored him to the character and exercise of a minister of the gospel of Christ, though declaring that he was not to be esteemed a minister of the Established Church of Scotland, or eligible for a charge, until he should have renounced the principles embraced and avowed by him that were inconsistent with the constitution of the church. Besides the *Testimony* Glas wrote a number of papers, expository, polemical, or practical, which were published in a collected edition at Edinburgh in 1761 (4 vols. 8vo), and again at Perth in 1782 (5 vols. 8vo). He died in 1773.

The Glassite denomination, which has never been a numerous one, is distinguished by a number of peculiarities alike in doctrine, discipline, and worship, some of which have already been indicated. One of the most characteristic of its tenets is that which owes its elaboration to Robert Sandeman (1718–1771), the son-in-law of Glas, from whom is derived the name of Sandemanians, by which the sect is principally known in England and America. In a series of letters (1757) to Hervey, the author of *Theron and Aspasio*, he maintained that justifying faith is a simple assent to the divine testimony concerning Jesus Christ, differing in no way in its character from belief in any ordinary human testimony. No distinctive theological system, however, has as yet been elaborated from this point of view. In their practice the Glassite churches aim at a strict conformity with the primitive type of Christianity as that is understood by them. Each congregation has a plurality of elders, pastors, or bishops, who are chosen according to what are believed to be the instructions of Paul, without regard to previous education or present occupation, and who enjoy a perfect equality in office. To have been married a second time disqualifies for ordination, or for continued tenure of the office of bishop. In all the action of the church unanimity is considered to be necessary; and if any member differ in opinion from the rest, he must either surrender his judgment to that of the church or be shut out from its communion. To join in prayer with any one who is not a member of the denomination is regarded as unlawful, and even to eat or drink with one who has been excommunicated is held to be a heinous sin. The Lord's Supper is observed weekly; and between forenoon and afternoon service every Sunday a love feast, at which it is incumbent on every member to be present, is held after the manner of the primitive Christians. Mutual exhortation is practised at all the meetings for divine service, it being lawful for any member who possesses the gift to speak. The practice of washing one another's feet was at one time observed; and it is still customary for each brother and sister to receive new members, on admission, with a holy kiss. "Things strangled" and "blood" are rigorously abstained from; the lot is regarded as sacred; the accumulation of wealth is regarded as unscriptural and improper, and each member considers his property as liable to be called for at any time to meet the wants of the poor and the necessities of the church. The number of adherents at present belonging to the denomination is probably a little under 2000.

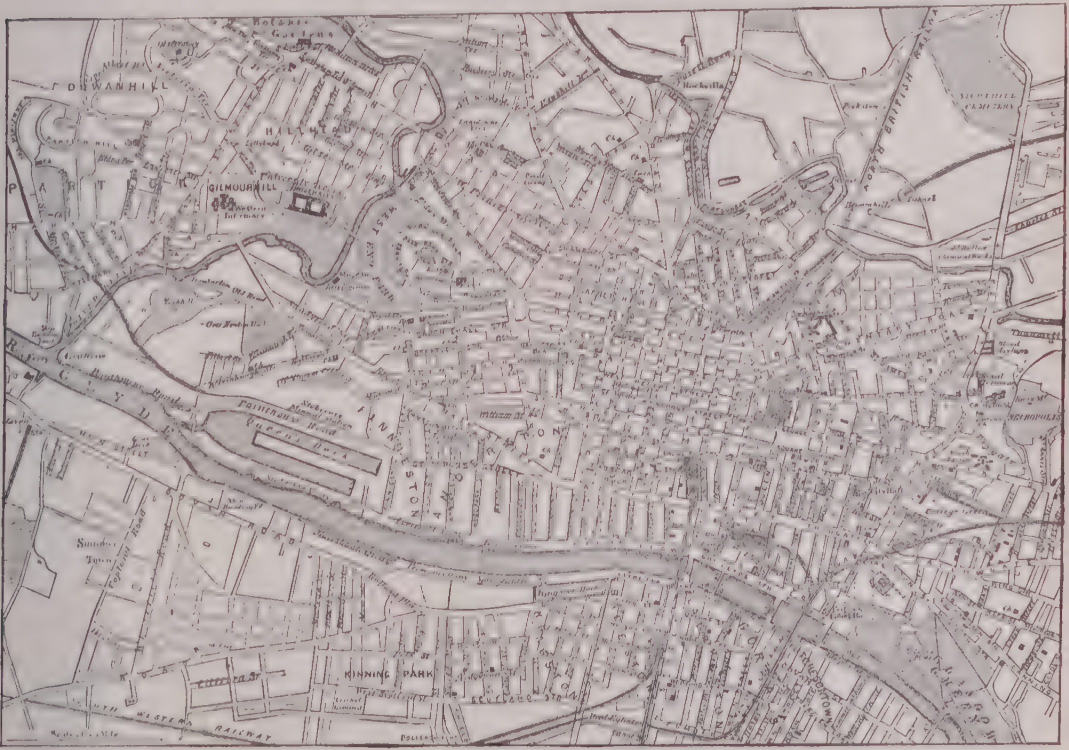
GLASER, Christopher, one of the minor chemists of the 17th century, concerning the details of whose life very little is known. He was a native of Basel, came to Paris, succeeded Lefebvre as demonstrator on chemistry in the Jardin du Roi, and was appointed apothecary to Louis XIV. and to the duke of Orleans. He is best known to us by his *Traité de la Chymie* (Paris, 1663), which gives a very favorable idea of the chemical science of his time. The little work went through some ten editions in about five-and-twenty years, and was translated into both German and English. Dumas and other writers, indeed, have spoken very disparagingly both of the *Traité* and of the author's merits and character, but this adverse judgment appears to rest on altogether insufficient grounds. One thing very much against Glaser is his alleged connection with the marchioness de Brinvilliers. It does not appear, however, that he had any share in the notorious poisonings beyond making the deadly substances which the marchioness and others employed in secret. He appears to have died some years before 1676. A salt (the normal sulphate of potassium) which he showed how to prepare, and the medicinal properties of which he pointed out, was named *Glaseri sal polychrestum*, or salt of many uses. The native sulphate is still known as *glaserite*.

GLASGOW, the most populous city in Great Britain next to London, is situated on the banks of the river Clyde, in the Scottish county of Lanarkshire, about 20 miles above Greenock, where the river spreads out into a noble estuary, with branching lochs running deep into the heart of the Western Highlands. It is within ten hours' railway run (405½ miles) of the metropolis, and an hour and a quarter (45 miles) of Edinburgh—the latitude being 55° 51′ 32″ N., and the longitude 4° 17′ 54″ W. The extreme breadth of the city is about 3¼ miles from north to south, and the extreme length 5 miles from east to west. The circumference is about 10 miles; and the area embraced within the municipal boundaries is now (1879) 6111½ acres. The population when the last census was taken in 1871 was 477,732, but, during the eight years that have elapsed, the increase of inhabitants both in the city proper and in its suburbs has been very great. It is within the mark to say that above 100,000 have been added to the population of the city; this indeed is the estimate given in official registration returns, which set down the population estimated to the middle of 1879 as 578,156. The smaller burghs which have sprung up round Glasgow within the last twenty or thirty years have kept pace with the mother burgh in development, and now contain a population amongst them of about 170,000. As these burghs are essentially parts of Glasgow, having been formed by the overflow of its population, they ought to be added to the city in any estimate of its size and importance. The population of Glasgow, taking this basis, is therefore close upon three-quarters of a million (750,000). The increase of the population during the present century has been greater perhaps than that of any other city or town of the Old World. In 1801 it was only 77,385; in 1821 it was 147,043; in 1841, 255,650; in 1861, 395,503; and in 1871, 477,732. In 1877 the dwelling-houses numbered 105,062, and the rental exceeded £3,250,000.

Unlike the "grey metropolis of the north," Glasgow shows rather poorly in the history of Scotland. Its own real history—the history of its commerce and industries—can hardly be dated farther back than the beginning of the last century, when the union of England and Scotland roused into extraordinary activity the trading spirit of its inhabitants. And yet Glasgow is an old city. Its foundations were laid when the half-mythical Kentigern sat down by the banks of the Molendinar, to teach the rough Celts of Strathclyde the truths of Christianity. It was about the middle of the 6th century that this apostle of truth made his appearance in the west of Scotland, and built his little wooden church on the spot upon which some centuries later his successors reared the noble cathedral which still stands in perfect beauty. One can only guess that the inhabitants of this portion of Strathclyde gathered round the abode and church of St. Mungo, and that as the site was pleasant, and the Molendinar and the Clyde supplied ample store of trout and salmon, the village under the fostering care of the

[1] His argument is most fully exhibited in a treatise entitled *The Testimony of the King of Martyrs concerning His Kingdom* (John xviii. 86, 37) *Explained and Illustrated* (1729).

monks grew slowly till it became a place of importance. Of that growth, however, nothing is really known till we reach the 12th century. In the year 1115 an investigation was ordered by David, then prince of Cumbria, of the lands and churches belonging to the bishopric of Glasgow, and from the deed which still exists it is evident that at that time a cathedral had been endowed. A few years later David succeeded to the Scottish throne on the death of his brother, Alexander I., and among the many endowments he made for religious purposes, we find that he gave to the see of Glasgow the lands of Partick, besides restoring many possessions of which it had been despoiled. Jocelyn was bishop of Glasgow for a long period, and is memorable for the efforts he made to rebuild the cathedral which had been destroyed by fire. He collected funds with so much success that in 1197 the new structure was sufficiently advanced to be dedicated. The next bishops of note were Bodington and Wisheart. The former carried on the building work of Jocelyn; the latter was a patriotic Scot who resisted the conquering army of Edward I., and was among the first to join in the revolt of Wallace, and to receive Robert Bruce when he was proscribed by Edward and lay under the ban of the church for the murder of the Red Comyn. Wisheart was a prisoner from the year 1306 to the battle of Bannockburn, and he lived to see Bruce firmly established upon the Scottish throne. Bishop Rae deserves mention for having built a stone bridge over the Clyde (1345). Bishop Turnbull was the greatest benefactor the city had till then found; for he was the founder of Glasgow university (1450). He also received a charter from James II. in 1420, erecting the town and the lands of the bishops into a regality. In 1491 the see was made metropolitan through the influence of James IV., who had been a canon of the cathedral in early life. The last Roman Catholic archbishop of Glasgow was James Bethune, consecrated in 1552. At the Reformation in 1560 the archbishop fled to France, carrying with him all the relics, documents, and valuables belonging to the see. The cathedral, upon which so much care had been bestowed by the successors of Bishop Jocelyn, very nearly suffered the devastation which was inflicted upon so many abbeys and churches by the more bigoted of the Reformers. It was saved by the craftsmen of Glasgow turning out in their strength and chasing away the destroyers of the "rookeries," who had already begun to lay sacrilegious hands upon the venerable building. After the Reformation, and till the Revolution of 1688, which re-established Presbyterianism as the religious form of worship in Scotland, the see of Glasgow was occupied by a number of archbishops, the tenure of whose office in many cases was precarious. The most notable fact after the Reformation in the history of the Glasgow Church was the Assembly of 1638 which was held in the city, when Episcopacy was energetically abjured, the Solemn League and Covenant accepted, and its signature made binding upon all who claimed the ordinances of the Presbyterian Church. The fact that the craftsmen were zealous for the preservation of their fine old cathedral indicates probably that the Reformation doctrines were not received so enthusiastically in Glasgow as in many other places in Scotland; but they took deep root latterly, and in the struggles for religious and civil liberty in the 17th century the inhabitants were among the foremost to assist and endure in the good cause.



Plan of Glasgow (central portion).

Glasgow owed its erection into a burgh to its ecclesiastic lords. One of these obtained a royal charter from William the Lion in the last quarter of the 12th century (between the years 1175 and 1178), which made the town a burgh, and gave it a market with freedom and customs. Another charter, it is supposed, was granted in 1190, and according to a deed dated 1268 the town was governed by a provost and bailies, and had courts of justice for settling disputes among the inhabitants. There are no records, however, till almost quite recent times. A few incidents of national history with which Glasgow was connected may be noted, to fill up the blank from the period when it was an ecclesiastical town to the date at which it started its great career as the capital of Scottish industry and commerce. Wallace fought one of his successful battles for Scottish liberty in the High Street of Glasgow in the year 1300. In 1350 the plague raged in the city, and returned thirty years afterwards, though not in so severe a form. About 1542 the bishop's castle, which was garrisoned by the earl of Lennox, was besieged by the earl of Angus, then regent, and after its surrender on terms which were dishonored, a skirmish took place between the parties at the Butts to the east of the town. The regent's troops were successful, and to punish the inhabitants for their devotion to the Lennox family the town was pillaged. The unfortunate Queen Mary visited her husband Darnley when he lay ill at his father's house Limmerfield, near Glasgow—a visit which afterwards was made of fatal significance to her when her case was heard before Queen Elizabeth in council. The inhabitants of Glasgow had no liking for the fair queen, for many of them fought against her at the battle of Langside, where she lost her crown and kingdom. Glasgow seems to have been fairly prosperous after the accession of James VI. and the union of the crowns of England and Scotland. It was recovering from the loss which it sustained by the Refomation through the dispersion of the wealth of its ecclesiastical lords. A little trade was springing up with foreign parts, chiefly with the Low Countries. But the city suffered somewhat severely in the reign of Charles I. Its inhabitants had become fiercely anti-prelatical, and were obnoxious to the ruling powers. When Montrose in his victorious course marched into the city after the battle of Kilsyth he levied a heavy contribution, although the city was suffering at the time from one of the periodical visits of the plague. In 1648 the provost and his bailies were deposed for contumacy to Charles I., and were imprisoned for a few days, while four regiments of foot and horse were quartered on the magistrates, council, and session. Plague and famine prevailed during the following year; in 1652 there was a great fire which destroyed about a third of the town and £100,000 worth of property. After the restoration of Charles II., and during the persecutions of his and his brother's reign, Glasgow suffered severely. It was a centre of disaffection against the Government, the headquarters of the Whigs of the west of Scotland. Glasgow prison was filled to overflowing with the rebels, as they were called, and it is a proof of the sympathy with which they were regarded by the citizens that on the occasion of another great fire in 1678 the doors of the prison were thrown open, and the prisoners set at liberty. The Government retaliated by sending an army of wild Highlanders to the city, who savagely oppressed the inhabitants and roused up the spirit of resistance which vented itself at London Hill and Bothwell Bridge. With the Revolution peace and prosperity came to Glasgow, only to be partially interrupted by the risings in 1715 and 1745. A regiment of 500 men was raised in Glasgow to support William and Mary and Presbyterian rights and privileges; and in return the city was declared free by a charter, the citizens having the right of electing their own municipal rulers.

Glasgow was not aware of the vast benefits that were conferred upon her by the union of England and Scotland in 1707. The measure was stoutly resisted by the inhabitants, and its proclamation nearly led to a riot; but the merchants very soon saw that by the water highway which flowed through the town they could have access to the profitable trade that had been opened up in North America. Glasgow's situation for the western foreign traffic was the best in Scotland, and inferior to none of the great towns of England. The Treaty of Union put every Scottish port, so far as trade was concerned, on an equal footing with the English ports; and there was no reason why Glasgow should not share in the wealth which in ever-increasing amount was yearly coming across the Atlantic. As has been already stated, after the troublous times of the Reformation the trade prosperity of Glasgow was considerable. In the middle of the 16th century there were ten towns in Scotland above it in population and importance, but by the close of the 17th century it had risen to the second rank, with a population of about 10,000 or 11,000. This increase is to be ascribed to the monopoly which the inhabitants had secured in the middle of the 17th century of the sale of raw and refined sugars for the most of Scotland. Besides this they had the right of distilling spirits from molasses free of duty; they conducted a considerable trade in cured herrings and salmon, were manufacturers of soap, and sent to the English ports hides and linen, bringing back in exchange tobacco and manufactured goods, which they distributed north of the Tweed. Bristol was then the great emporium of tobacco, and Glasgow's commercial connections with it naturally turned the attention of its traders to that lucrative branch of commerce. When it became possible for Glasgow merchants to enter into competition with the merchants of Bristol, companies were formed to carry on the trade with the North American colonies, and a large trade was soon established. Ships were chartered, and as wealth poured in were built, and sailed regularly for Virginia, Maryland, and Carolina, taking out goods in barter for cargoes of tobacco. In 1760 Glasgow had completely rivalled Bristol in the tobacco trade, and in 1772 its importations were more than half of the entire quantity brought into the United Kingdom. The Virginian trade being exceedingly lucrative, Glasgow flourished under it. The town rapidly extended westward, handsome mansion-houses for the "tobacco lords" were erected, and the austerity of manners which had come down from the covenanting days was somewhat relaxed. The money made by tobacco found its way into other branches of commerce and stimulated new industries. The tobacco trade, however, received a crushing blow at the outbreak of the American War,—a blow from which it never wholly recovered, for after the war was over, and the thirteen colonies had become the United States of North America, Glasgow was engaged in other commercial enterprises. The distress in the city was keen during the first years of the war, and Glasgow capitalists turned their attention to the West Indies and the cultivation of the sugar cane. The manufacture of cotton goods was introduced also about this time, and proved a new source of wealth and prosperity. Calico printing, which was soon to develop into a great industry employing thousands of persons, was started at Pollokshaws in 1742; the inkle loom was set up in 1732; glass-making was established in a feeble way in 1730; and the brewing of beer and ale on a large scale was attempted with success. In 1764 James Watt perfected his first model of a steam engine in a small workshop, which had been granted to him by the senatus of the university, within the college walls. From the Treaty of Union down to the end of the 18th century, the progress of the city had been remarkable. In 1708 the population was estimated to be upwards of 12,000; at the end of the century it was close upon 80,000.

The Harbor.—The energies of the traders of Glasgow were naturally somewhat confined by having a port so far away as Port-Glasgow, and there is little wonder that, when their commerce began to extend, they should have cast about for plans to deepen the water-way and enable them to bring their merchandise to their own warehouses in the city. The task which lay before them was one involving numerous difficulties. "A hundred years ago," says Mr. Deas, the engineer of the Clyde trust, in his interesting sketch of *The Rise and Progress of the Harbor of Glasgow*, "the river was almost in a state of nature, and was fordable on foot at Dumbuck Ford, more than 12 miles below Glasgow." As early as 1566 the authorities of the towns of Glasgow, Renfrew, and Dumbarton endeavored to remove a sandbank, a little above the latter town, and though operations were intermittingly carried on for some years, they do not appear to have been very successful. Prior to 1658 the shipping port of Glasgow was Irvine in Ayrshire, but the passage of lighters from that place was tedious and the land carriage expensive. It was determined in 1658 by the magistrates of Glasgow to purchase ground at Dumbarton, and construct a spacious harbor there. The magistrates of that royal burgh, however, objected, on the plea that "the great influx of mariners and others would raise the price of provisions to the inhabitants." The Glasgow authorities, however, were determined to have a harbor nearer than Irvine, and in 1662 they purchased 13 acres of ground on the south side of the river (now Port-Glasgow), where they built harbors and constructed the first graving dock in Scotland. In 1688 a quay was built at the Broomielaw, although nothing had yet been done for the deepening of the river. It was only after the city had experienced the vast importance of foreign traffic that the magistrates, most of whom were "tobacco lords," seriously turned their attention to the question. In 1740 the town council authorized the expenditure of £100 in making a deepening experiment below the Broomielaw quay, and fifteen years later they employed Smeaton the well-known engineer to report on the subject. He found the two shallowest places at the Pointhouse Ford, now the western boundary of the harbor, and at Hirst, now within the harbor. The depth at low water at the former was 15 inches, and at the latter 18 inches, while at high water it was 3 feet 3 inches and 3 feet 8 inches respectively. Smeaton proposed a lock and dam, four miles below Glasgow Bridge, so as to secure 4 feet 6 inches of water at the Broomielaw quay. Fortunately his report was not adopted. In 1768 the first beginnings were made on the report of Mr. John Golborne, who suggested the contraction of the river by the construction of rubble jetties and the removal of the shoals by dredging. James Watt reported in 1769 to the magistrates on the declivity of the bed of the Clyde from Broomielaw quay to that obdurate obstacle Dumbuck Ford. In 1773 Mr. Golborne contracted with the town council to make this ford 6 feet deep at low water and 300 feet wide, and carried out his contract successfully in 1775. Rennie reported on the river in 1799, and recommended "the shortening of some of the jetties, the construction of new ones, and the building of low rubble walls from point to point of the jetties so as to render the channel uniform, and prevent the accumulation of shoals." His suggestions were carried out, and upwards of 200 jetties were constructed between Glasgow and Bowling, the result being a considerable improvement in the navigation, and reclamation of land to the proprietors on both banks from the alveus of the river, the greater portion of which has since had to be purchased at high prices for other improvements. Telford reported in 1806, and Rennie again in 1807, and the deepening process went on without pause. In 1836 the engineer of the Clyde Trust reported to the trustees that there was then from 7 to 8 feet of water at the Broomielaw quay at low water, that the lift of a neap tide, which was only sensible in 1755, was 4 feet, and of a spring tide 7 or 8 feet, making a depth of 12 feet at high water of a neap and of 15 feet of a spring tide. The river had become capable of taking craft of 400 tons to Glasgow. In 1840 parliament sanctioned an Act for carrying out plans for the further improvement of the navigation of the entire river under the jurisdiction of the trustees. Upon the lines then laid down the improvements have ever since proceeded, with only very slight modifications, but the result may probably be best expressed in the following figures. In 1839 vessels of 17 feet draught of water were safely navigated to and from the harbor, in 1854 of 19 feet draught, in 1861 of 20 feet draught, in 1862 of 21 feet draught, and in 1870 of 22 feet draught. Only a few years ago vessels of 15 feet draught were two and often three tides in the river in their passage up and down, but now vessels of 22 feet draught leaving Glasgow two or three hours before high water get to sea in one tide. The rapidity of the deepening process has been due almost entirely to the powerful steam dredgers employed by the trustees, to the use of the diving bell for blasting purposes, and latterly to the introduction of steam drilling and dynamite. The quantity of dredged matter taken from the river every year is somewhere about a million and a quarter of tons, which is carried off by barges and deposited in Loch Long, an arm of the Firth running up into the Western Highlands. During the last thirty-one years upwards of 20 million tons have been dredged from the river, and since the year 1770 the cost for dredging and depositing alone has been between £500,000 and £600,000. The total expenditure upon the river since the year above named has been upwards of seven millions sterling; and the revenue, which a hundred years ago was £1733, is now about £210,000. The first dock constructed at the Glasgow harbor was opened so late as 1867. Though Acts of parliament had been obtained more than twenty years before, the sides of the river were utilized for quayage extension; but within the last ten or twelve years the pressure for space became very great, and the new dock, which is tidal, and covers 5⅓ acres of water space, was found to be quite inadequate. A new Act was obtained in 1870 to construct docks at Stobcross, and these, which are now nearing completion, will have an area of 30 acres, and will accommodate one million tons of shipping. The estimated cost, including the purchase of land, is £1,163,000.

The traffic on the Clyde received an extraordinary impetus by the application of steam to navigation, and from the date of the "Comet," which was built on the Clyde in 1811–12 for Mr. Henry Bell, Glasgow has been the true home of steam navigation. The steam shipbuilding trade has become one of the largest industries of the city, and with its growth the commerce of Glasgow has kept pace. The river has been the fruitful source of the city's greatness. As the accessibility of the water-way became greater year by year, so the commerce and the industries of the city developed, and the material wealth increased. Glasgow, too, is fortunate in being the centre of an enormous coal and iron field, in the working of which she has greatly benefited. Her industries, now very numerous, are referred to in detail below. They embrace almost every species of manufacture to be found in Great Britain; and this variety is probably the reason for the all but uninterrupted prosperity of the city, for it is rare that every department of manufacture and commerce is dull at the same time. Her resources are so numerous that she is not much affected by stagnation in one or two branches. But Glasgow has undoubtedly come through one or two crises of a serious character in the course of her industrial career. In 1857 the failure of the Western Bank struck a hard blow at her trade and commerce, though it was wonderful how soon she recovered from the heavy loss and the derangement of commercial affairs which were caused by the failure. The American Civil War paralyzed the cotton manufactures of Glasgow, as it did those of Lancashire; but otherwise it did little harm, and the stimulus that was given to shipbuilding by the carrying trade of the world practically falling into British hands more than compensated for other losses. The close of the American War was followed by a period of commercial and industrial activity in the city, which, however, sustained a severe check within the last two years, during which time trade has been languishing everywhere. While enterprising citizens were looking forward with some slight hope for signs of a revival, the collapse of the City of Glasgow Bank on the 2d October, 1878, fell upon them like a thunderbolt. In a few days after the stoppage it was known that matters were far worse than the most sinister prophet of evil could have imagined, much lest foretold. The whole of the capital and reserve of the bank, amounting to close upon a million and a half sterling, was squandered, and nearly five and a quarter millions besides. The total loss cannot be set down at much less than eight millions sterling, and the most of this enormous sum had gone to support great Indian and colonial firms, which had been hopelessly bankrupt for years. The inquiry into the affairs of the bank revealed such recklessness and misconduct on the part of some of those who were responsible for its management that the manager and the directors were tried on a charge of fabricating and uttering false balance sheets. They were all convicted, and sentenced to varied terms of imprisonment. Since this gigantic failure Glasgow has been passing through the greatest crisis of its existence.

Administration.—The affairs of Glasgow are managed by a corporation consisting of 48 representatives of the 16 wards into which the city is municipally divided, and by one representative from the Trades' and one from the Merchants' House. The lord provost is the head of the corporation, and is assisted in his executive functions by 10 bailies. The bailies hear and decide cases in the police courts, aided by assessors, who are local legal practitioners of good standing. There is also a stipendiary magistrate who sits every day in the central police court, and undertakes the heavier portion of the cases. The dean of guild court has a certain jurisdiction over the construction of new and the alteration of old buildings. The corporation of Glasgow, since it became popularly elected, has shown great and enlightened interest in the welfare of the city. It has during the last quarter of a century acquired three public parks for the recreation of the citizens, and laid them out in an ornamental manner. Within the same period, too, it has undertaken and carried out immense works for a supply of water unequalled in the kingdom, has bought up the old gas-works and supplies artificial light within and beyond the municipal boundaries, and is at present engaged in bringing to a successful close a series of city improvements on a very large scale.

City Improvements.—As the last-mentioned work is the most important upon which the corporation has been engaged since the introduction of Loch Katrine water, and formed the model upon which Mr. Cross, the home secretary, framed his Artisans Dwellings Act, a slight sketch of the plan upon which it was founded may be given here.

The city had grown so fast in population during the present century that it had become greatly overcrowded, especially in the central portions. From the leading thoroughfares of High Street, Saltmarket, Trongate, Gallowgate, and Argyll Street long narrow closes and wynds penetrated into the densely-built spaces behind. The population in these regions varied from 400 to 1000 per acre, and the dirt, darkness, and foul air in which the poor creatures lived, made their homes breeding-places of fevers and disease of every kind. In some of the worst spots the death-rate was 70 per 1000 per annum. The closes and wynds, besides being dens of disease, were the haunts of the criminal class of the population, who were able to dispose of their plunder and escape the police with comparative ease in these deep alleys, many of them connected with each other by ways only known to the experienced criminal. Some benevolent citizens made a small effort at improvement about twenty years ago, by buying up one of the most notorious of these closes; but it was not till the City Union Railway was projected that the attention of the municipality was fairly called to the question, or that any step was taken by it. The Union Railway passed through some portions of the old town which were densely overcrowded, and it was suggested by the late Mr. Blackie, who was then chief-magistrate, that the corporation might work in harmony with the railway company, and clear out old and densely-crowded properties, which the railway only touched at certain spots. Mr. Carrick, the city architect, drew out improvement plans, and in 1866 an Act was passed by parliament enabling the corporation to acquire old over-crowded localities, to borrow money, and to levy rates. The improvements contemplated involved the destruction of 10,000 houses, all of them really unfit for habitation, but which were filled by upwards of 50,000 souls. The corporation was bound by the Act to find accommodation for the dispossessed when the numbers exceeded 500. In point of fact, the corporation never required to build houses, as private enterprise more than kept pace with the operations of the improvement scheme. By the Act the corporation was empowered to borrow £1,250,000, and to levy a rate of 6d. per pound on the rental for five years, and 3d. per pound for ten years, by which time it was calculated the whole work would be completed. No sooner was the Act passed than the trustees—all of them members of the town council—proceeded to purchase the properties scheduled, a delicate and difficult task, which, however, was most economically carried out, first by Sir James Watson, and afterwards by Mr. James Morrison, the conveners. The work of demolition also went on; the densely-built districts were cleared out, open spaces and squares secured, streets driven through huge blocks of building, others widened, till now there is hardly a remnant left of the old notorious abodes of fever and crime. There is still a good deal to do, and it may be necessary to get an extension of the time fixed in the Act, as it expires in 1881; but up to the present time upwards of 30,000 people have been turned out of their unhealthy homes, and have been provided with better ones elsewhere. So far the improvements have been very cheaply executed. The great amount of demolition effected by the trustees and the railway companies greatly raised the value of building ground in the central portions of the town; and the corporation has been able to sell the properties which it had acquired at considerable profit, after utilizing large portions of them for streets and open spaces. The cost to the citizens will be the rates which have been and are to be levied; but perhaps to this should be added an uncertain amount represented by the rise of house rents. Up to May, 1878, the sum raised by rates was £305,867; and, adding to that other three years' rates, the total amount which the improvements will cost will be about £375,000, £40,000 of which was spent in buying a park for the use of the people in the north-eastern district of the city.

Public Health.—The result of these improvements has been a marked decrease in the mortality. In 1866 Glasgow was one of the least healthy towns in Great Britain; in 1877 it was nearly as healthy as London. In 1866 the annual death rate was 29·6 per thousand, and continued slightly rising or falling till 1875, when there was a fall to 28·7. This was the year in which the work of the improvement trustees began to tell. In 1876 the death rate was 25·2 per thousand, in 1877 it was 24·9, and in 1878 it was 25·0. The improvement scheme has done good otherwise in directing attention to sanitary questions of all kinds. There is now in Glasgow a public department of health, at the head of which there is a most efficient medical officer, and provision has been made for the isolation of contagious diseases immediately on their breaking out. Great attention is paid to cleansing the city, and fever epidemics, which not long ago were seldom absent, are now very rare, and hardly ever assume large proportions. Crime has also diminished as one of the results of the city improvements, and its detection is much surer.

There can be no doubt that the demolition of so large a number of small dwelling-houses in such a short period was no small grievance to those who inhabited them; not that there ever was any lack of accommodation, but because families had in many cases to remove to places at inconvenient distances from their work, and into houses which, though much better in a sanitary sense, were somewhat dearer. The distance difficulty, however, was greatly mitigated by the construction of tramways throughout the town, and by the authorities providing for the running of morning and evening workmen's cars at exceedingly low fares; and it is scarcely doubtful that the change from unhealthy and overcrowded houses into others roomier and built with some regard to sanitary principles has been a blessing to the lower class of the population. When the works are completed, Glasgow in its older regions will be a city transformed.

Water Supply.—Previous to 1859 Glasgow was supplied by water from the river Clyde and from ponds erected some miles south of the city, to which the water was conveyed by gravitation. The supply was insufficient, and the Clyde water bad. In 1848 the idea of bringing water from Loch Katrine was first spoken of. The citizens at that time began to see that something far more extensive than had ever been attempted was required to supply the rapidly growing wants of the city. Between 1848 and 1855 many schemes were proposed by the water companies and by private individuals, none of which came to anything. In 1852 the corporation took the matter up, and, after a long and arduous struggle, the Act for tapping Loch Katrine was carried in 1855. The corporation it is believed would have been defeated again but for the attention which Lord Palmerston paid to a subject in which Glasgow was so deeply interested, and for the influence which he brought to bear in favor of the works. The engineer selected to bring the water from a distance of 34 miles was Mr. J. F. Bateman, and four years after the passing of the Act the waters of the Highland loch, at the touch of Her Majesty the Queen, flowed into the city.

The sources of the supply are Loch Katrine with a surface of 3000 acres, Loch Vennacher with an area of 900 acres, Loch Drunkie, 150 acres,—altogether about 4000 acres of water surface, and containing within the limits to which they may be raised or lowered about 1,600,000,000 cubic feet of water. The drainage area is 45,800 acres, and the rainfall is from 80 to 90 inches per annum. The source is ample for the supply of a population double that which is at present supplied, but the works are not more than sufficient to provide 50,000,000 of gallons of water per day, and it will be necessary before many years are past to construct other works, probably to double that quantity. Loch Katrine is 360 feet above the tide at Glasgow, which, allowing for the loss of fall, secures a pressure of 70 or 80 feet above the highest summit in the city. The water is conveyed by mined tunnels, built tunnels, aqueducts, and iron pipes. There are altogether 70 tunnels, one of which is 2650 yards and another 2325 yards in length, and 8 feet in diameter. One of these works is 600 feet below the surface. The aqueducts over rivers and ravines of an important character are 27 in number: some of these are of iron and some of masonry. Twenty-six miles from Loch Katrine and 7 or 8 from Glasgow a large reservoir was constructed, 70 acres in extent and capable of holding 500,000,000 gallons of water; and from this reservoir the water, having undergone a filtering process, is conveyed in pipes to Glasgow. The engineering cost of the works was £700,000, or ten per cent, above the estimate, but as the contract was only for 20,000,000 gallons per day, and the actual product was 30,000,000 gallons, the cost cannot be said to have been excessive. There have been great additions made to the works since they were opened in 1859, the total capital expenditure at the end of 1877 being a little over £2,000,000. The quantity of water brought into the city from Loch Katrine is now 30,000,000 gallons per day, but the area of distribution is much larger than Glasgow. In a very short time the corporation will be able to bring in 50,000,000 gallons a day, which is the limit of the capacity of their present works. The cost of the water to the inhabitants is 8d. per pound on the rental, and 1d. per pound is charged for public purposes. The quality of the water is excellent, and there can be no doubt that it has been an active agent in improving the health of the city. Besides the Loch Katrine works there is a supply of water from the Gorbals gravitation works amounting to rather more than four millions of gallons per day. The consumption of water over the area of distribution is thus 34,000,000 gallons in the 24 hours, or 45 gallons for every man, woman, and child,—a very large supply even when deduction is made for the water used in large public works, and for purposes other than domestic.

Lighting.—In the parliamentary session of 1868–9 the corporation applied for and obtained powers to purchase the works of the two gas-light companies which had until that period supplied Glasgow and its suburbs with gas. The capital of these companies consisted of £415,000, on £300,000 of which the shareholders were entitled to profits not exceeding 10 per cent. per annum, the remaining £115,000 paying dividends at the rate of 7½ per cent. per annum. The corporation agreed to give for the works to the shareholders annuities of 9 per cent. on the stock which paid 10 per cent., and of 6¾ per cent. on the stock which paid 7½ per cent. These annuities were guaranteed by a six-penny rate upon the whole rental within the municipality. Besides these rates the corporation took over mortgages amounting to £119,265. It is needless to state that no rate has ever been levied upon rental for the maintenance of the gas-works, the manufacture having proved remunerative at a moderate charge per thousand cubic feet. The gas-works, as taken over by the corporation, were capable of producing 6,500,000 cubic feet; but since then they have been greatly extended at a cost of half a million sterling, and are now capable of making 12 million cubic feet of gas. The consumption varies between 2 million cubic feet in twenty-four hours in summer and 11 million cubic feet during the same time in winter. The area of supply includes nearly all the surrounding suburbs, in addition to the city. The cost of gas to the consumer is 4s. per thousand cubic feet, and no rent is charged for the use of meters.

Tramways.—The next project with which the corporation has had to do in recent years has been laying down lines of tramways along the principal thoroughfares of the city. This work was undertaken for the purpose of preventing the control of the streets and the street traffic from passing out of the hands of the corporation; the cost was about £200,000 for 13½ miles of tramway; but this sum, with interest at 4½ per cent. per annum, is to be repaid in the course of twenty-three years by the lessees, who also keep up the roadway between the tramway lines, and pay a rent of £150 per mile per annum. The fares are one penny per mile, and the number of passengers carried is very great. Pecuniarily the tramways have been successful.

Income and Expenditure.—The income and expenditure of Glasgow are larger than those of many a flourishing state. The trusts, which till quite recently were semi-independent, but are now simply committees of the town council, are the police board, the water commissioners, the gas commissioners, the city improvement trustees, parks and galleries trust, market trust, etc. The revenues which they collect and distribute amount altogether to close upon one million sterling per annum. The common good of the city, that is to say, property belonging to the corporation, is estimated as being worth about £300,000, the interest of which is expended in maintaining what are called the city churches, and generally on municipal purposes for which the citizens are not taxed. The number of parliamentary voters in 1877–8 was 60,582, and the list of school-board electors, which includes all ratepayers, when the roll was last made up, numbered 112,897. Glasgow returns three representatives to the House of Commons since 1868, each elector having, however, only two votes. Previous to this, and from the passing of the great reform measure of 1832, the city had only two representatives. Glasgow has a police force of about 1000 men, which is maintained at an expense of £78,000 per annum, half of which is paid by the Government. The sheriff-depute of Lanarkshire holds his court in Glasgow, and is assisted by five sheriffs-substitutes resident in the city. The amount of legal work which is gone through in the disposal of civil and criminal cases is very great, being equal to about one-third of the whole disposed of in Scotland, including the supreme courts in Edinburgh.

Bridges and Railway Stations.—There are three fine bridges over the river within the municipal boundaries, and two iron suspension bridges. One railway bridge was erected a few years ago by the City Union Railway Company, and another by the Caledonian Railway Company is now nearly completed. All the bridges are free. Glasgow is the centre of a vast railway system, the Caledonian and Glasgow & South-Western Railways having their termini in the city; these work with the great English lines, the Midland and the London & North-Western Companies. The St. Enoch's Square station, which provides for the traffic over the Glasgow & South-Western, City Union, and Midland Companies, is one of the most spacious in the United Kingdom. The same companies are erecting an equally commodious goods station in High Street; the Caledonian Company, finding themselves greatly hampered for room at the old terminus in Buchanan Street, are building a colossal structure in Gordon Street; and the North British Company, which have their headquarters in Edinburgh, are greatly extending their present limited accommodation in Dundas Street.

Public Buildings.—There are not many of these of importance in Glasgow. The one which naturally attracts the greatest attention of strangers is the cathedral, which is now in a complete state of repair, and a few years ago, through the munificence of Glasgow citizens and of noblemen and gentlemen of the vicinity, its windows were filled with richly stained glass from one of the great stained glass establishments of Munich. The cathedral is acknowledged to be a fine specimen of Early English Gothic. It is situated in a good position in the north-east quarter of the city, and is about 104 feet above the Clyde level. Its form is that of a Latin cross with short transepts. The length from east to west is 319 feet, its breadth 63 feet, the height of the choir 93 feet, and of the nave 85 feet. At the intersection it has a tapering octagonal spire, the height of which is 225 feet. It contains 147 pillars and 159 windows. The crypt under the choir is exceedingly fine and complete. The Royal Exchange, in the centre of the city, contains a newsroom 122 feet in length by 60 feet broad. Its portico is formed of 12 fluted Corinthian columns, supporting a rich frieze and pediment; the north and south sides of the building are ornamented by a colonnade of Corinthian pillars. The Royal Infirmary is in the Roman style of architecture from a design by Adams. It has been greatly extended since its erection in 1792. The City Hall is a plain building capable of holding upwards of 3000 people. The new Public Halls, opened in 1877, are the most recent addition to the architecture of the city. The building cost upwards of £80,000, and since its opening has been mainly used for musical entertainments, music being one of the arts which has been cultivated with the greatest success in Glasgow of late years. The principal hall in this fine building, which is of the classic style of architecture, is capable of holding between 4000 and 5000 persons. By far the grandest building in Glasgow, however, is the new university structure on Gilmorehill, which is described below. During the last thirty years a vast improvement has been made in Glasgow in church architecture. Dissenters who were satisfied in the earlier part of the century with plain meeting-houses now vie with each other, and with the Church of Scotland, in the elegance and adornment of their places of worship. There is probably no town in the United Kingdom which has spent more upon ecclesiastical buildings in recent times than Glasgow, or which in this respect has made greater improvements in taste. The Roman Catholics and Episcopalians, nearly one-fourth of the population of the city, have also erected some very fine ecclesiastical edifices. The street architecture of Glasgow has greatly improved, many of the large business firms having rebuilt their warehouses upon a splendid scale. The new post-office buildings in George Square also deserve mention. The work of the post-office of Glasgow has increased with the increase of the city, and is now practically larger than that of any other town save London. It was found necessary a few years ago to extend the accommodation, and now the greater part of one side of George Square is devoted to postal and telegraph purposes. The new buildings are plain but massive, and seem to have been planned on the principle of the least ornament with the most room. The corporation have obtained an Act for the erection of municipal buildings on the east side of George Square. Not without reason has Glasgow been called one of the best built cities of the empire, its substantial masonry owing much to the excellent quality of the material, a sandstone quarried in abundance all round the city.

Statues.—The public statues in Glasgow are not numerous, though several of them are very fine. Most of them are in George Square. The equestrian statue of the great duke of Wellington stands opposite the main entrance to the royal exchange, and that of William III. is close to the junction of Trongate with the Saltmarket, High Street, and Gallowgate, the ancient cross of the city. In George Square there are equestrian statues of the Queen and the late Prince Consort, a seated figure of James Watt, statues of Sir John Moore, Lord Clyde, Sir Robert Peel, Sir Walter Scott, James Oswald of Auchincruive, Thomas Graham the celebrated chemist, Robert Burns, Thomas Campbell, and David Livingstone. The statue of Burns, executed by Mr. George E. Ewing, a Glasgow sculptor, was subscribed for in shillings by the working classes of Scotland.

University and Schools.—Of the educational institutions of Glasgow precedence must be given to the university. As already stated this great seminary of learning was founded by Bishop Turnbull, who obtained a papal bull for the purpose, dated 7th January, 1450. By this bull a corporate body was formed, consisting of a chancellor, rector, and dean, with doctors, masters, regents, and students, in the several faculties into which it was divided. One of these was known as the pedagogium, or college of arts. This school of learning was first situated in Rottenrow (1459). James, Lord Hamilton, bequeathed to the principal regent of that college some buildings and several acres of land, on part of which in the High Street the college was afterwards erected. The college of arts was restored and endowed by James VI. During the period which intervened between 1577 and 1688 the university underwent many changes; but in the year 1693, each of the Scottish colleges having received a grant of £300 per annum out of the bishops' rents, the Glasgow institution again revived; and having received other public and private gifts, its progress has been since uninterrupted. The academic body of the university consists of the chancellor, the lord rector, the dean of faculty, the principal and vice-chancellor, and the professors. The whole business of the university is transacted in three distinct courts, viz., the senatus, the faculty, and the comitia. There are many bursaries connected with the college, the most important being those bequeathed by Mr. Snell, by Mrs. Black, the widow of a late minister of the Barony church, and by Mr. Orr-Ewing, M. P. for Dumbartonshire. The college buildings in High Street were principally erected in 1593 and 1658. The spire, which was 153 feet in height, possessed a lightning conductor which was reared under the auspices of Franklin in 1772.

The present university buildings at Gilmorehill occupy a magnificent site above the Kelvin, overlooking the Kelvingrove Park, and commanding a splendid view of the valley of the Clyde. In 1860 the commissioners under the "Universities Scotland Act" reported that in the interests of the university it was necessary that the college should be rebuilt, and that the site which it occupied in High Street was most ineligible for the purpose of the university. In 1863 the promoters of the City of Glasgow Union Railway company offered to purchase the college grounds for the sum of £100,000, which was ultimately accepted; and during the negotiations Government offered to give £21,400, on condition that £24,000 for the erection of an hospital was raised by private subscription. On the 29th July, 1864, the lands of Gilmorehill, consisting of 43 acres, were purchased by the senate for £65,000; about six months later the adjacent lands of Donaldshill were secured for £16,000, and the property of Clayslaps, containing 5 or 6 acres, was bought for an hospital site for the sum of £17,400. Part of the lands of Gilmorehill not required for the university were advantageously sold to the corporation of Glasgow. Sir Gilbert Scott was appointed architect of the new buildings at the end of September, 1864, and the plans were completed and approved of in the beginning of 1866. The estimated cost of the building, including hospital, was £266,000—a sum far beyond the means of the university authorities. The citizens of Glasgow, however, came heartily to their help, and subscribed liberally to the building fund. In January, 1868, Government agreed to give £120,000, on condition that the same amount was raised by private subscriptions. The work at once progressed under these assurances of support, and on the 8th October, 1868, the foundation stone of the new buildings was laid by the Prince of Wales. In 1870 the buildings were so far completed that the removal from High Street took place, the last meeting of the senatus in the old college buildings having been held on 28th July of that year. The financial difficulty, however, proved a very serious one. The cost of the buildings greatly exceeded the estimate, and went far beyond the funds placed at the disposal of the senatus, although the public subscriptions amounted to nearly £160,000. The fine building is therefore up to the present time incomplete. The tower had to be stopped when less than half-way up, and the grand hall, designs of which were prepared by Sir Gilbert Scott, is still untouched. The senatus, however, has now been practically relieved of its difficulties by the splendid contributions of the marquis of Bute and of Mr. Charles Randolph, one of the pioneers of steam shipbuilding on the Clyde. The marquis has given £40,000 for the erection of the common hall, and Mr. Randolph bequeathed £60,000 for the completion of the buildings. With these sums at its disposal the senatus will no doubt in a few years finish this noble structure, and it will then be unequalled, so far as the building is concerned, as an educational institution.

The following notes, descriptive of the new buildings, are from the pen of the architect:—

> The architectural style of the building is founded on that of works of the 14th century, subject to some modifications introduced with a view to giving the building a character allied to that of the old Scottish buildings. It is probable, however, that during the 14th century this specific character may not have prevailed in Scotland. It seems, in fact, to have been introduced from France at a later period, and worked up with so much originality into buildings in Scotland as to have become quite received as the style of the country. In France it had existed at least from the 13th century, so that what has been done in the design of the college is to *translate back* the characteristics in question, and to unite them with the general style of the architecture of the 14th century, though in Scotland they may not probably have actually existed till a later date. As the building stands on the crown of a hill, whose principal and rapid slope is toward the south, it has been made to occupy, as far as may be, the whole of the ridge facing in that direction by a long and continuous front of about 540 feet in length. In advance of this lengthened façade is a system of terraces, bringing the ground down by gradual steps towards the Kelvin, which flows through a deep ravine along its base. The southern façade comprises three more lofty portions, a central block and two corner towers, between which are two ranges of buildings of smaller elevation. The centre of the line of building facing the south is occupied by a lofty tower, through which, on the ground floor, is the principal entrance to the building. There is also a gateway through the centre of each of the lower ranges of building, arched and groined, leading into the east and west quadrangles. Another main entrance is provided in the central block of the northern range of building. This entrance consists of a double gateway, the passages from which turn round to meet one another in the basement within the building. Much in the same manner, the north side of the building is divided into five parts, the angle blocks forming towers, similar to those in front; but facing each quadrangle there is a building of great dimensions, one of which is devoted to the museum and the other to the library. Between these is a central block, in this case of less elevation than the main side portions, containing the students' reading-room below and the hall of the Hunterian museum above.
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> The whole rectangular range of buildings, thus briefly described, is about 540 feet in length by 300 feet in breadth, occupying a greater part of the crown of the hill. From it to the west extend the different ranges of the principal's and professors' houses, while towards the south-east the outline is prolonged and diversified by the chemical laboratory, a partially detached building of octagonal form, and, at the north-east, by the anatomical rooms. The library and museum are alike in design. There are two great halls in each, occupying respectively the ground and first floors, these being 129 feet long by 60 feet wide.

Anderson's College, formerly called Anderson's (or the Andersonian) University, was founded by John Anderson, professor of natural philosophy in the university of Glasgow in 1795, and endowed by him with valuable philosophical apparatus, a museum, and a library. It is governed by 81 trustees, and its object is to bring literary and scientific education within the reach of the mass of the community. Every branch of study taught in Glasgow university is provided for, with the exception of divinity. Drs. Garnett and Birbeck were the original professors of natural philosophy and chemistry; Dr. Ure and Thomas Graham also occupied chairs in this college; and it was there that the first mechanics' class was established in Great Britain. The trustees contemplate the removal of the institution to the west end of the city, where it is believed it will greatly extend its sphere of usefulness. The number of students in 1878 was 986; and those attending popular evening classes, at which lectures are delivered in various branches of science, numbered 992.

The High School or Grammar School, formerly in John Street and under the charge of the corporation, is the oldest educational institution in the city. It appears that a grammar school existed in Glasgow early in the 14th century, being then dependent on the cathedral church. Up to 1834 its masters taught only Latin and Greek, but at that period the school underwent a complete alteration. Two of the classical masterships were suppressed, and in lieu of these teachers of English grammar, foreign languages, writing, arithmetic, geography, mathematics, and drawing were introduced. The name was also changed from the grammar school to the high school. The school was up to 1873 under the control of the corporation, but it was in that year placed under the jurisdiction of the school board of the city. In 1878 the school was removed to Elmbank Street, to the premises occupied by the Glasgow academy—a commodious building. The high school has been greatly improved by the school board, and is now one of the best secondary educational establishments in Scotland. It has upwards of 500 pupils. There are other secondary schools in Glasgow that are doing good educational work. Among these may be mentioned the Glasgow academy, the Kirklee academy, and the schools belonging to Hutcheson's hospital. There is also a Government school of design well attended, a technical school recently instituted, the mechanics' institution, founded in 1832, for the purpose of diffusing a knowledge of science among the working classes, the athenæum, which draws its students principally from the lower middle class, and the normal schools belonging to the Church of Scotland and the Free Church, for the training of teachers.

The passing of the Education (Scotland) Act in 1872 gave Glasgow an opportunity of dealing practically with the dense ignorance that prevailed within her boundaries. Before the Act passed it was believed that at least 20,000 (possibly far more) children in the city received no education whatever. The school board has persistently dealt with these uneducated waifs, and the most of this large ignorant mass have been reached. There are now not more than 3000 children of school age who are not receiving some education in the board and other schools. The school board rate in the city is 4d. per pound on the rental. The amount raised per annum is about £30,000.

Libraries, Museums, etc.—The libraries open to the public are Stirling's public library, a large collection of literature, and famous for its tracts of the 16th and 17th centuries, and the Mitchell public library, established a few years ago by the munificence of a citizen of Glasgow, who left about £80,000 for the purpose. This library is under the management of the town council, and during the short period of its existence has collected a large number of valuable books. It is meant to be a consulting library. The college library is very extensive, but can only be used by alumni of the university. An industrial museum was instituted some years ago in the old residential building of the West End Park. An addition was made to it about three years since, and the collection is now very considerable. It is supported under the Parks and Galleries Act, as are also the corporation galleries of art, a collection of pictures and statuary, acquired partly by purchase but more largely by donation and bequest. The galleries contain a very valuable series of old Dutch masters, and there is a noble statue of Pitt by Chantrey. The Hunterian and Andersonian museums are accessible to the public. The Hunterian contains a noble collection of anatomical subjects, and a most valuable assortment of coins. There is a botanical garden in Glasgow, but this has never been worthy of the city.

Theatres.—The drama has always been tolerably well patronized in Glasgow, which now contains some half dozen theatres.

Commercial Institutions.—The Chamber of Commerce was instituted in 1783, for the purpose of encouraging and protecting trade, and keeping a watchful eye on whatever might be supposed to affect the commercial interests of Glasgow and its neighborhood. There are eight banks and branch banks in the city, two of them being properly Glasgow institutions; they are all joint-stock companies. In 1815 the first attempt was made in Glasgow to establish an institution for the accumulation of the savings of the community, the Provident Bank. This and some others of a like kind in 1836 were all merged in the National Savings Bank, which has had a most successful career. The deposits now amount to about £2,771,066, and the depositors are 104,329 in number.

Parks.—The city is specially well provided with public parks, although not more than a quarter of a century has elapsed since it possessed only one—Glasgow Green—a noble expanse along the north bank of the river, which was long neglected and uncared for. Since that time Kelvingrove Park, in the Kelvin valley at the west end of the city, was acquired, and laid out under the direction of Sir Joseph Paxton, and it has been frequently added to. At a later date the Queen's Park, on the southern outskirts, was formed; and subsequently the city improvement trust expended £40,000 on the purchase and laying-out of the Alexandra Park on the north-east side of the city. These parks are all liberally maintained by the parks and galleries trust of the town council.

Glasgow has been almost exclusively a commercial city within the last half century. As wealth increased culture also increased, though more slowly. The university has always been the centre of intelligence in the city, and many of its professors have been conspicuous for their devotion to the applications of pure science to the development of the arts and manufactures. Of the great names connected with this institution it may suffice to mention Baillie, whose letters on the troubles of the 17th century, recovered by the late Dr. Laing of Edinburgh, added considerably to our knowledge of that period, and Professors Adam Smith and Thomas Reid. James Watt, though not a member of the university, was generously protected by it when the burgesses of Glasgow refused to allow him to open shop within the jurisdiction of the trades house and magistrates of the city. There are many literary men, and poets of the minor class, who claim Glasgow as their birthplace, but none of them reached sufficient eminence to claim particular notice. Of the practical workers who by their mechanical aptitude, amounting in many cases to genius, have pushed on the industries of the city, it is impossible here to give even meagre biographical details. The commercial capital of Scotland has prospered more by the general energy and indomitable perseverance of its inhabitants than by the special genius of individuals.

INDUSTRIES.—The most outstanding feature in the industrial position of Glasgow is the great variety and wide range of its manufacturing and trading activity. While no one of the great industries occupies a position of predominant importance so as to stamp itself as the peculiar characteristic of the town, there are numerous leading departments of industry which have been long established and are prosecuted on a great scale, while a variety of special manufactures have found their principal centre in Glasgow and the Clyde valley. When to this fact is added the consideration that Glasgow is one of the three principal seaports of the United Kingdom, it will at once be obvious that the wealth and prosperity of the city are contributed to by many separate and important streams. The circumstances and conditions which have favored the establishment of the leading industries in Glasgow are quite as varied as are the industries themselves. The abundance of pure water in the hill streams around the city led at an early date to the introduction of bleaching, calico-printing, and allied pursuits; and these, in their turn, reacted favorably on hand-loom weaving and other textile manufactures. In a similar way the first beginnings of the now great chemical industries are clearly related to the early stages of the bleaching and printing trades. The fact, however, that the town is actually built within the richest coal and ironstone field in Scotland has had, of all causes, the most important influence in determining the current and prosperity of local industries. Further, the river Clyde, rendered navigable for vessels of the largest tonnage, flowing through the centre of that great coal and iron region, presents incomparable facilities for the prosecution of shipbuilding and marine engineering. But beyond the advantages of natural position and mineral wealth it is right to say that Glasgow owes much of her industrial prestige to a long line of highly-gifted, ingenious, sagacious, and energetic citizens, whose influence has not only been stamped on local industries, but has been felt and acknowledged throughout the entire world.

The principal industries of Glasgow range themselves under the heads separately noted below. With respect to many of them it is a matter of regret that no trustworthy source of specific information exists; and thus the origin, vicissitudes, and progress of really important trades can only be recorded in vague and general terms.

Textile Manufactures.—The industries embraced under this head were the first which gave Glasgow a place among the great manufacturing communities; but though, through many changes and fluctuations, they continue to yield extensive employment, they now occupy a comparatively secondary position. In the cotton trade, which originated about 1780, Glasgow possesses several factories which are reckoned among the largest in the trade; the industry has, however, for a number of years been in a stationary if not declining condition. The manufacture of light textures has always been the leading feature of the Glasgow trade,—plain, striped, and figured muslins, ginghams, and fancy fabrics forming the staple. Thread manufacture, although specially a Paisley industry, is also extensively prosecuted in Glasgow. According to a return obtained in 1875 the whole cotton industry of Scotland afforded employment to 33,276 individuals, and excepting about 10 per cent. it was entirely centred in Glasgow and the surrounding district. Jute and silk are staples worked only to an inconsiderable extent in Glasgow, though about a century ago the manufacture of silk gauze flourished extensively, and has left traces of its former importance to the present day. The most characteristic of woollen and worsted manufactures is carpet weaving, all the leading kinds of carpets being extensively made, and the "tapestry" curtains and portières made by several firms are examples of highly artistic woollen fabrics.

Bleaching, Printing, and Dyeing.—These allied industries took root in the Glasgow district at an earlier period than that of their introduction into the rival regions of Lancashire, calico-printing having been begun near Glasgow in 1738. The use of chlorine in bleaching was first introduced in Great Britain at Glasgow in 1787, on the suggestion of the illustrious James Watt, by his father-in-law, a local bleacher; and it was a Glasgow bleacher—Charles Tennant—who first made and introduced bleaching powder (chloride of lime). The dyeing of Turkey red was begun as a British industry at Glasgow by two eminent citizens—David Dale and George M'Intosh—

and that unequalled color was long locally known as Dale's red. All these industries continue to hold a foremost place in Glasgow, a large amount of grey cloth being sent from the Lancashire looms to be bleached and printed in the Scotch works. In particular, Turkey red dyeing and printing have developed to an extent unequalled in any other manufacturing centre.

Chemical Manufactures.—The operations of bleaching and calico-printing in the early part of last century gave rise to such chemical manufactures—the preparation of dye liquors, etc.—as these industries demand. The discovery of bleaching powder by Charles Tennant in 1799 led directly to the development of the great chemical works of C. Tennant & Co. at St. Rollox and its various branches, and gave the first great impetus to chemical manufactures in Glasgow. Among the prominent chemical industries are to be reckoned the alkali trades—including soda, bleaching powder, and soap-making—the preparation of alum and prussiates of potash, bichromate of potash manufacture (an industry peculiarly identified with Glasgow), the extraction of iodine and other products from seaweeds, dynamite and gun-powder manufacture, the making of flint glass, bottle glass, paper, white-lead and other pigments, and brewing and the distillation of spirits. The numerous chemical preparations used in the bleaching and calico-printing trades are also among the local manufactures, as well as the preparation of starch, British gum, and dextrine, and the manufacture of lucifer matches.

Iron Manufacture and other Metallurgical Industries.—Although the blast furnaces of Scotland are distributed over several of the midland counties, the great proportion of them are in Lanarkshire and Ayrshire, and the trade is entirely controlled and practically monopolized in Glasgow. The discovery of the value of blackband ironstone by Mushet and the invention of the hot-blast by Neilson were two events which exercised a wonderful influence on the development of iron smelting in Scotland. So rapid was the expansion of the industry during the earlier half of this century that in 1859 one-third of the whole iron produced in the United Kingdom was Scotch. For 20 years past the trade has shown little elasticity, the annual production averaging about a million of tons of pig iron,—the maximum output having been reached in 1870, when 1,206,000 tons were smelted. In 1877 of a total of 152 furnaces existing there were 109 in blast, and of the whole 131 were situated in Lanarkshire and Ayrshire, 102 of these being in operation. The entire output of pig iron in that year was 982,000 tons, while in 1878 from 90 furnaces in blast the production is estimated at 902,000 tons. The number of malleable iron works in Glasgow and its neighborhood is 22, having had during 1877 345 puddling furnaces and 53 rolling mills in operation. Mild steel is manufactured on an extensive scale by the Siemens-Martin process, and a small amount of crucible cast steel is also made. Other metallurgical industries include the extraction of copper by Henderson's wet process, and a limited amount of zinc smelting.

Engineering.—With abundance of iron and coal, and great facilities of both land and water carriage, it is only to be expected that mechanical engineering should be carried on in Glasgow with peculiar energy and success. Almost all departments of engineering work are well represented in the district; and among the special features of the industries may be enumerated the great water and gas pipe casting establishments, sanitary and general iron-founding, malleable iron tube making, locomotive engine building, the manufacture of sugar machinery and of sewing machines,—two great establishments on the model of American factories for the latter trade being conducted by the Singer and the Howe Machine Companies respectively. The marine engineering works of the Clyde—which in many instances are worked in direct connection with shipbuilding yards—are equipped on a scale worthy of the great industry of which they form an important part; and few establishments exist in any other quarter capable of producing the enormous forgings for propeller shafts, etc., of ocean steamers, which form a regular item in the undertakings of Glasgow engineering firms.

Shipbuilding is the greatest of all the modern industries of Glasgow, and the position attained by the shipbuilders of the Clyde is a matter of imperial consequence and national pride. The shipbuilding yards of the Clyde extend from Rutherglen above Glasgow to Greenock,—Dumbarton, Port-Glasgow, and Greenock having an important stake in the industry. In some years about half the total tonnage built in the United Kingdom has been launched from the Clyde yards, as is shown by the following statement:—

	1871.	1872.	1873.	1874.	1875.	1876.	1877.
Tonnage launched, Clyde...............	196,229	230,347	232,926	262,430	211,482	174,824	169,383
Tonnage launched, United Kingdom	391,058	474,718	453,543	603,867	472,058	378,020	450,963

During the year 1878 the tonnage launched on the Clyde from the yards of 35 different firms amounted to 222,353 tons, one vessel, the "Gallia," built for the Cunard Company, being of 5200 tons burthen,—a tonnage, however, which has been exceeded by the Guion steamer "Arizona" (5500 tons), launched in 1879. The work turned out is very diversified, but as a rule of the highest class, and includes armor-plated and other vessels for the Royal Navy, mail and passenger ocean steamers for the great Transatlantic and other lines, river steamboats famous throughout the world for swiftness and elegance of appointments, merchant sailing vessels, dredging plant, and hopper barges. With the exception of a very insignificant proportion of wooden vessels, the whole of the shipping built on the Clyde is of iron and steel, the latter having recently been introduced with great success. The shipbuilding trade in Glasgow indeed owes its extraordinary expansion almost entirely to the rapid supplanting of wood by iron as a building material. Twenty years ago, in 1859, the tonnage launched measured only 35,709 tons, from which amount, by rapid strides, it reached in 1863 a total of 123,262 tons, and in 1874 the maximum amount of 262,430 tons was floated off.

COMMERCE.—For a century past the records of the Clyde Navigation Trust indicate that the trade of Glasgow, so far as regards shipping, has progressed, with few and unimportant fluctuations, with steady rapidity. In 1778 the annual revenue of the Clyde Trust was £1733; in 1828 it amounted to £17,669, a tenfold increase in 50 years; and in 1878 the total amounted to £217,100. Of course these figures do not necessarily indicate a corresponding expansion of shipping trade, though they probably bear a close relation to the comparative value of cargoes carried. In the year 1828 the tonnage of vessels of all kinds which arrived in the harbor of Glasgow was 696,261, the sailing vessels having numbered 4405 of 214,315 tons, and the steamers 7100 of 481,946 tons. For the year ending 30th June, 1878, the arrivals of sailing ships numbered 2727, with 457,290 tons capacity, and of steamers there were 13,210, the tonnage of which amounted to 2,154,733 tons,—in all 15,937 arrivals with a gross tonnage of 2,612,023 tons, being the greatest amount on record. In that year the weight of goods imported from abroad was 658,319 tons; and coastwise 586,576 tons were landed at Glasgow, making in all 1,244,895 tons. The foreign imports consisted in largest measure of Indian corn, wheat, flour, and other food substances, with timber, pyrites, iron ore, and sulphur, the coasting arrivals containing principally limestone, iron, cement, potter's clay, salt, timber, and food stuffs. The goods shipped to foreign ports amounted to 712,249 tons, and coastwise 603,374 tons left Glasgow, making in all 1,315,623 tons. The principal exports were coal, iron, cast pipes, chairs and other railway iron, chemical manufactures, and general machinery, with malt liquors and spirits; and in the coasting trade the leading articles were of a similar general description. The great bulk of the foreign trade is with New York and Canadian ports, India, France, Spain, and Belgium; and coasting traffic beyond the Clyde estuary is directed principally to Liverpool, Belfast, Dublin, Londonderry, Waterford, Bristol, and London; but there are few commercial ports throughout the world which have not more or less direct trading communication with the port and harbor of Glasgow. (J. H. S.—J. PA.)

GLASS. HISTORY.—The art of glass-making, unlike that of pottery, would appear not to have been discovered and practised by different nations independently, but to have gradually spread from a single centre. No trace of it was observed among the inhabitants of America at the time when that continent was discovered, although considerable progress in the arts had been made by some among them, *e. g.*, the Mexicans and Peruvians; but the steps by which it reached China may be indicated with much probability. The credit of the invention was given by the ancients to the Phœnicians, as is shown by the well-known story of its fortuitous discovery by Phœnician merchants, who rested their cooking pots on blocks of natron (sub-carbonate of soda), and found glass produced by the union under heat of the alkali and the sand of the shore (Pliny, *Nat. Hist.*, xxxvi. 26, 65). A glassy mass may, however, be produced in the smelting of many metallic ores, silica being present, while the fuel supplies the alkali; or by the combustion of great masses of reeds or straw, in which the elements of glass are present,—lumps of coarse imperfect glass being often found on the spot where a stack of wheat has been burned. Now the Egyptians practised metallurgic operations from a very early period, and vast heaps of straw are, and no doubt have been from the earliest times, accumulated in that country, and probably not unfrequently set on fire. The adoption of glass as a substance capable of being made subservient to the use of mankind may therefore be due to the intelligence of some one who noticed its fortuitous production there. Be this as it may, by far the earliest examples of glass existing of which the dates are attested by inscriptions are of Egyptian origin. The earliest of these, a small lion's head of opaque

Egyptian glass.

blue glass of very fine color, but changed externally to an olive green, was found at Thebes by Signor Drovetti, and is now in the British Museum;[1] on the underside are hieroglyphics containing the name of Nuantef IV. whose date according to Lepsius's chronology was 2423–2380 B. C. A bead of dusky green glass bears the prænomen of Hatasu, a queen who is conjectured to have lived about 1450 B. C. (Wilkinson, *Manners and Customs of the Ancient Egyptians*, vol. iii. p. 88). That such may be the real dates of these objects is confirmed by the fact that glass bottles containing red wine are represented on monuments of the fourth dynasty, more than 4000 years old; and in the tombs at Beni Hasan, dating from the reign of Usurtesen I., at least 2000 years B. C., the process of glass-blowing is represented in an unmistakable manner (Wilkinson, vol. iii. p. 89). Very many examples of glass found in Egypt may be seen in museums, but as they rarely bear inscriptions, it would be difficult to trace the progress of the art through them; no competent person has hitherto undertaken the task. The manufacture probably continued to flourish as well during the period of the native monarchy as in that of the Greek dynasty; and its importance after the subjugation of the country to Rome was probably even increased by the new market then opened to its products. Martial (*Ep.*, xxi. 74) alludes to the importation of Egyptian glass into Rome; and it is mentioned in an ordinance of Aurelian. Hadrian in a letter addressed to the consul Servianus mentions glass-blowing as one of the chief industrial occupations of the inhabitants of Alexandria. The manufacture was not confined to that city, but was also carried on in the lower Diospolis on Lake Mensaleh, as appears by a passage in the *Periplus Maris Erythræi* (c. 6).

Much of the Egyptian glass was uncolored and of a somewhat dusky hue; of the colored and ornamental varieties perhaps the most characteristic examples are the small vases usually in the form of either alabastra or amphoræ, but occasionally in that of an Egyptian column. In these the prevailing color is a deep transparent blue, but not unfrequently the color of the body of the vase is some shade of pale buff, fawn, or white (an imitation probably of arragonite, Egyptian alabaster), sometimes deep green, and in rare cases red. In almost every example the surface is ornamented by bands of color, white, yellow, or torquoise blue, forming zigzag lines; in some examples there are only two or three such lines, in others the whole surface is covered by them. These lines are incorporated with the surface of the vessel, but do not penetrate through its entire thickness. By the Greeks and Etruscans such vessels were evidently much valued; the amphoræ have been occasionally found in tombs, furnished with a stand of gold. In Rhodes and elsewhere they have been found associated with objects which probably do not date from an earlier period than the 3d or 4th century before Christ, and it does not appear that they are met with in tombs later than the Christian era; when colored or ornamental glass vessels are discovered in these last, they are of a different character. Another species of glass manufacture in which the Egyptians would appear to have been peculiarly skilled is the so-called mosaic glass, formed by the union of rods of various colors in such a manner as to form a pattern; the rod so formed was then reheated and drawn out until reduced to a very small size, a square inch or less, and divided into tablets by being cut transversely, each of these tablets presenting the pattern traversing its substance and visible on each face. This process was no doubt first practised in Egypt, and is never seen in such perfection as in objects of a decidedly Egyptian character in design or in color. Very beautiful pieces of ornament of an architectural character are met with, which probably once served as decorations of caskets or other small pieces of furniture, or of trinkets; also tragic masks, human faces, and birds. Some of the last-named are represented with such truth of coloring and delicacy of detail that even the separate feathers of the wings and tail are well distinguished, although, as in an example in the British Museum, a human-headed hawk, the piece which contains the figure may not exceed three-fourths of an inch in its largest dimension. Works of this description probably belong to the period when Egypt passed under Roman domination, as similar objects, though of inferior delicacy, appear to have been made in Rome.

Phœnician.

The Phœnicians probably derived their knowledge of the art from Egypt; whether this be so or not, they undoubtedly practised it from a very early period and to a very large extent. Probably much the same processes were employed in Phœnicia and Egypt during some centuries before the Christian era, as they certainly were in Phœnicia, Egypt, and Rome for some centuries after. It seems probable that the earliest products of the industry of Phœnicia in the art of glass-making are the colored beads which have been found in almost all parts of Europe, in India and other parts of Asia and in Africa. The "aggry" beads, so much valued by the Ashantees and other natives of that part of Africa which lies near the Gold Coast, have probably the same origin. These colored beads are usually of opaque glass; they exhibit great variety of color and pattern, and very different degrees of skill in manipulation. Their wide dispersion may be referred with much probability to their having been objects of barter between the Phœnician merchants and the barbarous inhabitants of the various countries with which they traded. It is probable, however, that many of the specimens which exist in our museums date from times several centuries later than those in which Tyre and Sidon flourished; for, as we may learn from the *Periplus* and Strabo, glass in various forms was an article imported in the 1st and 2d centuries, as well into the emporia of the Red Sea as into the ports of Britain. Even at the present day beads are very extensively made at Venice for export to Africa, which bear a resemblance, doubtless not accidental, to those which we have reason to believe to be of very early date.

Assyrian.

Next in date to the earlier Egyptian examples mentioned above would appear to be the vase of transparent greenish glass found in the north-west palace of Nineveh, and now in the British Museum. On one side of this a lion is engraved, and also a line of cuneiform characters, in which is the name of Sargon, king of Assyria, 722 B. C. Fragments of colored glasses were also found there, but our materials are too scanty to enable us to form any decided opinion as to the degree of perfection to which the art was carried in Assyria. Many of the specimens discovered by Layard at Nineveh have all the appearance of being Roman, and were no doubt derived from the Roman colony, Niniva Claudiopolis, which occupied the same site.

Greek.

The Greeks, excellent in the ceramic art, do not appear to have cultivated the art of glass-making at a very early period; but it was probably made in many places on the shores of the Mediterranean for some centuries before the Christian era. At Mycenæ many disks of opaque vitreous pastes were found by Schliemann, and very similar objects at Ialyssus in Rhodes; but it is not certain that these may not have been brought from Egypt, where very similar objects have been found, or whether they ought not to be attributed to Greek or to Phœnician artisans. At Camirus in Rhodes, however, many vessels of glass of very elegant forms have been discovered, which were probably made in the island.

In Etruscan tombs in Italy are also found glass vessels of peculiar character; these are small bowls resembling in form the half of an egg; they are usually of the variety of glass which is mentioned further on as "madrepore," the ground green and transparent, the stars yellow, while patches of color of gold and of filigree glass are sometimes interspersed. They differ from and appear to be earlier than the madrepore glass, fragments of which are so often found in Rome. They are also said to be found in Magna Græcia. Another variety found in tombs in the same district is of blue and opaque glass, with much gold in leaf, all twisted together; the most frequent form in which this kind of glass has been found is that of a bottle several inches long and about one inch in diameter, without a neck, having probably had a mounting of gold. It remains to be determined whether these should be attributed to a Greek or to a Phœnician origin. Glass, however, was occasionally used for purposes of architectural decoration during the best period of Grecian art, for Stuart and Revett, when describing the temple of Minerva Polias at Athens, give the following note:—"A remarkable singularity observed in the capitals of this portico is in the plaited torus between the volutes having been inlaid at the interstices with colored stones or glass." Mr. H. March Phillips states that he well remembers having remarked these decorations, and that he believes them to be of blue glass.[1]

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[1] See introduction to *Catalogue of Glass Vessels in the South Kensington Museum*, where an engraving of it is given.

[1] An example of the employment of glass in a like manner is indicated by the odd story which Pliny tells (*Nat. Hist.*, xxxvii. 5, 17)

Roman.

In the first centuries of our era the art of glass-making was developed at Rome, and other cities under Roman rule, in a most remarkable manner; and it reached a point of excellence which in some respects has never been excelled or even perhaps equalled. It may appear a somewhat exaggerated assertion that glass was used for more purposes, and in one sense more extensively, by the Romans of the imperial period than by ourselves in the present day; but it is one which can be borne out by evidence. It is true that the use of glass for windows was only gradually extending itself at the time when Roman civilization sank under the torrent of German and Hunnish barbarism, and that its employment for optical instruments was only known in a rudimentary stage; but for domestic purposes, for architectural decoration, and for personal ornaments glass was unquestionably much more used than at the present day. It must be remembered that the Romans possessed no fine porcelain decorated with lively colors and a beautiful glaze; Samian ware was the most decorative kind of pottery which was then made. Colored and ornamental glass held among them much the same place for table services, vessels for toilet use, and the like, as that held among us by porcelain. Pliny (*Nat. Hist.*, xxxvi. 26, 67) tells us that for drinking vessels it was even preferred to gold and silver. Trebellius Pollio, however, relates of the emperor Gallienus that he drank from golden cups, despising glass, than which, he said, nothing was more vulgar. Glass was largely used in pavements, and in thin plates as a coating for walls. It was used in windows, though by no means exclusively, mica, alabaster, and shells having been also employed. Glass, in flat pieces, such as might be employed for windows, has been found in the ruins of Roman houses, both in England and in Italy, and in the house of the faun at Pompeii a small pane in a bronze frame remains. Glass of this description seems to have been cast on a stone, and is usually very uneven and full of defects; although capable of transmitting light, it must have given at best an indifferent view of external objects. When the window openings were large, as was the case in basilicas and other public buildings and even in houses, the pieces of glass were, doubtless, fixed in pierced slabs of marble or in frames of wood or bronze.

The invention and ingenuity employed by the Roman artisans in producing variety in glass vessels are most remarkable; almost every means of decoration appears to have been tried, and many methods of manipulating glass, which have been considered inventions, have in reality been anticipated by the glass-workers of the period under consideration. The fertility of invention which devised so many modes of ornamentation and so many shades of color, and the skill with which the manual execution is carried out, alike deserve great admiration. This prodigious variety seems to show that glass-making was at that time carried on, not as now in large establishments, which produce great quantities of articles identical in form and pattern, but by many artificers, each working on a small scale. This circumstance enables us to understand why very pure and crystalline glass was, as Pliny tells us, more valued than any other kind. To produce glass very pure and free from striæ and bubbles, long-continued fusion is required; this the system of working of the ancients did not allow, and their glass is in consequence remarkable for the great abundance of bubbles and defects which it contains.

The Romans had at their command, of transparent colors, blue, green, purple or amethystine, amber, brown, and rose; of opaque colors, white, black, red, blue, yellow, green, and orange. There are many shades of the former as well as of the latter, particularly of transparent blue, and of opaque blue, yellow, and green. Of opaque colors many varieties appear to be due to the mixture of one color with another. In any large collection of fragments it would be easy to find eight or ten varieties of opaque blue, ranging from lapis lazuli to turquoise or to lavender, and six or seven of opaque green. Of red the varieties are fewer; the finest is a crimson red of very beautiful tint, and there are various gradations from this to a dull brick red. One variety forms the ground of a very good imitation of porphyry; and there is a dull semi-transparent red which, when light is passed through it, appears to be of a dull green hue. With these colors the Roman *vitrarius* worked, either using them singly or blending them in almost every conceivable combination, sometimes, it must be owned, with a rather gaudy and inharmonious effect.

These combinations of color were effected in two ways:—first, by glasses of two or more colors being combined so as to traverse the entire substance of the object; and, secondly, by the superposition of the one color on the other.

To the former class belong all those termed mosaic and mille fiori, where the process of manufacture was the preliminary union, by heat, of threads of glass into a rod, which when cut transversely exhibited the same pattern in every section. Such rods were placed together side by side, and united by heat into a mass which was then formed into cups or other vessels. A vast quantity of small cups and pateras were made by this means in patterns which bear considerable resemblance to the surfaces of madrepores, and are of the same kind as those which by the Venetians are termed "mille fiori." In these every color and every shade of color seem to have been tried in great variety of combination with effects more or less pleasing, but transparent violet or purple appears to have been the most common ground color. Although most of the vessels of this mille fiori glass were small, some were made of large size; a fragment in the possession of the present writer must have formed part of a dish not less than 20 inches in diameter. Another variety of glass, evidently much used, is that in which transparent brown glass is so mixed with opaque white and blue as to resemble onyx. This was sometimes done with great success, and very perfect imitations of the natural stone were produced. Sometimes purple glass is used in place of brown, probably with the design of imitating the precious murrhine. Imitations of porphyry, of serpentine, and of granite are also met with, but these were used chiefly in pavements, and for the decoration of walls, for which purposes the onyx-glass was likewise employed. Under this head must also be included the interlacing of bands and threads both of white and of colored glass. Vessels are found composed of bands either so placed in sections as to present a plaited pattern, or simply arranged side by side; others, again, resemble the Venetian vitro di trina, threads of opaque white or yellow glass being twisted with clear transparent glass, and the vessel then formed by the welding together of the rods so made. Blue threads are occasionally intermixed, and several varieties of pattern may be found; but this branch of the art does not appear to have been carried by the Romans to anything like the perfection to which it was afterwards brought by the Venetians.

So few examples of glass vessels of this period which have been painted in enamel have come down to us that it has been questioned whether that art was then practised; but several specimens have been recently described which can leave no doubt on the point; decisive examples are afforded by two cups found at Vaspelev, in Denmark, engravings of which are published in the *Annaler for Nordisk Oldkyndeghed* for 1861, p. 305. These are small cups, 3 inches and 2½ inches high, 3¾ inches and 3 inches wide, with feet and straight sides; on the larger are a lion and a bull, on the lesser two birds with grapes. and on each some smaller ornaments. On the latter are the letters DVB . R. The colors are vitrified and slightly in relief; green, blue, and brown may be distinguished. They were found with Roman bronze vessels and other articles. Vessels also are not uncommon on the surface of which enamel colors appear in the form of spots; it is probable that these were applied in the form of melted glass, not, as in true enamel painting, in that of a finely divided powder tempered with an essential oil and applied cold.

The first place among those processes in which one color was superimposed on another may be given to that by which the cameo glass was produced. In this a bubble of opaque white glass was formed at the end of the tube used by the glass-blower; this was coated with transparent blue, and that again with opaque white, and the vessel required was formed from this threefold globe. The outer coat was then removed from that portion which was to constitute the ground, leaving the white for the figures, foliage, or other ornamentation; these were then sculptured by means of the gem-engraver's tools. Pliny no doubt means to refer to this when he says (*Nat. Hist.* xxxvi. 26, 66), "aliud

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that on the tomb of Hermias, a prince of the island of Cyprus, was a marble figure of a lion with eyes of emerald which shone so brightly into the sea that they frightened away the tunnies from the adjacent fisheries, so that it became necessary to change the eyes. In the great marble lion discovered by Mr. Newton near Cnidus, and now in the British Museum, in the place of the eyes are deep sockets which probably, like those of the Cypriote lion, were filled with colored glass.

argenti modo cælatur," contrasting it with the process of cutting glass by the help of a wheel, to which he refers in the words immediately preceding, "aliud torno teritur."

The famous Portland or Barberini vase is the finest example of this kind of work which has come down to us, and was entire until it was broken into some hundred pieces by a drunken medical student some years ago. The pieces, however were joined together by Mr. Doubleday with extraordinary skill, and the beauty of design and execution may still be appreciated almost as well as when it was intact. A letter written by Wedgwood in 1786 to Sir William Hamilton has been published in the life of the former by Miss Meteyard (vol. ii. p. 577), which contains some interesting remarks upon this beautiful work of art. He concludes with the assertion, "I do not think £5000 for the execution of such a vase, supposing our best artists capable of such a work, would be at all equal to their gains from the works they are now emplyed in." It is true that the gem-engravers of that day received very high pay for their work.

The two other most remarkable examples of this cameo glass are an amphora at Naples and the Auldjo vase. The amphora measures 1 foot ⅝ inch in height, 1 foot 7½ inches in circumference; it is shaped like the earthen amphoras with a foot far too small to support it, and must no doubt have had a stand, probably of gold; the greater part is covered with a most exquisite design of garlands and vines, and two groups of boys gathering and treading grapes, and playing on various instruments of music; below these is a line of sheep and goats in varied attitudes. The ground is blue and the figures white. It was found in a house in the Street of Tombs at Pompeii in the year 1839, and is now in the Royal Museum at Naples. It is well engraved in Richardson's *Studies of Ornamental Design*. The Auldjo vase, a part of which is or was in possession of Mr. Auldjo, and another in the British Museum, is an œnochoe about 9 inches high; the ornament consists mainly of a most beautiful band of foliage, chiefly of the vine, with bunches of grapes; the ground is blue and the ornaments white; it was found at Pompeii in the house of the faun. It also has been engraved by Richardson.

Costly as these beautiful objects must have been, a very great number of them existed, for even now fragments of ten to fifteen may probably be met with in the hands of the curiosity dealers in Rome in the course of three or four months. The same process was used in producing large tablets, employed, no doubt, for various decorative purposes. In the South Kensington Museum collection is a fragment of such a tablet or slab; the figure, a portion of which remains, could not have been less than about 14 inches high.

The ground of these cameo glasses is most commonly transparent blue (often lined with opaque white to throw up the color), but sometimes opaque blue, purple, or dark brown. The superimposed layer, which is sculptured, is generally opaque white. A very few specimens have been met with in which several colors are employed.

At a long interval after these beautiful objects come those vessels which were ornamented either by means of coarse threads trailed over their surfaces and forming rude patterns, or by colored enamels merely placed on them in lumps; and these, doubtless, were cheap and common wares. But a modification of the first-named process was in use in the 4th and succeeding centuries, showing great ingenuity and manual dexterity,—that, namely, in which the added portions of glass are united to the body of the cup, not throughout, but only at points, and then shaped either by the wheel or by the hand. The attached portions form in some instances inscriptions, as on a cup found at Strasburg, which bears the name of the emperor Maximian (286–310 A. D.), on another in the Vereinigte Sammlungen at Munich, and on a third in the Trivulzi collection at Milan, where the cup is white, the inscription green, and the net-work blue. Probably, however, the finest example is a situla, 10½ inches high by 8 inches wide at the top and 4 inches at the bottom, preserved in the treasury of St. Mark at Venice. This is of glass of a greenish hue; on the upper part is represented, in relief, the chase of a lion by two men on horseback accompanied by dogs; the costume appears to be Byzantine rather than Roman, and the style is very bad. The figures are very much undercut. The lower part has four rows of circles united to the vessel at those points alone where the circles touch each other. All the other examples have the lower portion covered in like manner by a network of circles standing nearly a quarter of an inch from the body of the cup.[1]

The art of glass-making no doubt, like all other art, deteriorated during the decline of the Roman empire, but it is probable that it continued to be practised, though with constantly decreasing skill, not only in Rome but in the provinces. Some few existing vessels, as two chalices of coarse blue glass in the British Museum, may perhaps be referred to this period, but the most remarkable production was mosaic for the decoration of churches. Examples of such decorations may be still seen in Rome dating from every century through the dark ages; and, though glass for mosaic was certainly made at Constantinople, and perhaps also at Ravenna, it is probable that it was also made in Rome. Glass was largely used in the immense windows of the churches built between the 3d and the 10th centuries. The first mention of colored glass in a church window occurs in the time of Pope Leo III. (795–816); but probably it was used at a much earlier period.

Byzantine.

Some of the Roman artificers in glass no doubt emigrated to Constantinople, and it is certain that the art was practised there to a very great extent during the Middle Ages. One of the gates near the port took its name from the adjacent glass-houses. St. Sophia when erected by Justinian had vaults covered with mosaics and immense windows filled with plates of glass fitted into pierced marble frames; some of the plates, 7 to 8 inches wide and 9 to 10 high, not blown but cast, which are in the windows, may possibly date from the building of the church. Glass for mosaics was also largely made and exported. In the 8th century when peace was made between the caliph Walid and the emperor Justinian II., the former stipulated for a quantity of mosaic for the decoration of the new mosque at Damascus, and in the 10th century the materials for the decoration of the niche of the kibla at Cordova were furnished by Romanus II. In the 11th century Desiderius, abbot of Monte Casino, sent to Constantinople for workers in mosaic. The grounds of the Byzantine mosaics were usually either of gold or silver, a thin leaf of the metal having been enclosed between two layers of glass.

We have in the work of the monk Theophilus, *Diversarum Artium Schedula*, and in the probably earlier work of Eraclius, about the 11th century, instructions as to the art of glass-making in general, and then as to that of producing colored, gilt, and enamelled vessels, which these writers speak of as being practised by the Greeks. But we look almost in vain for existing specimens of such works. Perhaps the only entire enamelled vessel which we can confidently attribute to Byzantine art is a small vase preserved in the treasury of St. Mark at Venice, a very clever reproduction of which was exhibited by the Murano Glass Company at the Paris exhibition of 1878. This is decorated with circles of rosettes of blue, green, and red enamel, each surrounded by lines of gold; within the circles are little figures evidently suggested by antique originals, and precisely like similar figures found on carved ivory boxes of Byzantine origin dating from the 11th or 12th centuries. Two inscriptions in Cufic characters surround the vase, but they, it would seem, are merely ornamental and destitute of meaning. The presence of these inscriptions may perhaps lead to the inference that the vase was made in Sicily, but by Byzantine workmen.[2]

Of uncolored glass brought from Constantinople several examples exist in the treasury of St. Mark at Venice, part of the plunder of the imperial city when taken by the crusaders in 1204. The glass in all is greenish, very thick, with many bubbles, and has been cut with the wheel; in some instances circles and cones, and in one the outlines of the figure of a leopard have been left standing up, the rest of the surface having been laboriously cut away. The intention would seem to have been to imitate vessels of rock crystal.

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[1] An example connected with the specimens just described is the cup belonging to Baron Lionel de Rothschild; though externally of an opaque greenish color, it is by transmitted light of a deep red. On the outside, in very high relief, are figures of Bacchus with vines and panthers, some portions being hollow from within, others fixed on the exterior. The changeability of color may remind us of the "calices versicolores" which Hadrian sent to Servianus.

[2] The Sano Catino at Genoa, supposed throughout the Middle Ages to have been an emerald but really composed of green glass, is a shallow hexagonal dish rather clumsily formed and finished by cutting. It was perhaps originally a paten, and was taken at the capture of Cæsarea in 1101. At Reichenau in the Lake of Constance, is (or was) preserved a slab of transparent green glass 2 feet wide by 13 inches high and 3 inches thick, which was also supposed to be an emerald. According to tradition it was sent to Charles the Great by the empress Irene.

Alexandria.

Probably at Alexandria, one of the great seats of glass-making, the art survived the conquest of Egypt by the Saracens, for a glass disk serving as a weight has been met with in Egypt bearing the date 96 of the Hegira, corresponding with 715 A. D. (see memoir by Mr. E. T. Rogers, *Journal of the Royal Asiatic Society*, vol. x. pt. 1). Numerous later examples leave no doubt that the manufacture of glass continued to exist in Egypt, though perhaps in a languishing condition. In the 11th century, however, we find in the life of St. Odilo, abbot of Fulda (*ob.* 1049), mention of a "vas pretiosissimum vitreum Alexandrini generis," and in the same century Nasir Ibn Khusru (*Safarnamah*, published by Royal Asiatic Society), who visited Jerusalem in 1060, says that pictures of our Lord and others in one of the churches of that city were covered with plates of glass. No examples of ornamental vessels dating from this period have, however, come down to us. But we have many very remarkable examples of the skill of Egyptian and Syrian glass-workers in the 13th and 14th centuries,—large bottles, basins, and lamps, very striking objects from the free use of enamel and gilding in their decoration. This is, as in most objects of Eastern art, chiefly composed of inscriptions written in large characters ornamentally treated; but figures of birds, lions, sphinxes, etc., may be found, especially on vessels made in Egypt. Although there may have been some indigenous practice of the art of glass-making in the East,—for in the cup of Chosroes I. of Persia (531–579) preserved in the Bibliothèque Nationale at Paris are medallions of colored and moulded glass,—the arts of gilding and enamelling, as we see them exhibited in the Syrian and Egyptian works of the 13th and 14th centuries, were probably derived from the Byzantines. Damascus was also the seat of a like manufacture. In inventories of the 14th century, both in England and in France, mention may frequently be found of glass vessels described as of the manufacture of Damascus. That city was taken by Timur in 1402, and we are told by Clavijo, who visited his court in 1403–1406, that he carried off to Samarcand "men who made bows, glass, and earthenware, so that of these articles Samarcand produces the best in the world."

Syria.

Persia.

Glass no doubt continued to be made, as it still is, in Syria and Persia, but no very remarkable products of the manufacture are known in Europe, with the exception of some vessels brought from Persia, blue richly decorated with gold. These probably date from the 17th century, for Chardin tells us that the windows of the tomb of Shah Abbas II. (*ob.* 1666) at Kom were "de cristal peint d'or et d'azur." At the present day bottles and drinking vessels are made in Persia which in texture and quality differ little from ordinary Venetian glass of the 16th or 17th centuries, while in form they exactly resemble those which may be seen in the engravings in Chardin's *Travels*.

India.

Pliny states (*Nat. Hist.*, xxxvi. 26, 66) that no glass was to be compared to the Indian, and gives as a reason that it was made from broken crystal; and in another passage (xii. 19, 42) he says that the Troglodytes brought to Ocelis (Ghella near Bab-el-Mandeb) objects of glass. We have, however, very little knowledge of Indian glass of any considerable antiquity. A few small vessels have been found in the "topes," as in that at Manikyala in the Punjab, which probably dates from about the Christian era; but they exhibit no remarkable character, and fragments found at Brahminabad are hardly distinguishable from Roman glass of the imperial period. The chronicle of the Singhalese kings, the Mahawanso, however, asserts that mirrors of glittering glass were carried in procession in 306 B. C., and beads like gems, and windows with ornaments like jewels, are also mentioned at about the same date. If there really was an important manufacture of glass in Ceylon at this early time, that island perhaps furnished the Indian glass of Pliny; or it is possible that it really came from China. Glass is made in several parts of India—as Behar and Mysore—by very simple and primitive methods, and the results are correspondingly defective. Black, green, red, blue, and yellow glass is made. The greater part is worked into bangles, but some small bottles are blown (Buchanan, *Journey through Mysore*, vol. i. p. 147; vol. iii. p. 369).

China.

The history of the manufacture of glass in China is obscure, but the common opinion that it was learnt from the Europeans in the 17th century seems to be erroneous. A writer in the *Mémoires concernant les Chinois* (vol. ii. p. 46) states on the authority of the annals of the Han dynasty that the emperor Ou-ti (140 B. C.) had a manufactory of the kind of glass called "lieou-li," that in the beginning of the 3d century of our era the emperor Tai-tsou received from the West a considerable present of glasses of all colors, and that soon after a glass-maker came into the country who taught the art to the natives.

The Wei dynasty, to which Tai-tsou belonged, reigned in northern China, and at this day a considerable manufacture of glass is carried on at Po-shan-hien in Shantung, which it would seem has existed for a long period. The Rev. A. Williamson (*Journeys in North China*, i. 131) says that the glass is extremely pure, and is made from the rocks in the neighborhood. The rocks are probably of quartz, *i. e.*, rock crystal, a correspondence with Pliny's statement respecting Indian glass which seems deserving of attention.

Whether the making of glass in China was an original discovery of that ingenious people, or was derived *via* Ceylon from Egypt, cannot perhaps be now ascertained; the manufacture has, however, never greatly extended itself in China. The case has been the converse of that of the Romans; the latter had no fine pottery, and therefore employed glass as the material for vessels of an ornamental kind, for table services and the like. The Chinese, on the contrary, having from an early period had excellent porcelain, have been careless about the manufacture of glass. A Chinese writer, however, mentions the manufacture of a huge vase in 627 A. D., and in 1154 Edrisi (first climate, tenth section) mentions Chinese glass. A glass vase about a foot high is preserved at Nara in Japan, and is alleged to have been placed there in the 8th century. It seems probable that this is of Chinese manufacture. A writer in the *Mémoires concernant les Chinois* (vol. ii. pp. 463 and 477), writing about 1770, says that there was then a glass-house at Peking, where every year a good number of vases were made, some requiring great labor because nothing was blown (rien n'est soufflé), meaning no doubt that the ornamentation was produced not by blowing and moulding, but by cutting. This factory was, however, merely an appendage to the imperial magnificence. The earliest articles of Chinese glass the date of which has been ascertained, which have been noticed, are some bearing the name of the emperor Kienlung (1736–1796), one of which is in the South Kensington Museum.

In the manufacture of ornamental glass the leading idea in China seems to be the imitation of natural stones. The colored glass is usually not of one bright color throughout, but semi-transparent and marbled; the colors in many instances are singularly fine and harmonious. As in 1770, cutting is the chief method by which ornament is produced, the vessels being blown very solid.

Diffusion of the art in Europe.

The chief source from whence a knowledge of the art of glass-making spread through Europe was probably Rome; in the Roman imperial period glass was undoubtedly made, not only in Italy, but also in France, in Spain, and in all probability at or near Cologne, and perhaps in other places near the Rhine. Whether refugees from Padua, Aquileia, or other Italian cities carried the art to the lagoons of Venice in the 5th century, or whether it was learnt from the Greeks of Constantinople at a much later date, has been a disputed question. It would appear not improbable that the former was the case, for it must be remembered that articles formed of glass were in the later days of Roman civilization in constant daily use, and that the making of glass was carried on, not as now in large establishments, but by artisans working on a small scale. It seems certain that some knowledge of the art was preserved in France and in Spain, possibly even in England, and it seems improbable that it should have been lost in that archipelago, where the traditions of ancient civilization must have been better preserved than in almost any other place. In 523 Cassiodorus writes of the "innumerosa navigia" belonging to Venice, and where trade is active there is always a probability that manufactures will flourish. However this may be, the earliest positive evidence of the existence at Venice of a worker in glass would seem to be the mention of Petrus Flavianus, phiolarius, in the ducale of Vitale Falier in the year 1090. In 1224 twenty-nine persons are mentioned as friolari (*i. e.*, phiolari), and in the same century "mariegole" or codes of trade regulations

Venice and Murano.

were drawn up (*Monografia della Vetraria Veneziana e Muranese*, p. 219). The manufacture had then no doubt attained considerable proportions; in 1268 the glass-workers exhibited decanters, scent-bottles, and the like; in 1279 they made, among other things, weights and measures. In the latter part of this century the glass-houses were almost entirely transferred to Murano. From thenceforward the manufacture continued to grow in importance; glass vessels were made in large quantities, as well as glass for windows. The earliest example which has as yet been described—a cup of blue glass, enamelled and gilt—is, however, not earlier than about 1440. A good many other examples have been preserved which may be assigned to the same century: the earlier of these bear a resemblance in form to the vessels of silver made in the west of Europe; in the later an imitation of classical forms becomes apparent. Enamel and gilding were freely used, in imitation no doubt of the much-admired vessels brought from Damascus or Egypt. Many of the ornamental processes which we admire in Venetian glass were already in use or were invented in this century; as that of mille fiori, in which rods of various colors are joined by heat and so arranged as when cut transversely to form patterns resembling flowers or corallines. Such sections were then placed side by side and united by a lining of heated glass applied to them; the joint mass was then reheated and worked into the desired form. The beautiful kind of glass known as vitro di trina or lace glass, was made by a variation of the same process; the rods or canes, being composed of opaque white threads surrounded by transparent glass, were placed side by side in a mould, and a bubble of glass blown into the midst so as to adhere to the canes; the whole was then reheated and fashioned in the same manner as any ordinary glass. Sometimes two canes or cylinders were used, the lines of which ran in opposite directions, and a reticulated pattern was thus produced. An elaborate account of the process is given by M. Labarte (*Histoire des Arts Industriels*, iv. 575 *sq.*). Many of the examples of this process exhibit surprising skill and taste, and are among the most beautiful objects produced at the Venetian furnaces. Glass was made by the Romans in like manner, but no ancient example which has come down to us equals in correct execution some of those made at Venice. That peculiar kind of glass usually called schmelz, an imperfect imitation of calcedony, was also made at Venice in the 15th century. Avanturine glass, that in which numerous small particles of oxide of copper are diffused through a transparent yellowish or brownish mass, was not invented until about 1600.

The peculiar merits of the Venetian manufacture are the elegance of form and the surprising lightness and thinness of the substance of the vessels produced. The glass on the other hand wants brilliancy, and is often tinged with yellow, or if, as is not uncommon, too much manganese (which neutralizes the yellow tinge imparted by the presence of iron) has been used a faint purple. This slight coloration may not, however, appear a defect to eyes fatigued by the brilliancy of modern flint glass. The Venetian workmen perhaps somewhat abused their skill by giving extravagant forms to vessels, making drinking glasses in the forms of ships, lions, birds, whales, and the like.

Besides the making of vessels of all kinds the factories of Murano had for a long period almost an entire monopoly of two other branches of the art—the making of mirrors and of beads. Attempts to make mirrors of glass were made as early as 1317 A. D., but even in the 16th century mirrors of steel were still in use. To make a really good mirror of glass two things are required—a plate free from bubbles and striæ, and a method of applying a film of metal with a uniform bright surface free from defects. The principle of applying metallic films to glass seems to have been known to the Romans, and even to the Egyptians, and is mentioned by Alexander Neckam in the 12th century, but it would appear that it was not until the 16th century that the process of "silvering" mirrors by the use of an amalgam of tin and mercury had been perfected. During the 16th and 17th centuries Venice exported a prodigious quantity of mirrors, but France and England gradually acquired knowledge and skill in the art, and in 1772 only one glass-house at Murano continued to make mirrors.

The making of beads was probably practised at Venice from a very early period, but the earliest documentary evidence bearing on the subject does not appear to be of earlier date than the 14th century, when prohibitions were directed against those who made of glass such objects as were usually made of crystal or other hard stones. In the 16th century it had become a trade of great importance, and about 1764 twenty-two furnaces were employed in the production of beads. Towards the end of the same century from 600 to 1000 workmen were, it is stated, employed on one branch of the art, that of ornamenting beads by the help of the blow-pipe. A very great variety of patterns was produced; a tariff of the year 1800 contains an enumeration of 562 species and a vast number of sub-species. Beads to the value of £200,000 are still annually made in Venice (*Monografia della Vetraria Veneziana e Muranese*).

The efforts made in France, Germany, and England, in the 17th and 18th centuries, to improve the manufacture of glass in those countries had a very injurious effect on the industry of Murano. The invention of flint glass in England (about 1620?) brought in its train the practice of cutting glass, a method of ornamentation for which Venetian glass from its thinness was ill-adapted. One remarkable man, Giuseppe Briati, exerted himself, with much success, both in working in the old Venetian method and also in imitating the new fashions invented in Bohemia. He was especially successful in making vases and circular dishes of "vitro di trina," one of the latter in the Correr collection at Venice, believed to have been made in his glass-house, measures 55 centimetres (nearly 23 inches) in diameter. The vases made by him are as elegant in form as the best of the Cinquecento period, but may perhaps be distinguished by the superior purity and brilliancy of the glass. He also made with great taste and skill large lustres and mirrors, with frames of glass ornamented either in intaglio or with foliage of various colors. He obtained a knowledge of the methods of working practised in Bohemia by disguising himself as a porter, and thus worked for three years in a Bohemian glass-house. In 1736 he obtained a patent at Venice to manufacture glass in the Bohemian manner. He died in 1772.

The fall of the republic was accompanied by interruption of trade and decay of manufacture, and in the last years of the 18th and beginning of the 19th century the glass-making of Murano was at a very low ebb. In the year 1838 Signor Bussolin revived several of the ancient processes of glass-working, and this revival was carried on by C. Pietro Biguglia in 1845, and by others, and later by Salviati, to whose successful efforts the modern renaissance of the glories of Venetian art glass is principally due. Salviati revived the former processes and practised them, not in mere slavish imitation, but with freedom, invention, and fine artistic instinct. Every general industrial exhibition has contained brilliant examples of the products of the Venice and Murano Glass Company, composed chiefly of English capitalists, and formerly managed by Salviati.

The fame of Venice in glass-making so completely eclipsed that of Italian cities that it is difficult to learn much respecting their progress in the art. It appears, however, that as early as 1295, furnaces had been established at Treviso, Vicenza, Padua, Mantua, Ferrara, Ravenna, and Bologna. In 1634 there were in Rome two and in Florence one glass-house; but whether any of these produced ornamental vessels, or only articles of common use and window glass, would not appear to have as yet been ascertained.

Western Europe during Roman period.

The history of glass-making in France, Spain, Germany, and England offers many points of resemblance. In the first three, and probably in England also, glass was made at the period of the Roman empire; in France about Lyons, as is shown by a monument in the Musée Lapidaire to one Julius Alexander, described as an "opifex artis vitriæ," in Normandy and Poitou, and probably in many other parts. In Spain glass, according to Pliny, was manufactured (*Nat. Hist.*, xxxvi. 26, 66) in many parts of the country, "per Hispanias," but the remains of Roman glass-making have been chiefly found in the valleys which run down to the coast of Catalonia, but also near the mouth of the Ebro, in Valencia and in Murcia (Señor Rico y Sinobus, *Del Vidrio*, p. 11).

Glass-making in Germany during the Roman period would seem to have been carried on extensively at Cologne, near which city many remarkable glass vessels of peculiar character have been discovered. The art was probably not lost during the period which followed the downfall of the Roman power. In the year 758, Cuthbert, abbot of Jarrow, wrote to Lullo, bishop of Mainz, to request him to send him a maker of glass vessels. It is scarcely probable that the art had been forgotten and revived between the 5th and the 8th centuries.

It is not equally clear that glass was made in England, though it is probable that this was the case. Both vessels and window glass have been found in almost all parts of the country, and at Buckholt, near the Roman road from Winchester to Salisbury, the remains of a glass furnace, among which were numerous fragments of glass which may possibly have been of Roman origin, and a fragment of undoubtedly Roman pottery. But associated with these were fragments of glass of the 14th and later dates, and of pottery of the 16th century.

The dark ages.

Very little has been ascertained as to the practice of the art in either of the four countries during the dark ages, but it would seem to have been preserved in France and Germany, and perhaps also in England and Spain. The fact narrated by Bede, in his history of the abbots of Wearmouth, that Benedict Biscop about 675 procured workmen from France to make glass for his monastery, shows at once that it was preserved in France and lost or nearly so in England. But a great quantity of drinking vessels are found in the tombs of the Anglo-Saxons while still pagan; and although the like are found both in France and in Germany, it is said that a greater number and more varieties occur in England, and it has thence been inferred that they were probably made in the country. Welsh poets of the 6th century (?), Aneurin and Llywarch Hen, both mention glass vessels by a name, "wydr," evidently derived from vitrum, and it is possible that the Welsh retained a knowledge of its manufacture. Some knowledge of the art of manipulating glass existed in Ireland in and before the 12th century, as is shown by cameo heads and small pieces of mosaic glass of quite peculiar patterns which occur on objects of Irish workmanship (*Transactions of the Royal Irish Academy*, vol. xxiv., Antiq., part iv.).

In France "vitrarii" are mentioned in several centuries from the 6th to the 11th; in Germany, as has been shown above, there is ground for believing that the art was practised in the 8th century; and in the 12th artisans are found at Cologne with the designation "ustor" attached to their names, which Merlo (*Künst und Künstler in Köln*, p. 563) suggests may probably mean maker of glass. Nothing seems to have been ascertained about the existence of the art in Spain between the Gothic conquest and the 13th century, when it was practised at Almeria by the Moors.

Mediæval period.

During the mediæval period France produced large quantities of glass, as well in the form of vessels as in that of window glass. The first were made on a large scale in Dauphiné in the 14th century. In 1338 Humbert the dauphin granted a part of the forest of Chamborant to a glass-maker on condition that he should furnish him with more than 3000 vessels of glass annually (*Hist. Dalph.*, ii. 363). In 1302 window glass was made at Bezu le Foret, in the department of the Eure, for the king of France; a fragment of a roll of accounts for that year is preserved in the Bibliothèque Nationale. Glass was also made in Poitou, and a drageoir with the arms of Charles VIII. of France (1470–1498) has been engraved by M. Fillon (*L'art de Terre*, etc.) which is believed to have been made in that province.

Much glass was no doubt made for windows both in Germany and the Low Countries, during the Middle Ages, and in 1453 mention occurs of a fountain and four plateaux made for Philip the Good, duke of Burgundy, by a glass-maker of Lille; but if artistic objects were made, hardly any examples have been preserved. Glass-makers existed at Vienna in 1221 (Peligot, *Le Verre*, p. 342). In 1428 a Muranese artificer set up a furnace in the same city, and another was established by another Italian in 1486, which it is said was still at work in 1563. How far these efforts to rival the manufactures of Murano may have succeeded we have no information, but contemporaneously the native artificers continued to produce articles for common use, as we may see by the woodcut in the edition of George Agricola *De Re Metallica*, published at Basel in 1561, representing the interior of a glass-house. In this the tall cylindrical drinking-glasses known as wiederkoms, bottles with big bellies and slender necks, and retorts may be seen. A glass-house was founded at Daubitz in Bohemia in 1442, others in 1504 (Peligot, *Le Verre*, p. 343).

In England vessels of glass seem to have been but little used during the Middle Ages; they occur very rarely in inventories, and when they do, as in the Calendars of the Treasury of the Exchequer, they are usually described as mounted in gold or silver, or as painted, being probably enamelled glass vessels from Constantinople, Damascus, or Venice, objects rather of virtu than of daily use. It has even been asserted that there is no evidence that any description of glass was made in England before the 15th century, but in the roll of the taxation made at Colchester in 1295 three of the principal inhabitants are designated "verrer;" and it would seem hardly probable that so many in such a town were glaziers only and not glass-makers. In the 14th century Andrew le glasswright is mentioned in the records of Great Yarmouth. In 1439 (or 1447) English glass is mentioned in the contract for the windows of the Beauchamp chapel at Warwick, but disparagingly, as the contractor binds himself not to use it. In 1485, however, it is mentioned in such a manner as to lead to the conclusion that it was dearer and presumably better than either "Dutch, Venice, or Normandy glass" (*Domestic Architecture of the Middle Ages*, by Hudson Turner, p. 78).

In Spain glass was made at Barcelona in considerable quantities in 1324; and Almeria, according to an Arab author of the 13th century, was famous for its manufacture of glass. In the 15th century the export of glass from Barcelona was considerable; Jeronimo Paulo in 1491 says that glass vessels of various sorts were sent thence to many places and even to Rome.

16th century.

In the 16th century the fashion of using glass vessels of ornamental character spread from Italy into France, England, and the Low Countries. Henry VIII. had a large quantity, chiefly or wholly, it would seem, of Venetian manufacture (see inventory in 1542, *Archæological Journal*, vol. xviii.). This increasing use of glass led to the reflection that large sums of money went annually to Venice for such wares, and to the question whether the manufacture might not be carried on at home. We therefore find that about the middle of this century attempts were made to introduce the Venetian methods of manufacture into the several countries; Henry II. of France established an Italian named Mutio at St. Germain-en-Laye, and Henry IV. in 1598 permitted two "gentilshommes verriers" from Mantua to settle themselves at Rouen in order to make "verres de cristal et autres ouvrages qui se font à Venise." A like attempt was made in England about 1550, for in that year eight glass-makers from Murano addressed from London a petition to the Council of Ten at Venice praying to be excused from the penalties decreed by that body in 1549 against Venetian subjects who taught the art to foreigners (*Cal. State Papers*, Venetian, No. 648). The council allowed the eight workmen to remain until the end of the term for which they had engaged themselves. Other attempts followed: Stow says (*Chron.*, p. 1040) that Venice glasses were first made in London by one Jacob Vessaline about the beginning of the reign of Queen Elizabeth, and in 1565 one Cornelius de Lannoy (or Launoy) was working in the pay of the Government (*Cal. State Papers*, Dom.). Others, as Carre or Quarre, and Becku *alias* Dolin, from the Low Countries, were engaged in similar undertakings during the latter part of this century, but it does not seem that any great success was attained, as the importation of glass from Venice continued until long after.

These attempts to rival Murano seem to have been most successful in the Low Countries and in Spain. Ambrozio de Mongarda had a privilege in the former country to make "voirres de cristal à la faschon de Venise," which in 1599 was continued to Philippe de Gridolphi; his glass-house was at Antwerp. Glass-works also existed at Liége. Much glass in the 16th century was sent from Antwerp to England (Houdoy, *Les Verreries à la façon de Venise*). This manufacture went on during the following century, and many examples remain, more or less resembling the products of Murano.

In Germany Ferdinand I. established a glass-house at Weidlingen near Vienna, which was to work in the Italian manner; but no great success it would seem attended these efforts, partly no doubt because about the same time the native glass-makers struck out a new and original style of ornamentation for the great cylindrical beakers, sometimes 20 inches in height, usually called wiederkom (come again), but which M. Peligot says ought to be called willkomm (welcome). This was a somewhat coarse but very effective system of painting in enamel such subjects as the emperor and electors of Germany, or the imperial eagle bearing on its wings the arms of the states which composed the empire, etc. The earliest example which has been met with bears the date 1553, but the system had great vogue, and continued in use until about 1725.

Spanish writers have not as yet acquainted us with the precise means by which the Venetian methods of working were brought to their country; but Gaspar Baneiros in his *Chronographia*, published in 1562, says that the glass made at Barcelona was almost equal to that of Venice, and during this and the next century large quantities were exported. Venetian glass was imitated in several other places in Spain, and with considerable success, as several examples in the South Kensington Museum testify. The native forms and methods of working, however, went on contemporaneously, and it would appear do so down to the present day.

17th century.

The branch of glass-making in which the greatest results were obtained in France during the 17th century was that of the manufacture of mirrors. In 1665 the services of eighteen Venetians were obtained, and a factory established in the Faubourg St. Antoine at Paris, and another factory was founded at Tour-la-Ville near Cherbourg. These were united and worked with great success; the plates which ornament the "Galerie des Glaces" at Versailles were made at Tour-la-Ville. In 1688 the process of casting plates of glass was first adopted in modern times (for the window glass of Roman times was cast); and thus it became possible to make mirrors of dimensions which could not be attained as long as the plates were produced by blowing. The manufacture was carried on at St. Gobain, still the seat of an immense production of glass.

English glass-making of the 17th century is distinguished by one of the most important innovations in the practice of the art which has at any time been introduced, that of using a large proportion of oxide of lead in combination with potash. Glass so made is more brilliant than other kinds, and is known in England as "flint glass," in France as "cristal." The employment of lead as one of the ingredients of glass was not a discovery, for it had been practised to a small extent and for certain purposes, as in the imitation of gems by the Romans, and through the Middle Ages. Neither the date when flint glass was first made nor the inventor of the process is known.

Sir William Slingsby before 1611 (*Cal. State Papers, Dom.*) had obtained a patent for making glass with sea coal; and in 1615 the use of wood for that purpose was forbidden by royal proclamation. How far this proclamation may have been obeyed does not appear, but Sir R. Mansel, who held a patent of monopoly for glass-making from 1616 until about 1634 (and perhaps even later), states in 1623 that furnaces erected in London, the isle of Purbeck, Milford Haven, and on the Trent, had all failed, but that he had established them successfully at Newcastle-on-Tyne. Probably coal was used at this last place, and it seems not unlikely that flint glass may have been first made there. Merret, however, writing about 1665 (in his edition of the *Ars Vitraria* of Neri), says that glass made with lead was not in use in the English glass-houses on account of its too great fragility; but in 1673 Evelyn notes in his diary a visit to the Italian glass-houses at Greenwich "where glass was blown of finer metal than that of Murano," and in 1677 a visit to the duke of Buckingham's glass-works (at Lambeth), "where they made huge vases of metal as clear, ponderous, and thick as crystal, also looking-glasses far larger and better than any that come from Venice." From this time much glass was made in England, and Dr. Pococke, who travelled in Germany in 1736, gives the preference in point of quality to English glass over Bohemian.

During this century much art and labor were employed in Germany in the ornamentation of vessels for drinking, such as goblets and wiederkoms. Sometimes they were painted in grisaille, the subjects being battles, processions, and the like, sometimes engraved or etched; common subjects are escutcheons with arms, views of cities, ciphers, etc. Many excellent artists worked in these various styles (Beckmann, *Hist. of Inventions*, iii. 209; Doppelmayr, *Nürnbergische Künstler*, p. 231, 233, etc.), and their works brought high prices. Dr. Pococke mentions seeing some at Rispen, to which the glass-works formerly carried on at Potsdam had been removed, which cost from £100 to £150. Excellent material for these artistic efforts was furnished by the Bohemian furnaces; the art was patronized by several German princes; the celebrated Kunkel was, in 1679, director of the glass-houses at Potsdam, which were carried on at the cost of the elector, and where the beautiful ruby glass was produced. Etching and engraving on glass was also much practised in Holland.

In Spain glass was made in 1680, at San Martin de Valdeiglesias, in imitation of Venetian; and Barcelona, Valdemaquada, and Villafranca are named in a royal schedule of the same date, fixing the prices at which glass was to be sold in Madrid, as places where wares imitative of Venetian were made. There was also an important manufactory at La Granja (see Introduction to *Cat. of Spanish Glass in South Kensington Museum*, by Señor Riano). Some of the products of the Spanish furnaces closely resemble those of Murano, but rarely exhibit much beauty or much originality. Others again, attributed to the factory of San Ildefonso and to the 18th century, bear a very close resemblance to some of the Dutch glass of that period.

18th and 19th centuries.

Although during the 18th and earlier part of the 19th century progress was made both in the purity and in the beauty of the material (especially in the case of glass for optical purposes), and in the organization and working of factories, it was a period marked in no country by much of novelty or of artistic effort in the manufacture of glass. M. Labarte even goes so far as to say (*Hist. des Arts Industriels*, iv. 597) that in France in 1759 the fabrication of "vases de verre" had so completely fallen into decadence that the Academy of Sciences offered a prize for an essay on the means by which the industry could be revived. In the beginning of the present century cut glass was much in vogue, and was produced in England of great brilliancy, though the forms of the objects often left much to be desired in point of elegance.

The manufacture of colored glass for windows was a consequence of the revival of Pointed architecture, and England, France, Belgium, and Germany have in this century rivalled each other in its production.

The Exhibition of 1851 did not perhaps produce a more marked effect on any of the industrial arts than on that of glass. The progress made since that date in the fabrication of artistic glass wares (the verrerie de luxe of the French) has been surprising, and at the present moment enlightened and enterprising manufacturers of glass are in every country studying the products of the furnaces of all times and all countries, as their predecessors at Murano in that great period of the art—that of the Renaissance—did the relics of Roman glass-working (Biringuccio, *Pirotechnia*, lib. ii.) in order to glean from them lessons and suggestions of further advance in their art. (A. NE.)

The Manufacture of Glass.

Glass, in its ordinary signification, is a brittle, transparent compound produced by the fusion, at a very high temperature, of silica (silicic acid) with one or more basic substances, one of which, in all cases, must be an alkaline metal. But the silicates of sodium and potassium, whether separate or combined, being soluble in water, and also readily acted on by other agents, are not in themselves suitable for most of the purposes to which glass is ordinarily applied. When, however, to these silicates, or to either of them, a silicate of an alkaline earth is added, the resulting body is not sensibly affected by water or ordinary solvents; and it is the fused amorphous mass thereby obtained that alone is glass in the restricted technical sense. Thus the definition given by Dumas that glass is a silicate of at least two metals belonging to different groups, one of which must be an alkaline metal, strictly embraces and limits all varieties of ordinary glass. Boracic acid, a substance closely allied in chemical properties to silica, has a similar influence on the alkalies and alkaline earths, producing by their mutual fusion a transparent amorphous compound; and indeed, for certain special purposes, a glass in which borates to a certain extent supplant silicates is used for optical purposes. The substances, however, which form the essential basis of all varieties of common glass are (1) silica as the acid element; (2) soda or potash as the alkaline base; and (3) lime and oxide of lead as the alkaline earths. To the alkaline earths commercially employed there ought also to be added baryta and alumina, the former being used in the place of lead, and the latter being a common ingredient in certain kinds of glass.

The following tabular statement shows the bodies capable of yielding transparent glass:—

Acid.	Alkaline.	Earthy.	
		Colorless.	Colored.
	Oxides of	Oxides of	Oxides of
Silica.	Potassium.	Calcium.	Iron.
Boracic acid.	Sodium.	Lead.	Manganese.
		Barium.	Copper.
		Strontium.	Chromium.
		Magnesium.	Uranium.
		Aluminium.	Cobalt.
		Zinc.	Gold.
		Thallium.	

Various authorities who have investigated the constitution of glass have endeavored to establish a chemical formula for what they term normal glass. The results arrived at, however, by different investigators disagree among themselves; and the balance of opinion is in favor of the view that no such substance as normal glass exists, and that glass does not result from any definite chemical compounds, but is simply a mixture of silicates, with usually an excess of uncombined silica. The proportions in which the ingredients of glass are present, however, have not only a very great influence on the fusibility of the mass; but these conditions also very materially affect the qualities of the substance. In general the more nearly the proportion of silica approaches the amount necessary to form definite compounds with the basic ingredients, the better and the more stable is the quality of the glass. The conclusion of Otto Schott in his investigation of the constitution of glass, that the simplest formula for glass is represented by $\left.\begin{matrix} x\mathrm{Na_2O} \\ y\mathrm{CaO} \end{matrix}\right\} z\mathrm{SiO_2}$, may be accepted as a safe statement.

The phenomenon of devitrification, which is exhibited most readily by glass of inferior quality, has important bearings on the chemical constitution of glass, as well as on the working of the material. Devitrification is a change which may be induced in all varieties, but only with difficulty in the finer kinds of potash glass—either by slowly cooling the glass from the state of fusion, or by heating it in a mixture of sand and plaster of Paris till it softens, and then allowing it to cool by very slow degrees. Thereby it partly or entirely loses its transparent amorphous form, and by the formation of innumerable minute crystals it becomes opaque. When such a change penetrates the entire mass it assumes a milky and porcelain-like appearance, whence it is in this condition known as Réaumur's porcelain—the phenomenon having been first investigated by that observer. Devitrification renders the material much harder and less fusible than the same glass in a transparent condition; and it is less subject to fracture on the application of heat. According to Pelouze, Splittgerber, and others, devitrification results simply from a re-arrangement of the molecules into the crystalline form while the mass is soft, no alteration in the proportions of the constituents taking place concurrently; but Dumas and his followers maintain, on the contrary, that in undergoing the change the glass loses part of its alkali, and that crystallization takes place through the formation of compounds infusible at the temperature existing at the moment of crystallization. These compounds may result either from the dissipation of alkaline matter or from the separation of the mass into two strata,—that most highly alkaline retaining its amorphous condition more persistently than the other more siliceous portion.

The physical properties upon which the great value and utility of glass principally depend are (1) its well-known prevailing transparency combined with a brilliant lustre and great hardness; (2) its fusibility at a high temperature; and (3) its softness and viscosity at a red heat, whereby it can be moulded and otherwise worked with facility into any shape desired. Of great value also is its resistance to the influence of common solvents. Properly-made glass is not sensibly acted on by any of the acids except hydro-fluoric acid, which attacks it powerfully, combining with and removing its silica. Water affects glass so feebly that for practical purposes its action may be disregarded; but when it is submitted for a prolonged period to water at a high temperature, it is slowly dissolved. Even prolonged exposure to moist air so acts on glass, particularly on highly alkaline varieties, that the surface becomes clouded and obscure, and the beautiful iridescent scaling off observable in ancient glass is due to the exposure of the substance for long ages to the influence of moist air or damp earth.

Glass is an extremely bad conductor of heat, and from that property springs, in great measure, its brittleness. Owing to this imperfect conductivity it necessarily results that a mass of glass, or a glass object cooling from a state of fusion, becomes cooled and set or solidified on its outer surface before the internal molecules have parted with their heat, contracted, and established themselves in a stable relation to each other. The solidification of the superficial stratum thus necessarily hinders the contraction of the internal portion of the mass, and as the internal molecules cool down a state of tension is created, the central portion tending to draw the surface stratum inwards with a force held in check by the strain in the contrary direction of the outer range of molecules. In this condition a very moderate impact is sufficient to determine the fracture of the glass. The high degree of brittleness which results from unequal cooling is exhibited in a very marked manner by the philosophical toy known as "Rupert's drops." Such pear-shaped masses of glass are prepared by allowing molten glass to fall, drop by drop, into cold water, when the drops assume a more or less spheroidal form, with a finely tapering point. Of course a very sudden and rapid cooling of the surface takes place, while the interior is still at a high temperature, and correspondingly much dilated, the consequence of which is that a state of great tension is established between surface and centre. The breaking off of a small portion of the tail is sufficient to destroy the equilibrium established between the hard superficial and the dilate internal molecules; and immediately the whole mass is shattered to dust with explosive violence. Excessive brittleness is overcome by the operation of annealing to which glass is submitted,—a process which has been explained under ANNEALING, and which will be further referred to in dealing with a method of tempering or hardening glass which has been introduced by M. de la Bastie within the last few years.

It is difficult to give a consistent and systematic view of the manufacture of glass, because not only chemical constitution, but the mechanical operations by which glass is prepared, and the purposes to which the material is applied, have also to be taken into consideration. A good classification, from a chemical point of view, is that given by Stein (in Bolley's *Technologie*), who distinguishes three classes:

(1.) Glass containing one or two bases belonging to the same group. This class embraces only the soluble silicates which do not fulfil the ordinary functions of glass.

(2.) Glass with several bases which belong to different groups, comprehending two classes:—(1) calcium glass, under which come sodium-calcium glass and potassium-calcium glass; and (2) lead glass, which constitutes ordinary flint glass or crystal and strass.

(3.) Colored and opaque glass, of which there are also two classes,—the first embracing the varieties of transparent colored glass which may belong to any of the above classes, with the addition of coloring oxides, and the second being devoted to the various kinds of opaque glass.

The raw materials of the glass manufacture embrace the following principal ingredients. (1.) Silica is used in the forms of pure quartz (for very fine qualities of glass), crushed sandstone, pulverized flints, and especially sand of degrees of purity varying in proportion to the quality of the glass to be made. The finest iron-free sand in the United Kingdom is obtained from Alum Bay in the Isle of Wight, from Lynn, Norfolk, and from Leighton Buzzard, Bedfordshire; but much pure sand is imported into the United Kingdom from Fontainebleau in France, from Belgium, and other localities. (2.) Lime is employed in the form of chalk or marble, either burned or unslaked, and it also must for colorless glass be free from iron impurities. Of (3.) potash and (4.) soda, any of the ordinary salts except chlorides, but especially the sulphates and carbonates, are indifferently utilized, the point of real importance being here also the freedom of the compound from contamination when fine glass is being made. At no very remote date kelp was the principal source of soda alkali in glass, but this is now entirely disused, and the principal source of potash is the salt mines of Stassfurt and Leopoldshall in Prussia, and at Kalusz in

Galicia. Both potash and soda are frequently constituents of the same glass; but glass made from potash is free from the decided sea-green tinge which invariably is seen in soda glass, although the latter is the more brilliant in lustre. (5.) Lead is the characteristic ingredient of a distinct class of glass of which ordinary flint glass is the type. It is usually employed in the form of minium or red lead ($2PbO,PbO_2$), partly on account of its fine state of division and partly because by giving off oxygen it helps to purify the metal. (6.) Baryta and witherite or baric carbonate have been introduced with much success as a partial substitute for alkali in soda or potash glass, and for a part of the lead in ordinary flint glass, and in all probability barium compounds are destined to occupy a much more important place in glass manufactures than hitherto they have done. (7.) Cullet or waste and broken fragments of the special kinds of glass to be made is an important and essential ingredient, being added to the extent of about one-third of the whole charge in the melting and preparation of glass. These materials constitute the essential ingredients which go to the formation of glass. In coarse varieties, such as bottle glass, alumina and iron are present, but their presence simply results from the inferior and impure nature of the raw materials employed, and are neither essential nor desirable. Some portion of alumina too, is taken up from the pots in which the materials are melted. Bleaching or oxidizing agents are also employed to produce a high degree of colorlessness in clear glass, and for this purpose peroxide of manganese, arsenious acid, and nitrate of potash are the materials generally used. These bodies oxidize carbon compounds which may be present, and neutralize to a large extent the color yielded by iron by converting its protoxide into peroxide. Too much manganese, however, gives the glass a reddish tinge, and excess of arsenic produces a milky cloudiness. The various substances employed to produce colored and opaque varieties of glass will be enumerated when these special kinds are described. The requisite proportions of the raw materials ground and prepared are intimately mixed with the aid of a mixing apparatus, and in this form constitute the "batch." Formerly it was the habit to frit or partially decompose and fuse the ingredients in a form of reverberatory furnace called a calcar arch, but since the use of kelp was abandoned that operation is no longer essential, and generally the well-mixed batch is placed at once in the melting pots, or the tank in the case of tank furnaces.

Melting Pots.—These pots or crucibles are made of the finest fire-clay, that from Stourbridge in Worcestershire being exclusively used for glass pots in Great Britain. Great care is requisite in the selection, and in cleansing the clay from extraneous particles, the presence of which, even in the smallest degree, will injure the pot. A fine powder procured by grinding old crucibles is generally mixed, in a proportion seldom larger than a fourth, with what is termed the virgin clay. This mixture dries more rapidly, contracts less while drying, and presents a firmer resistance to the action of the fire and alkali used in the composition of glass than the simple unmixed clay. These ingredients, having been mixed, are wrought into a paste in a large trough, and carried to the pot loft, covered in such a way as to exclude dust and other minute particles. Here a workman kneads the paste by trampling it with his naked feet, turning it from time to time until it becomes as tough as putty. It is then made into rolls, and wrought, layer upon layer, into a solid and compact body, every care being taken to keep it free of air cavities, which would, by their expansion in the furnace, cause an immediate rupture of the pots. After pots are made, very great care is necessary to bring them to the proper state of dryness before taking them to the annealing or pot arch. In drying they commonly shrink about 2 inches in the circumference. When pots are made during summer, the natural temperature is sufficient for drying them; but in winter they are kept in a temperature of from 60° to 70° Fahr. They remain in the room where they are made for a period varying from nine to twelve months. Being afterwards removed to another apartment, where the heat is from 80° to 90° Fahr., they are kept there for about four weeks. They are then removed for four or five days, more or less, according to their previous state of dryness, to the annealing arch, which is gradually and cautiously heated up till it reaches the temperature of the working furnace, whither, after being sufficiently annealed, they are carried as quickly as possible. Pots last upon an average from eight to ten weeks, and they form a costly item in the manufacturing operations, as each pot is worth on an average about £10; and many of them, notwithstanding all care, crack and give way as soon as they are placed in the melting furnace. For all varieties of glass, excepting lead glass, open pots in the form of a truncated cone, as represented in fig. 1, are employed; but for flint glass a covered pot with an opening at the side, as shown in fig. 2, is essential. Dr. Siemens proposed a form of melting pot divided into three compartments, the materials being melted in the first, and passing into the second by an opening at the lower part of the partition, where the metal was to be fined and freed from included air-bubbles, and afterwards to pass by a like opening to the third compartment, whence it was to be drawn for working. The specific gravity of the charge in the first compartment would rise in proportion as the materials melted and became homogeneous in structure. Therefore the metal would sink in proportion as it melted; and the best melted portions pass into the second compartment, in which, under the influence of the direct furnace heat, it would be cleared. There, similarly, the perfectly fined glass falling to the bottom would pass into the cooler working compartment, which is protected by a covering cap. Dr. Siemens's idea has been practically developed in his continuous tank referred to below.

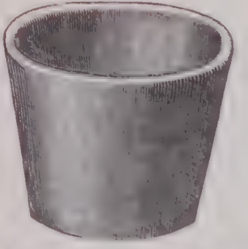


Fig. 1.—Crown-Glass Pot.

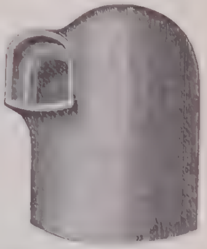


Fig. 2.—Flint-Glass Pot.

Furnaces.—A glass-melting furnace or oven is a modified form of reverberatory furnace, which assumes many different shapes and arrangements according to the kind of glass to the manufacture of which it is devoted, and the nature of the fuel used. As regards the latter cause of difference it may be noted that, while coal is the principal fuel employed in Great Britain, dried wood and peat are extensively consumed in Germany, and in modern times gas furnaces on the Siemens and other principles are being freely introduced. In the construction of a furnace the principal objects to be kept in view are not only the production and maintenance of an intense heat, but its uniform distribution throughout the furnace, and the bringing of the charges of glass materials directly under its fusing influence. The form assumed by melting furnaces is, in general, square or oblong for sheet and plate-glass making, and circular in English flint-glass making. The fire-space or grate occupies the centre of the furnace, and the fire, when fuel is used for direct heating, is either fed or stoked from both ends, or raised from under the bars by a patented method. The fire-grate is usually on a level with the floor of the house in which it is erected, but under it is an arched subterranean passage forming the "cave" or ash-pit, both ends of which extend to the open air outside the glass-house. The fire-grate bars are placed in the top of this arched passage, which thus serves as a canal for the atmospheric air required to maintain combustion within the furnace; and for regulating the admission of air, and so controlling the heat, there are doors at both ends of the archway. In some cases two such arched passages at right angles to each other, and intersecting at the fire-bars, are constructed, so that either can be used according to the prevailing direction of the wind, etc. In general no flue or chimney is directly connected with the furnace, the only exit for the products of combustion being the working holes, and thus the heat is directed around and over each pot placed opposite a working hole in the furnace. Within the furnace, around the grate space in the case of circular furnaces, or on both sides of it in quadrangular furnaces, is a raised bank or narrow platform termed the "siege," on which the melting pots are placed. The number of pots arranged in a furnace vary from four to ten, and each is reached, either for charging or for working off the prepared metal, by means of "working holes" in the side of the furnace situated directly over the pots. The general form and construction of a six-pot crown-glass furnace, which also may be taken as the type of sheet and plate-glass furnaces, is shown in Plate V., where fig. 3 is a ground plan at the level of the siege of a common form of furnace, while in fig. 1 is seen a front elevation of the same furnace, 1, 2, and 3 being the working holes, 4, 5, 6, and 7 pipe-holes for heating the blowing pipes, and 8, 9, and 10 foot-holes for mending the pots and sieges. The furnace is covered with a low-roofed crown or dome, and the whole structure is bound together with a system of iron bars. The materials used in the construction and lining of all furnaces must be selected with the utmost care, and built with special regard to the enormous temperature to which they are subjected. Formerly a fine-grained purely siliceous sandstone was much used, but now the principal materials are large moulded bricks or blocks of fire-clay of the most infusible and refractory description. For the crown of the furnaces used in plate-glass melting, Dinas silica blocks are employed. In laying the blocks and throwing the arches no mixture containing lime can be used, but only fire-clay or Dinas sand, in as small quantity as possible. Should any of the materials of the crown of the furnace gradually fuse under the influence of the heat, the dropping of the molten matter into the glass-pots is the cause of most serious annoyance and loss to the manufacturer.

Plate V.

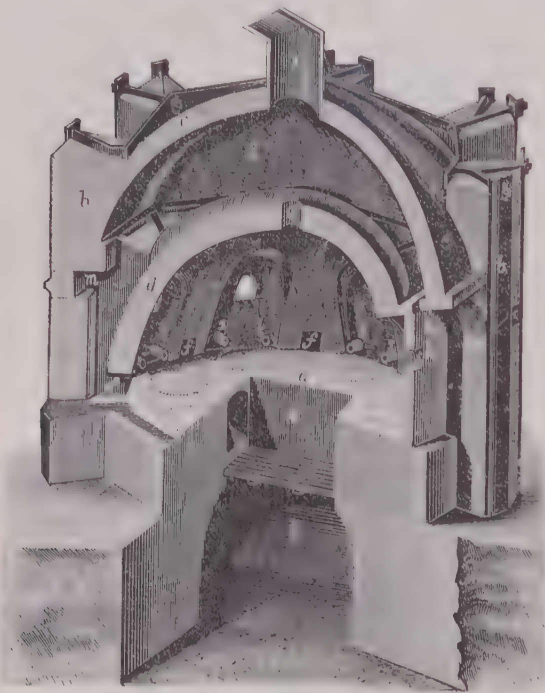
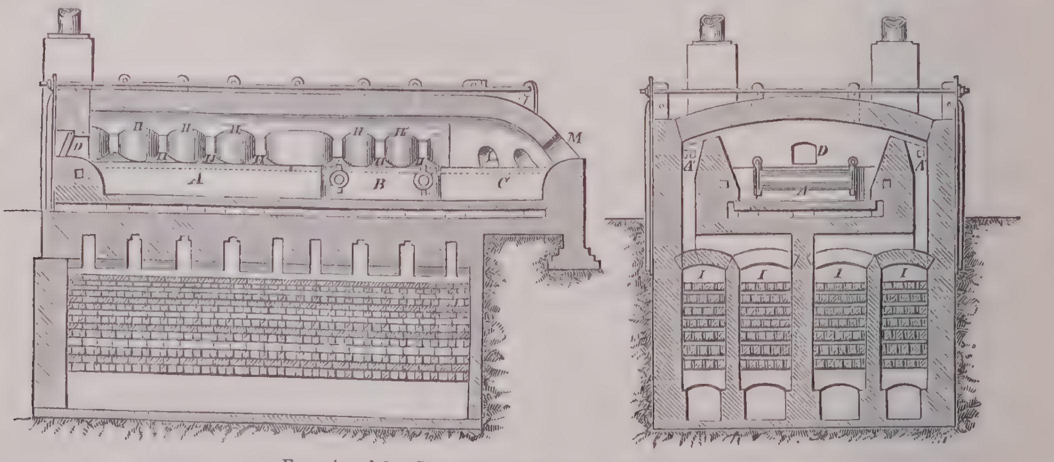


FIG. 3.—Section of Flint-Glass Furnace.

An English flint-glass furnace furnishes the type of circular furnaces. Usually a large number of pots, sometimes ten, are provided for in such a furnace, because, the objects made in flint-glass being in general of small size, the metal is worked off only slowly, and a large number of glass-blowers can be accommodated at the separate work-holes. The arrangements of the cave and fire-grate are the same as in the case of square or oblong furnaces, but flint-glass furnaces differ from the prevailing rule in others by being provided with a system of flues and chimneys, one flue being placed between each pair of pots. The general appearance presented within a flint-glass house is illustrated in Plate VI. fig. 1; and the accompanying wood-cut (fig. 3) is a sectional illustration showing the construction and internal appearance of a seven-pot furnace. The furnace is composed of a double arch or vault springing from strong pillars or abutments *bb*. The space *c*, between the outer arch and the vault proper of the furnace *d*, is a common receptacle for the flues *ff* led from within the furnace, and the products of combustion escape by the chimney *i*. The work-holes are at *h*, and at that place the furnace wall is taken down when a pot requires to be removed and renewed. The "cave" or air canal is seen at *k*; *n* is the fire-grate, stoked in this case from one side only; *l* shows openings at which the blowing tubes are heated; *m* is an opening for cleaning the flues; and *a* is the bank or siege with the position of the pots indicated. Frequently instead of being arched the outer portion of the furnace is carried up in the form of a wide truncated cone or open chimney stalk, and in other cases short separate chimney stalks are built for each flue terminating within the glass-house, which itself forms such an open-topped cone or chimney. Of course in cases where such separate small chimneys are provided no second or outer vault is required.

Plate VI.



FIGS. 4 and 5.—Siemens's Continuous Tank Furnace.

In the year 1861 Dr. C. W. Siemens introduced a form of furnace in which the use of melting pots was altogether abandoned, and the batch was introduced into, melted in, and worked from a tank which occupied the whole bed of the furnace. This furnace he heated from the sides by means of his well-known regenerative gas system, described under FURNACE and IRON. In 1872 he effected a further development of the tank furnace by dividing the tank, on the principle of his melting pot, by means of two floating bridges or partitions into three compartments, and thus he elaborated what is termed Siemens's patent continuous melting furnace. Of this improved furnace fig. 4. shows a longitudinal section, and fig. 5 is a transverse section. A is the melting compartment, B the refining compartment, and C the working-out compartment. The

compartment A is fed with raw material (or batch) through the door D at the back end of the furnace; it is separated from the compartment B by the floating bridge E, under which the partially melted glass passes to reach the latter. In the compartment B the metal, by the influence of the higher temperature maintained on its surface, is completely purified, and sinks to flow under the bridge F in a complete workable condition. Suitable provision is made, by means of air-passages, to keep the sides of the tank of the requisite temperature to prevent any egress of glass through them, and the floating bridges E and F are renewed as often as necessary. The regenerative gas furnace is employed, and the gas and air ports H H′, leading from the regenerators I I′ respectively, are arranged along each side of the tank, so as to cause the flames to play across the furnace. The temperature of the different parts is regulated according to the various stages of preparation of the glass in the several compartments, this regulation being effected by constructing the gas and air ports of larger dimensions, or increasing their number, where the greatest heat is required; it is also facilitated by means of division walls (not shown in the figures) which may be built over the floating bridges to separate the compartments. The temperature of the working-out compartment C is controlled by regulating the draught of the furnace chimney, by diminishing which more or less flame must necessarily pass from B over the floating bridge F into C, and through the working holes M. The principal advantages resulting from the use of the continuous melting furnace are the following:—

1. An increased power of production, as the full melting heat may be employed without interruption, whilst with the old method of melting nearly half time is lost by cooling and settling the metal, the working it out, and the re-heating of the furnace.
2. An economy in working, as only half the number of men are required for the melting operations.
3. A greater durability of the tank and furnace, owing to the uniform temperature to which they are subjected.
4. A much greater regularity of working, and more uniform quality of the product than in other furnaces.
5. For the manufacture of window glass, the compartment C may be so arranged that the blowers can work without interfering with the gatherers; this would do away with the separate blowing furnace now in use.

Although the Siemens regenerative gas firing is generally used with tank furnaces, that system is not essential to the successful working of tanks. Mr. Archibald Stevenson of Glasgow has patented a tank furnace fired by common coal from one end, with working holes on the other three sides, and furnaces on this principle are worked in a perfectly satisfactory manner with much economy of coal and working room. Tank furnaces are used principally in bottle works and in the manufacture of rolled plate. The following statement shows the extent to which Siemens furnaces and tanks have been introduced by manufacturers.

Furnaces using Pots.

	Plate Glass.	Window and Bottle Glass.	Flint Glass.
Great Britain	5	5	2
France	7	4	11
Belgium	4	1	1
Other countries	6	10	15

Furnaces with Tanks.

Great Britain	6

Furnaces with Continuous Tanks.

Great Britain	4
France	10
Belgium	1
Other countries	3

Formerly it was the habit that to the sides or wings of the main melting furnace there were attached calcar or fritting arches, annealing ovens, pot-firing arches, and other subsidiary furnaces required in certain stages of glass manufacture. These were heated by flues leading from the fire-space of the principal furnace; but such a practice is now generally abandoned, and distinct furnaces or ovens, arranged and fired according to the necessities of the case, are provided instead. In the manufacture of common bottle glass, however, for which highly impure materials are used, it is still the practice to prepare a frit in a side arch occasionally attached to the melting furnace.

The whole of the pots in a common furnace are charged or filled with the prepared "batch" at the same time. Immediately the heat is forced, and the stoking must thereafter be carefully regulated to maintain the high temperature. As the mass begins to fuse it settles down and occupies considerably less space in the pot, to which thereon a second quantity of material is added, and generally a third portion is subsequently filled in so as to have at the close of the melting process as large a quantity of metal as possible. When the fusion is complete a scum composed of uncombined salts, and known as glass-gall or sandiver, rises and collects on the surface. It consists almost entirely of sulphate of soda, with sulphate of lime, and a small percentage of chloride of sodium. This scum of glass-gall is carefully removed with a perforated scoop, and the heat of the furnace is then forced to the most intense degree with the view of rendering the metal as fluid and limpid as possible, so as to free it from all included gaseous bubbles which it still contains. This process of "fining," "refining," or hot-stoking, as it is indifferently termed, involves a temperature which is estimated in certain cases to reach from 10,000° to 12,000° Fahr.; and the operation is sometimes assisted by stirring the molten mass with a pole of wood, in a manner analogous to the poling of copper in the refining of that metal. Throughout the operation of melting, test pieces are periodically withdrawn from the pots for the purpose of observing the progress and condition of the glass. When it is found that the vitrification is complete and the object of refining fully accomplished, the heat of the furnace is considerably reduced, so that the glass may be brought into that condition of viscosity in which it is capable of being worked. In contradistinction to the refining or hot-stoking period, this is known as cold-stoking.

Glass Working.—The means by which melted glass is caused to assume its varied forms for use are (1) by blowing; (2) by casting; and (3) by pressing in moulds—an operation in which the other two processes may be partly combined. Minor manipulative processes which do not fall under any of these heads are called into action; but these are for the most part merely subsidiary to the others, which really comprehend all the lines along which the formation of glass proceeds.

Having regard principally to the forms into which glass is worked and the uses to which it may be applied, the following classification embraces the principal departments of the glass-making industry.

I. Flat glass.
    Crown glass.
    Sheet glass.
    Plate glass.
II. Hollow glass.
    Flint glass, blown.
    Bohemian glass.
    Venetian glass.
    Bottle glass.
    Slag glass (Britten's).
    Tube and gauge glass.
III. Pressed and massive glass.
    Flint glass.
    Optical glass.
    Strass.
    Rod glass, marbles, and beads.
IV. Colored, opaque, and enamel glass, including glass mosaics and hot cast porcelain, etc.

So far as they involve distinct manufacturing processes, these varieties of glass will be here noticed in the above order. Such of the divisions as result from the application of special methods of ornamentation, and as come under the head of art glass, do not fall within the scope of this article.

CROWN GLASS.—This, with sheet or cylinder glass, forms all ordinary blown window glass. Both varieties are precisely the same in composition, being a mixture of sodic and calcic silicates, and differ only in the manner in which the sheets of finished glass are produced. The raw materials employed for this and all other kinds of glass vary within rather wide limits, and, as already explained, the form in which the sodic and calcic compounds are used may also be varied. The following composition of batch for window glass must therefore be regarded as only one out of very many mixtures in use:—

Sand, purified	100	parts.
Chalk or limestone	35 to 40	"
Sulphate of soda	40 to 45	"
Cullet	50 to 150	"

To these materials a minute proportion of white arsenic and peroxide of manganese, as bleaching agents, may also be added.

Crown glass was, in the early part of the present century, the only form of window glass made in Great Britain, and consequently it was generally recognized as English window glass, having been manufactured only on a very limited scale in any other country. Since the introduction of sheet-glass making, the crown-glass industry has steadily declined, and now its manufacture may be regarded as practically a thing of the past, not more than one or two crown furnaces being in operation. Seeing that it possesses little more than an historical interest, it is now unnecessary to enter into much detail as to the processes employed in the manufacture of crown glass.

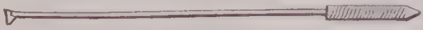


Fig. 6.—Blowing Tube.

The metal being brought to a proper condition for working, the "gatherer" dips into the pot of metal an iron pipe or tube, 6 or 7 feet in length, of the shape shown in fig. 6, heated at that end which takes up the glass, and, by turning it gently round, gathers about 1½ ℔ of liquid glass on the end of it. Having allowed this to cool for a little, he again dips the rod into the pot and gathers an additional quantity of from 2½ to 3 ℔. This is also permitted to cool as before, when the operation of dipping is again repeated, and a sufficient quantity of metal, from 9 to 10 ℔ weight, is "gathered," to form what is technically called a table or sheet of glass. The rod, thus loaded, is held for a few seconds in a perpendicular position, that the metal may distribute itself equally on all sides, and that it may, by its own weight, be lengthened out beyond the rod. The operator then moulds the metal into a regular form, by rolling it on a smooth iron plate, called the "marver," a term corrupted from the French word *marbre*. He then blows strongly through the tube, and thus causes the red-hot mass of glass to swell out into a hollow pear-shaped vessel. The tube with the elongated sphere of glass at the end of it is then handed to the "blower," who heats it a second and third time at the furnace, pressing the end, between each blowing, against the bullion bar, so called from the part thus pressed forming the centre of the sheet or "bull's eye," and by the dexterous management of this operation, the glass is brought into a somewhat spherical form. The blower now heats a third time at the "bottoming hole," and blows the metal into a full-sized flattened spheroid. When this part of the process has been completed, and the glass has been allowed to cool a little, it is rested on the "casher box," and an iron rod, called a "pontil" or punty rod, on which a little hot metal has been previously gathered, is applied to the flattened side, exactly opposite the tube, which is detached by touching it with a piece of iron, dipped beforehand in cold water, leaving a circular hole in the glass of about 2 inches diameter. Taking hold of the punty rod, the workman presents the glass to another part of the furnace called the "nose hole," where the aperture made by its separation from the tube is now presented and kept until it has become sufficiently ductile to fit it for the operation of the flashing furnace. Whilst here, it is turned dexterously round, slowly at first, and afterwards with increasing rapidity; and the glass yielding to the centrifugal force, the aperture just mentioned becomes enlarged. The workman, taking great care to preserve, by a regular motion, the circular figure of the glass, proceeds to whirl it round with increasing velocity, until the aperture suddenly flies open with a loud ruffling noise, which has been aptly compared to the unfurling of a flag in a strong breeze; and the glass becomes a circular plane or sheet, of 4½ feet diameter, of equal thickness throughout, except at the point called the bullion or bull's eye, where it is attached to the iron rod. The sheet of glass, now fully expanded, is moved round with a moderate velocity until it is sufficiently cool to retain its form. It is carried to the mouth of the kiln or annealing arch, where it is rested on a bed of sand and detached from the punty rod by a shears. The sheet or table is then lifted on a wide-pronged fork, called a faucet, and put into the arch to be tempered, where it is ranged with many others set up edge-wise, and supported by iron frames to prevent their bending. From 400 to 600 tables are placed in one kiln. A sketch of the interior of a crown-glass house, during the progress of these operations, has been given in Plate VI., fig. 2. The kiln having been clayed up, the fire is permitted to die out, and the heat diminished as gradually as possible. When the glass is properly annealed, and sufficiently cold to admit of its being handled, it is withdrawn from the oven after the removal of the wall built into the front of the arch, and is then quite ready for use. The largest-sized tables of crown glass made will cut into slabs 30 inches across, from which squared pieces measuring 38 by 24 or 35 by 25 inches may be obtained.

Sheet Glass, as already mentioned, is the same in composition as crown glass, which it has now entirely supplanted. The success of sheet glass is due principally to the fact that it can be produced in sheets of much greater dimensions than is possible in the case of crown glass: it is free from the sharp distorting striæ and waves common in crown glass; there is no loss of glass as there is with the bull's eye of crown; and modern improvements effected in the manufacturing process leave little distinction in brilliancy of surface between the two qualities. Sheet glass is made on the greatest scale in Austria, Germany, and Belgium, and it was long distinguished in the British market as German sheet glass. In 1832, Chance of Birmingham and subsequently Hartley & Co. of Sunderland introduced the manufacture into England, and in the hands of these firms, as well as of others who followed in their footsteps, the industry prospered and developed, till it has now attained dimensions equal to those it has reached in most of the Continental nations, where the art was long established before it came into use in England.

Sheet-glass making involves two principal operations,—(1) the blowing of the cylinder, and (2) the opening, flattening, or spreading of the glass. The structure and internal arrangements of the melting furnace is practically the same as in the case of crown glass. The ordinary type of oblong furnace usually contains 10 pots—5 in each side of the fire-grate—each pot being of a capacity of about 1 ton or 22 cwt. of metal. Radiating from the work-holes, and raised about 7 feet above the floor level, or a correspondingly deep sunk pit, are ten long stages with an open space between each sufficient to allow the workman to swing about his long tube freely in forming the elongated cylinder of glass. Fig. 7 is a ground plan of a common sheet-glass furnace and staging of planks *c*, at the extremities *d* of which are placed a tub of water and a wooden moulding-block. Instead, however, of having these stages erected in front of the melting furnace, it is now a common practice to gather and block the glass at the melting furnace, and to blow it in front of a seperate oblong reheating or blowing furnace, from each opening of which the wooden stage runs out over a pit excavated to the depth of 7 feet or thereby. Common bricks may be used for the construction of this reheating furnace, as the heat required in it is by no means intense.

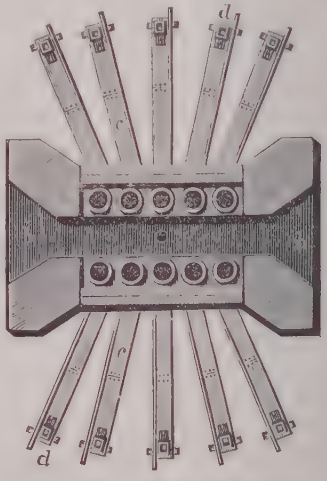


Fig. 7.—Plan of Sheet-Glass Furnace.

Blowing.—The charge or batch requires about 16 hours to melt, and other 8 hours are consumed in cooling it to the working consistency. When the metal is ready for working, the workmen take their stations, each having his own pot and stage and also an assistant, and commence making the cylinders. After gathering the quantity of metal required (which on an average amounts to 20 ℔), the workman places it in a horizontal position in the large hollow of a wooden block (fig. 8), which has been hollowed so that, when the workman turns the metal, it shall form it into a solid cylindrical mass. In the meantime, the assistant, with a sponge in his hand, and a bucket of water by his side, lets a fine stream of water run into the block, which keeps the wood from burning, and also gives a brilliancy to the surface of the glass. The water, the moment it comes in contact with the glass, is raised to the boiling point, and in that state does no injury to the metal; but it is only when the metal is at a high temperature that such is the case; for, whenever the glass is cooled to a certain degree, it immediately cracks upon coming in contact with water. When the workman perceives that the mass of metal is sufficiently formed and cooled (fig. 9), he raises the pipe to his mouth at an angle of about 75 degrees, and commences blowing it, at the same time continuing to turn it in the wood block, till he perceives the diameter to be of the requisite dimensions (fig. 10), which are usually from 11 to 16 inches. The workman then reheats this cylindrical mass, and, when it is sufficiently softened, commences swinging it over his head, continuing to reheat and swing till he has made it the desired length, which is commonly about 45 inches. It is now

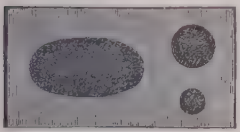


FIG. 8.

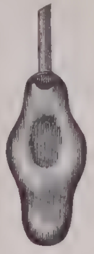


FIG. 9.

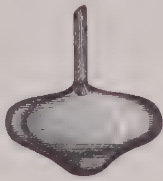


FIG. 10.

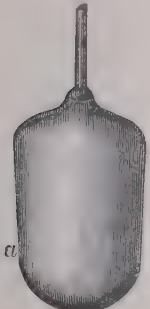


FIG. 11.

FIG. 12.

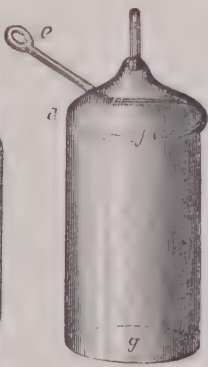


FIG. 13.

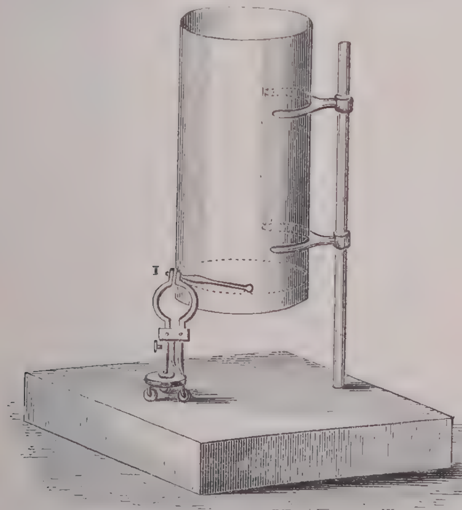


FIG. 14.

a cylinder of say 45 inches long by 12 inches in diameter, one end being closed, and the other having the pipe attached to it. The workman begins to open the end which is closed, for which purpose he encloses the air in the cylinder, by stopping the aperture of the pipe with his finger; and then placing the close end of the cylinder towards the fire, it becomes softened, while at the same time the air within is expanding, and, in about thirty seconds, the softened glass at the extremity of the cylinder gives way, forming an aperture as in fig. 12. The workman then turns the cylinder round very quickly, and, by keeping the opened extremity warm at the same time flashes it out perfectly straight as at *g*, fig. 13. If the burst edges are ragged in appearance they are trimmed by cutting with a pair of scissors before finally expanding. The bursting of the end of a thick heavy cylinder has to be determined by allowing a glowing drop of glass to fall on the spot to be burst before presenting it to the fire. The other end, which is attached to the pipe, has now to be cut off, and is done in the following manner. The workman, having gathered a small quantity of metal on the pontil, draws it out into a thread of about one-eighth of an inch in diameter, laps it round the pipe end of the cylinder, and, after letting it remain there for about five seconds, withdraws it suddenly, and immediately applies a cold iron to the heated part, which occasions such a sudden contraction, that it cracks off where the hot string of glass has been placed round it. Another method is to draw a semi-cylindrical rod of iron *e* (fig. 13) heated to redness around the line *d* of desired fracture, and a drop of water then allowed to fall on the line so drawn determines its fracture. The stages in the development of a cylinder to its full length are illustrated in figs. 9 to 13.

Flattening.—The cylinder so blown and detached is now allowed to cool; and, previous to its flattening, the burst extremity being thinner than the remainder, and slightly contracted at its edge, has to be removed to the depth of about two inches. For this purpose the cylinder is placed vertically in the jaws of a cutting instrument, having a diamond cutter, pressing by a spring, inside the glass (fig. 14). The cutter moves by small wheels on the table on which it is placed, and being pushed around the cylinder it makes an accurate cut of uniform height. The cylinder has then to be split longitudinally to allow it to be opened out to a flat sheet. To accomplish this the practice was formerly to lay the cylinder horizontally on a bench, and draw a red-hot iron two or three times along the inner surface at the line of desired fracture. Now the splitting is done with a diamond cutter fixed in the cleft of a stick, and (fig. 15) guided from end to end of the cylinder by a straight-edge K laid within it. The cylinder is now ready to be taken to the flattening kiln, which consists of two chambers built together, the one for flattening the cylinders, the other for annealing the sheets, the former being kept at a much higher temperature than the latter. The cylinder, after being gradually reheated, is placed in the centre of the flattening oven, upon a smooth stone, with the split side upwards. In a short time it becomes softened with the heat, and by its own weight falls out into a flat square sheet of 45 inches by 36. The flattener, with a piece of charred wood, rubs it quite smooth, and then places it on edge in the annealing arch, where it remains about three days to be annealed.

In the arrangement of the flattening and annealing ovens numerous improvements have been effected, which have resulted in greatly increased smoothness and uniformity of the glass, and in considerable economy of time and labor in the operation. Fig. 16 shows a section of a flattening (L) and annealing kiln (M) in common use. The split cylinder O is introduced and gradually pushed forward so as to be uniformly heated till it reaches P, the flattening stone, or table, mounted on a movable wagon N. On this wagon, after it has been flattened, it is carried into the annealing arch M, as shown by the dotted outline. Here in a less heat it gradually stiffens, till it is ready to be moved by a forked tool to a horizontal position on the bed of the annealing oven. The wagon then goes back to the flattening arch, and when it is reintroduced with another sheet, that previously flattened is ready to be piled up on edge at R, and thus the work proceeds till the annealing oven is filled, when it is closed up and allowed to cool down by slow degrees. Chance Brothers & Co. of Birmingham are the introducers of a system of continuous flattening and annealing furnaces. This they accomplish by means of two contiguous circular kilns having revolving soles, the fires being arranged and the inside partitioned so that the split cylinder gradually approaches the greatest heat, where the flattening takes place, and then passes round in a decreasing temperature till at the opening into the annealing arch it has attained sufficient consistency to be moved into the yet cooler annealing arch, round which the sheet is slowly carried till it arrives fully annealed at the point where it is withdrawn.

Although the average size of finished sheet glass as now made is about 50 inches by 36 inches, very much larger sizes may be and occasionally are produced, the extreme trade limit being 85 inches long by 49 broad; but both these extremes cannot be obtained in the same sheet, and few workmen attain the dexterity necessary for properly manipulating the larger sizes. In Belgium sheets from blown cylinders measuring 10 feet by 4 feet have been made. The thickness of finished sheet glass is estimated by the amount it weighs per square foot, and the commercial range of weight is from 15 oz. to 42 oz. per foot, the thicker and heavier kinds, of course, selling at the highest price.

Polishing of Sheet Glass.—Polished sheet glass is known in commerce as patent plate glass, to distinguish it from ordinary polished cast-plate. The practice of polishing sheet glass was first introduced and patented by Chance of Birmingham, and polished sheet is now in considerable demand for photographic purposes, for framing engravings, and generally where a fine true surface combined with lightness or thinness is requisite. The polishing process involves two operations—smoothing and finishing or polishing. The smoothing is done on a thick slab of slate which must possess a surface as smooth and level as possible. This is covered with a piece of wet cotton cloth, and, the sheet of glass to be smoothed being laid thereon, by gentle pressure all air is expelled from between the surfaces, and the atmospheric pressure then keeps the glass firmly in position. The process of smoothing and the subsequent finishing are from this point the same as in the case of ordinary plate glass, under which head these operations will be detailed. It is only selected plates of fine clear metal that are used for polishing.

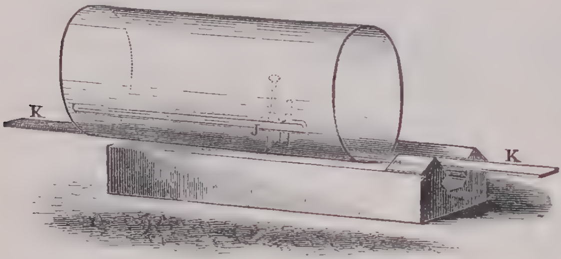


Fig. 15.

Plate Glass is manufactured by a process entirely different from any of those yet described, consisting as it does of glass cast and spread in sheets. As plate glass is invariably thicker than blown sheet, it is of the utmost consequence that the "metal" should be prepared from the purest possible materials, and that the founding or melting should be done with great care to ensure the expulsion of air bubbles. It is only thus that the fine clear homogeneous and flawless plates aimed at in the manufacture can be produced. Formerly the French excelled all other nations in the manufacture of plate glass, and the manufactures of the great St. Gobain Company yet command the highest prices in the market: but the increased care which has now for about a quarter of a century been given in England to the purity of materials, and the ingenious machinery which has been devised for polishing plate in England, have resulted in placing British-made plate glass on a level with the best productions of France.

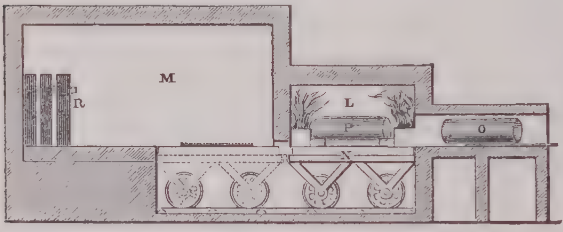


Fig. 16.

The following is given as an example of the materials employed for the preparation of fine French plate:—

White quartzose sand	100·0 parts.
Sodic carbonate	33·3 "
Lime (slaked)	14·3 "
Manganese peroxide	0·15 "
Cullet	100·0 "

The materials are melted in furnaces and pots of the ordinary construction, but in some cases the melting pots are of greater capacity, and contain charges of from 2 to 2½ tons. In French establishments, and in many others, two forms of pot are placed within the furnace—(1) the ordinary melting pot, and (2) a pouring pot or *cuvette*, quadrangular in form, made of the same material as the melting pot, and capable of holding sufficient metal for casting a single sheet of the superficial extent and thickness desired. Melting pots and cuvettes are placed side by side in the furnace, and the molten mixture is ladled with copper or malleable iron ladles from the pot into the cuvette, in which it is allowed to clear before casting. In some works, however, the molten glass is poured direct from the melting pots, and in other cases it is ladled to the casting table from the huge melting pots with large malleable iron ladles.

The casting table is a heavy, thick, flat table of cast-iron, of a length and breadth exceeding the size of the largest plate of glass which may be cast on it. At one end is placed a heavy cast-iron roller, the full breadth of the table, and fitted to roll the whole length of the table by means of spur wheels working into gearing along its sides. The cast-iron roller determines the thickness of the glass by the height at which it is caused to roll above the table, and that height is regulated by placing narrow strips or ribs of metal of the required thickness of the glass along the edges of the table on which the two extremities of the roller bear as it revolves. The breadth of the plate again is determined within the limits of the table by the two sides of the "gun," an apparatus consisting of two plates of cast-metal, placed in front of the roller, and bolted together by cross-bars at a distance apart which can be easily altered and adjusted according to the breadth of plate the apparatus is intended to control. The edge of the plates abutting against the roller are accurately fitted to the roller curvature, and thus they and the roller form three enclosing sides for the molten mass poured on the table, and as they travel forward they carry in front of them all the semi-fluid mass except the uniform layer which represents the distance between the moving surface of the roller and the surface of the casting table on which the glass is spread. As the glass does not instantly solidify the moment the roller has passed over and spread it into a sheet, the edges generally assume a rounded and somewhat wavy, cast-like appearance. Immediately the plate has sufficiently solidified to bear moving, it is taken to the annealing furnace, the heat of which has been carefully raised to the proper pitch. The sole of the annealing oven on which the plate is to rest (for with large plates any piling on edge is impracticable) must be as smooth and level as possible, since the still semi-plastic mass moulds itself to the surface on which it is laid. As the oven only accommodates a single plate of the largest dimensions, and since the annealing process occupies several days, a large number of ovens, occupying a great space and involving the expenditure of much labor and fuel, are needed in works where many plates are cast. In dealing with plates of small size they may be laid horizontally on the furnace bed for a little till they come to the furnace temperature, after which they are piled up on edge in twenties or thirties, leaning against a range of iron bars running across the furnace. When the plates have been deposited in the annealing oven, the openings are all carefully stopped up, and the furnace with its contents is cooled by slow degrees down to a temperature at which the glass may safely be withdrawn and exposed to ordinary atmospheric influences. The cooling of such furnaces is now hastened as far as the safety of the plates and the completion of the annealing will permit by allowing cold currents of air to pass under their sole.

The plates, as withdrawn from the annealing oven, have a very irregular, rough, undulating surface, and although the glass is perfectly pure, they have, owing to their uneven surface, no transparency. In this condition they constitute the "common rough plate" of commerce, and as such they are extensively used for the glazing of roofs, for floor and cellar lights, and generally in positions where light without transparency is requisite.

Polishing.—When the annealed plates are withdrawn from the oven they are carefully examined for any defects, such as spots, air-bells, etc., which they frequently exhibit. If serious defects are found, the plates are cut into the largest pieces which can be obtained free from flaws, and the selected pieces are then submitted to the operations of polishing, consisting of (1) grinding, (2) smoothing, and (3) polishing. Various forms of machine have been devised and introduced for effecting these operations. The grinding and smoothing table, invented by Mr. Daglish, of Ravenhead works, consists of a great revolving flat table A (fig. 17), with a strong fixed bar CE, stretched across it about 10 inches above its surface, to which two runner-frames, B, B, shod with iron, are pivoted at Q. The glass to be ground is cemented with plaster of Paris on the surface of the table, and the runner-frames rest on that surface. When the table A is set in motion, each oblong runner-frame B has communicated to it a revolving motion also, owing

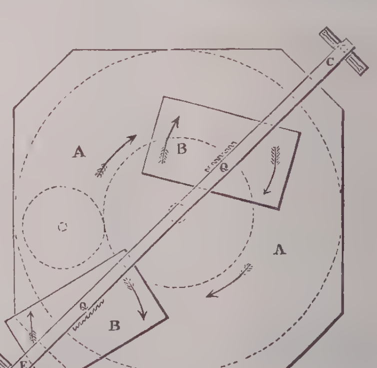


Fig. 17.—Plate-Glass Grinding Table.

to the excess of friction brought into action by the more rapid revolution of the outer edges of the revolving table. The effect of these compound revolutions is that every point of the surface of the glass is equally and uniformly abraded, when the apparatus in revolution is fed with sharp sand and water. When a level surface is thus prepared, the smoothing process is next begun on the same table, the only difference being that emery powder of increasing degrees of fineness is substituted for the sand, and, as the operation approaches completion, the utmost care must be exercised as to the purity and uniformity of the emery, seeing a single particle of grit would effectually destroy the smoothness of a whole plate. The quality of the emery is thus of essential consequence, and an ingenious apparatus is brought into use for arranging the sizes by means of a current of water of diminishing velocity, obtained by passing a uniform stream with agitation successively through cylinders or troughs of increasing size. In these troughs the emery powder is deposited in increasingly fine division, according to the growing capacity of the trough and the consequent slow replacement of its contents. The last touches of the smoothing process can only be given by the hand, which at once detects any appearance of grittiness. Both sides of the glass are in succession submitted to these operations, after which it is again bedded in plaster and fixed on the polishing table. The polishing is done with reciprocating rubbers, covered with fine felt, and supplied with rouge (peroxide of iron) in a liquid state. While a reciprocating motion is communicated to the rubbers, the table itself moves backward and forward in a transverse direction, so that all parts of the plate are equally brought under the polishing influence of the rubbers. About 40 per cent. of the weight of the rough plate is removed in the three polishing operations.

Ordinary finished plates vary in thickness from about ¼th to ⅜th inch, and the largest sizes measure about 17 feet by 9 feet 6 inches. The great St. Gobain Company of France quotes regular prices up to 324c. (10 feet 8 inches) by 204c. (6 feet 8 inches), beyond which size the price becomes special. In the Paris Exhibition of 1878 that company showed a silvered plate 24 feet by 14 feet, the largest piece of plate glass which has hitherto been polished.

Rolled Plate.—A form in which unpolished plate glass is extensively employed is the patent rolled plate, originally made by Hartley & Co. of Sunderland. The surface of the casting table on which the rolled plate is spread, instead of being smooth and plain, is engraved or otherwise indented with fine lines, grooves, or flutes, or it may be with small squares, lozenges, or even ornamental patterns, and the glass, of course, takes on its lower surface an accurate impression of any such pattern. Rolled plate is now very largely used for partitions, and in places where obscure lights are required. Such plates are always cast comparatively thin, and of moderate size, so that a large number may be piled in the annealing oven, They, as well as certain qualities of colored glass, are cast by ladling the molten metal from huge pots which may contain about 2½ tons of material. By this ladling numerous "air bells" are enclosed in the glass, but the circumstance does not affect the durability and usefulness of the glass.

FLINT GLASS OR CRYSTAL.—The name flint glass originated in the circumstance that at first the silica used in the manufacture of this variety of glass was in the form of ground flints. The industry belongs characteristically to the United Kingdom, where it was first established on a large scale, and to the present day flint glass is much more extensively manufactured in England than in any other country.

Flint glass is a compound entirely different from those above described, consisting as it does of a silicate of potassium and lead. As is the case with all kinds of glass, its composition and the proportion of ingredients used in its preparation vary widely. The average composition of a batch has been stated thus:—

Fine white sand	100	parts.
Minium (red lead)	66	"
Refined potash	33	"
Nitre	10	"
Cullet	60 to 100	"

Small portions of bleaching ingredients, as white arsenic or manganese, are also sometimes added. Purity of materials is of the utmost consequence in the manufacture of flint glass, which is prized in proportion to the transparency, uniformity, sparkle, and freedom from color of the metal; and, as finished objects are in many cases massive, defects of color are very obvious. Flint glass is much more fusible than the kinds destitute of lead; it possesses great brilliancy owing to its high refractive and dispersive power, but being comparatively soft its surface is easily scratched and dulled. It is also slowly corroded by alkalies, and contact with solutions of sulphides blacken it. Its specific gravity varies according to the proportion of lead it contains; and, as the silicate of lead tends to sink when the glass is in the molten state, Faraday found glass from one melting to vary from 3·28 to 3·85, and in another instance from 3·81 to 4·75. The higher the specific gravity of the glass the greater is its refractive power and consequent brilliancy.

Flint glass is in no case used for architectural or structural purposes, but its purity and lustre peculiarly fit it for table glass, ornamental objects, glass globes and lustres, and for imitations of gems and precious stones. For the latter purpose a dense glass called strass, appropriately colored when necessary, is employed, and a glass of still greater density and refractive power is used for optical purposes. The softness of flint glass adapts it for engraving, cutting, and polishing: and these methods of ornamenting the finished glass are very much employed.

The special covered form of pot (fig. 2, *supra*) and the arrangement of the furnace have already been alluded to. Plate VI., fig. 1, represents the various arrangements, tools, and processes connected with a flint-glass house, the building in the centre being the large cone or chimney built over the furnace, which is seen through the arches *a*. At 5 and 6 men are seen at the working holes withdrawing metal from the pots on their long iron tubes; 7 is the marver on which the gathering is rolled till it acquires a circular shape; at 8 a blower is seen in process of expanding a gathering of glass by blowing; and at 9 a servitor or second man is attaching a post or lump of metal he has gathered on a pontil or punty to the end of a blown globe of glass. The two masses of glass are thus united together, and that attached to the hollow tube is separated by touching it, near to where the tube enters the globe, with a small piece of iron wetted with water. By this means the glass cracks, and a smart blow on the iron tube completes the disunion. The workman now takes the punty from his assistant, and laying it on his chair arm, rolls it backward and forward with his left arm, while with his right he moulds it into the various shapes required, by means of a very few simple instruments. By one of these, called a pucellas, the blades of which are attached by an elastic bow like a pair of sugar-tongs, the dimensions of the vessel can be enlarged or contracted at pleasure. Any superfluous matter is cut away by a pair of scissors. For smoothing and equalizing the sides of the vessel a piece of wood is used. After the article is finished it is detached from the punty and carried on a pronged stick to the annealing oven.

The annealing oven or leer for flint glass is a low arched furnace, generally of considerable length, with several openings at each end between which narrow lines of rails run. On these rails, small wagons, or trays mounted on four wheels, are placed, and the articles to be annealed are filled into such wagons. They are slowly pushed to the hottest part of the chamber, and passing that point they very gradually approach the cold end of the oven, from which they are withdrawn fully annealed. As each wagon is withdrawn at one end, another is entered at the other so that the line from end to end is kept constantly full. The ordinary method of gradually decreasing the temperature around the articles stationary in the leer is also practised.

Flint-Glass Cutting, Engraving, and Etching.—The sparkle and brilliancy of flint glass is developed by the process of grinding and polishing technically called glass-cutting. In fig. 18 is seen a representation of a glass-cutter's mill, *a* being the pulley and band communicating motion to the mill *b*, which is made of wrought or cast iron. Over it is suspended a wooden trough or cistern *c*, containing a mixture of sand and water, which is fed on the wheel as required for the operation of grinding. Smoothing is done on a wheel of fine sandstone to which water alone is applied, and for polishing, a wooden wheel supplied with emery, and finally with putty powder (oxide of tin), is employed. The trough *d* under the wheel receives the detritus of the grinding and other operations. The articles are held in the hand, and applied to the mill while rotating. The punty marks are ground off tumblers, wine-glasses, and the like, by boys holding them on small stone mills. Ground or obscured glass is made by rubbing the surface with sand and water. Iron tools fixed on a lathe and moistened with sand and water are used to rough out the stoppers and necks of bottles, which are completed by hand with emery and water. Engraving is the production of ornamental surfaces by a fine kind of grinding mostly done with copper discs revolving in a lathe. Etching is variously done by submitting the portions to be etched or bitten to the influence of hydrofluoric acid, the remainder of the glass being stopped off or protected by a coating of wax or some pitchy compound.[1]

PRESSED GLASS.—The most brilliant effect is produced by cutting, but moulding or pressing is much cheaper, and this branch of the art has now reached a high state of excellence. Glass formed by pressing in moulds, known distinctively as pressed glass, is peculiarly an English industry, principally because it is only flint glass, or glass possessed of similar properties, that can with advantage be formed in that way. Although moulded glass has existed from early Roman times, it is only

[1] A large proportion of the obscuring of the commoner varieties of glass and of the obscured ornamentation on plate and sheet as well as on flint glass is now produced by means of Tilghman's sand blast described below

within the present century that the modern industry has been developed, and of late years the trade has assumed important dimensions. A metal that melts at a comparatively moderate heat, and does not quickly pass from the plastic state, is essential for success in pressed glass making, because it has not only accurately to fill all the intricacies of the mould, but it must also be susceptible of fire-polishing. This operation consists of a reheating sufficient to melt a thin superficial stratum of the glass, whereby the roughness and obscurity of surface incidental to moulding is removed, and a smooth brilliant effect brought out, inferior only to the sparkling appearance produced by cutting. The moulds for pressed glass are made of iron or bronze; with great accuracy of surface; and they are, in use, kept a little under a red heat. The various segments of the mould are so hinged or connected as to close and leave internally a space representing the form and size of the article to be made, the internal hollow not being produced by blowing but by the plunger of the press under which the mould is placed. The required quantity of metal being dropped into the mould, the plunger descends and forces it into all parts of the cavity, completing immediately the formation of the article, which is then fire-polished by reheating, and afterwards annealed. In this way glass with elaborate facets, bosses, flutings, or other bold ornaments can be produced with rapidity and ease; and the only bar to great cheapness is the heavy cost of the lead and potash in flint glass. Several manufacturers both in England and on the Continent, where the pressed glass industry is extending, now partially supply the place of these costly materials by lime and baryta; and indeed English pressed glass of excellent quality is now in the market containing neither lead nor potash to any appreciable extent.

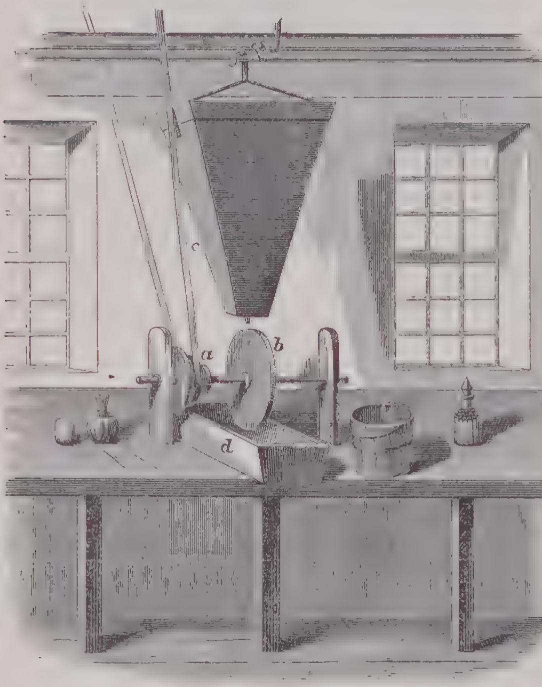


Fig. 18.—Glass-Cutter's Mill.

Baryta Glass.—The high price of red lead and various disadvantages connected with its use, have given rise to many efforts to find an efficient substitute for it in the manufacture of table and ornamental glass. Barium compounds, principally the native sulphate (common baryta or heavy spar) and the artificially prepared carbonate, have been more or less experimentally tried ever since 1830; but of late years the use of baryta has attracted much attention, and in several French and Belgian glass works it is understood to have taken its place as a raw material, without, however, much being publicly said regarding the subject. H. E. Benrath, the scientific director of the Lisette glass works near Dorpat has investigated the application of baryta in glass making with great fulness. Baryta, it appears, can be used as a partial substitute for the alkalies in glass-making; and indeed it was affirmed by Peligot that carbonate of baryta could altogether supplant either potash or soda, and yield a glass perfectly free of alkali. Such a glass is, however, shown by Benrath to be without practical value; but he has demonstrated that baryta may be used in the place of either lead or lime, to produce an easily fused dense glass much more brilliant than common glass, and in appearance and properties intermediate between that and flint glass. The qualities of the glass and its usefulness for various purposes can be modified by using both baryta and lime in varying proportions. There seems little doubt that baryta will occupy an important place in the future of the glass industry.

Bottle Glass.—This department of glass manufacture is of importance on account of its enormous extent; and although the raw materials employed in the trade are coarse and impure, and though the finished product has little appearance of excellence, the quality of the glass is in the highest degree important. Glass bottles, for example, are used for storing and preserving all manner of liquid substances for food, some of which undergo active chemical change, throughout a period of many years. In such a case it is of the highest consequence that the glass should be capable of resisting the solvent and corrosive action of acids and other substances which may be imprisoned or generated within the bottle, and such an object is attained by the high proportion of alumina which is found in bottle glass. Bottle glass varies in tint from the dark-green, almost black, semi-transparent claret bottles to clear and transparent qualities such as are employed for bottling aerated waters. The difference in color is partially due to the varying purity of the materials used, and partly to the action of bleaching or oxidizing agents. The materials ordinarily employed are common sand, gas-lime, brick-clay, common salt, and soap-boilers' waste; but local circumstances have much influence in determining the class of materials used. In Continental bottle works lava, basalt, and similar rocks of volcanic origin were formerly employed; and in Denmark and Sweden fluoride of calcium, left as a waste product of the manufacture of soda from cryolite, is used with marked advantage.

For bottle-making the tank furnace with or without compartments as already described is much used; but pot furnaces also continue in use. The arrangements of a common bottle house are seen in fig. 19, which is a ground-plan indicating a bilateral arrangement of a double bottle-house, with the complete plan of a four-pot furnace and ash arches. The furnace is oblong, similar to the crown furnace, but arched over in a barrel shape. It is erected in the centre of the brick cone, above a cave, which admits the atmosphere to the grating. The working holes of this furnace, opposite each pot, for putting in the materials and taking out the liquid glass, are each about 1 foot in diameter. At each angle of the furnace there is also a hole about the same size communicating with the calcining arch, and admitting the flame from the main furnace, which reverberates on and calcines the materials in the arch. In the figure, 1 shows the main furnace: 2, 3, 4, 5, the ash arches for calcining the materials; 6, 7, 8, 9, 10, 11, annealing arches; 12, two-pot arches; 14, clay-house for picking, grinding, sifting, and afterwards working the clay into paste for the purpose of manufacturing pots; 15, mill house for grinding clay; 16, a building containing a calcar furnace for experiments, or for preparing the materials, when the ash arch attached to the main furnace is under repair, including 1, a sand crib, and 2, an ash crib for sifting and mixing the materials, sufficient for two houses.

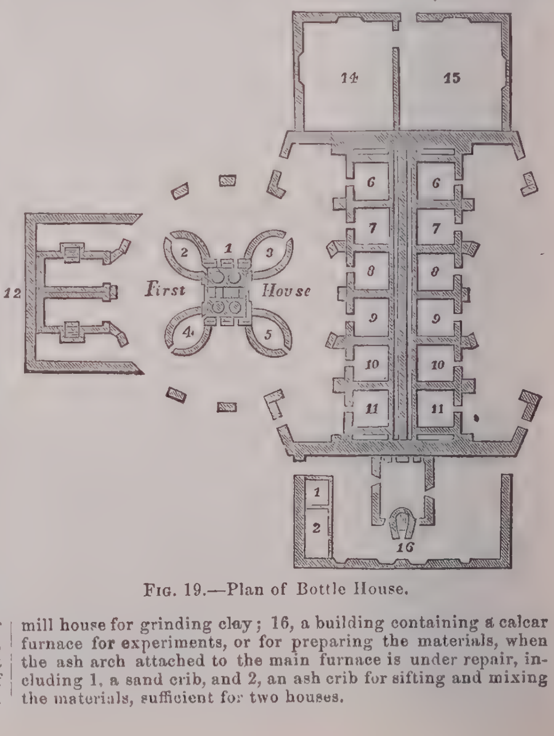


Fig. 19.—Plan of Bottle House.

The following is an outline of the process of making a common bottle. After the metal has been skimmed, the person who begins the work is the gatherer, who, heating the pipe, gathers on it a small quantity of metal. After allowing this to cool a little, he again gathers such a quantity as he conceives to be sufficient to make a bottle. This is then handed to the blower, who, while blowing through the tube, rolls the metal upon a stone, at the same time forming the neck of the bottle. He then puts the metal into a brass or cast-iron mould of the shape of the bottle wanted, and, continuing to blow through the tube, brings it to the desired form. The patent mould now in use is made of brass, the inside finely polished, divided into two pieces, which the workman, by pressing a spring with his foot, opens and shuts at pleasure. The blower then hands it to the finisher, who touches the neck of the bottle with a small piece of iron dipped in water, which cuts it completely off from the pipe. He next attaches the punty, on which is a little metal gathered from the pot, to the bottom of the bottle, and thereby gives it the shape which it usually presents. This punty may be used for from 18 to 24 dozen of bottles. It is occasionally dipped into sand to prevent its adhering to the bottle. The finisher then warms the bottle at the furnace, and taking out a small quantity of metal on what is termed a ring iron, he turns it once round the mouth, forming the ring seen at the mouth of bottles. He then employs the shears to give shape to the neck. One of the blades of the shears has a piece of brass in the centre, tapered like a common cork, which forms the inside mouth; to the other blade is attached a piece of brass, used to form the ring. The bottle is then lifted by the neck on a fork by a boy, and carried to the annealing arch, where the bottles are placed in bins above one another. This arch is kept a little below melting heat, till the whole quantity, which amounts to 10 or 12 gross in each arch, is deposited, when the fire is allowed to die out.

Slag Glass.—Under a patent obtained by Mr. Bashley Britten, a manufacture of bottles has recently been established with every prospect of success, the leading peculiarity of the process being the use of blast-furnace slag, molten as it issues from the furnace, as a principal ingredient. The use of slag in bottle-making is by no means new, but the catching of the intensely hot liquid mass and its immediate use for glass-making had not before been attempted; and therein results the great saving in fuel and consequent economy of the manufacture. A company formed to work the process has erected glass-works in Northamptonshire in the immediate neighborhood of a set of blast furnaces, and these works are now in constant and successful operation. A regenerative gas furnace applied to a glass tank working on Dr. Siemens's continuous principle is used, and in it the ingredients of the glass are fed at one end of the tank, where they are fused and fined, and the fused "metal" flows through a bridge to the other end of the tank, whence it is worked out, blown into bottles, and annealed in the usual way. The tank is from time to time fed with fused slag taken as it flows from the blast furnaces, and with it is introduced the required proportion of the other ingredients. The slag furnishes more than half the total material of the glass, and, as it is already melted, its use effects a saving of about half the heat or fuel and also half of the time necessary for the production of the "metal." Thus the prime cost of the glass as it is worked out is considerably less than that of glass made in the ordinary way. The natural tint of the glass thus produced is greenish, but it can be colored to any required tint, and by careful fining and bleaching it can be produced almost as colorless as common window glass. The working qualities of the glass are excellent; it comes from the furnace in that beautifully plastic condition which renders it capable of being blown, cast, pressed, or otherwise moulded into any desired form, and the company expects to manufacture other articles besides bottles from a material so cheaply produced.

Optical Glass is of two principal kinds—flint and crown—the combination of these two, with their different refractive powers, being necessary to produce perfect achromatism in the lenses of telescopes. For astronomical telescopes, for microscopes, and for all delicate scientific instruments in which optical glass occupies a place, glass of the utmost purity, transparency, freedom from color, streaks, and striæ is of the highest importance; and to secure these qualities to the fullest extent much care, trouble, and expense are requisite. The first really successful maker of optical flint glass was M. Guinand of Solothurn in Switzerland who succeeded in making discs 9 inches in diameter free from striæ. Guinand died in 1823, and from his son, M. George Bontemps learned his secret, and at Choisy-le-Roi, near Paris, further improved the manufacture. In 1848 M. Bontemps was induced by Messrs. Chance of Birmingham to establish the art in their great works. In the hands of that eminent firm the preparation of optical glass has attained a perfection not approached by any other glass workers, and the *chef d'œuvre* of optical glass hitherto made consists of a pair of flint and crown glass discs, 29 inches in diameter, exhibited by Chance Brothers at Paris in 1855. Regarding these Sir David Brewster said, "I have entertained the hope that the English Government would purchase these discs and construct with them the grandest achromatic telescope that ever was contemplated by the most sanguine astronomer." They were, however, purchased by the French Government in 1867.

Optical flint glass contains more lead, and is consequently heavier and more refractive, than the quality used for common purposes. It is made in a furnace having a single covered pot, and Guinand's secret consisted in constantly stirring the mass while it is in a molten condition so as to keep the heavier lead silicate from falling to the bottom. For the very highest qualities of optical glass, the contents of the pot are most scrupulously cleared, and the stirring is continued after the heat is lowered till the contents are cooled down to little more than a red heat. The furnace is then closed and the metal is allowed to cool and anneal gradually in the pot within the furnace. When withdrawn the pot is broken, and the mass of glass is polished on two opposite sides so that any imperfections may be detected by examination. From the mass, cut horizontally, perfect discs of such size as can be formed are then obtained. Optical glass is also blown into thick cylinders, and cast in slabs from ¼ inch to 1 inch in thickness.

Chance Brothers make six kinds of optical glass, of which the average densities and refractive indices for the three hydrogen lines and for the sodium line are given in the following table:—

	Density.	C.	D.	F.	G.
Hard crown............	2·485	1·5146	1·5172	1·5232	1·5280
Soft crown............	2·55	1·5119	1·5146	1·5210	1·5263
Light flint............	3·21	1·5700	1·5740	1·5839	1·5922
Dense flint............	3·66	1·6175	1·6224	1·6348	1·6453
Extra dense flint......	3·85	1·6450	1·6504	1·6643	1·6716
Double extra dense flint............	4·45	1·7036	1·7103	1·7273	...

In 1830 Faraday proposed the use of a compound silicate and borate of lead glass, with a density of 5·44, for optical use; and Maez and Clemandot have successfully introduced a borosilicate of zinc. An optical glass of higher refractive and dispersive power than any previously known has been made by Lamy from a mixture of silica, red lead, and carbonate of thallium. The glass is perfectly homogeneous, but of a yellow tint—an evil, however, said to be avoidable by the use of the sulphate instead of the carbonate of thallium. The extraordinary refractive power of the glass renders it peculiarly adapted for the fabrication of imitation precious stones.

Strass.—Remarkably faithful imitations of every kind of precious stone can be made from suitably prepared and, when necessary, colored glass. The transparent basis from which artificial precious stones is prepared is called *strass* or *paste*, a material which must of necessity be the purest, most transparent, and most highly refractive glass that can be prepared. These qualities are combined in the highest degree in a flint glass of unusual density from the very large percentage of lead it contains. Among various mixtures given by Donault-Wieland as suitable for strass the following is an example:—powdered quartz 300 parts, red lead 470, potash (purified by alcohol) 163, borax 22, and white arsenic 1 part by weight. Special precautions are adopted in the melting of the materials, and the finished colorless glass is used for imitating diamonds. When employed to imitate colored precious stones the strass is melted up with various metallic oxides, to which reference will be made under colored glass. Artificial precious stones are, of course, easily distinguished from real stones by their inferior hardness, and by chemical tests. They may also be generally detected by a comparatively soft warm sensation they communicate when applied to the tongue.

Glass Tubes, used for gauge glass for steam boilers and for many other purposes, are made by a very simple process; but as the manufacture is a separate department of industry it demands some notice. A gathering of glass is made on a blowpipe, which is marvered, and slightly blown, so as to form a thick-walled elongated globe. To the end of this globe opposite the blowing pipe a pontil-rod is attached by an assistant, and the two workmen move backwards the one from the other, drawing out the tube as they recede. One or two boys watch the process of elongation, and when the tube reaches the desired gauge they fan its surface so as to "set" the glass, and thus prevent further attenuation at that particular point. The relation of the mass of metal to the original cavity determines the comparative stoutness and bore or internal diameter of the tube, and it requires much dexterity to make a tube at once straight and of uniform gauge and diameter. In drawing out tubes of large gauge the operatives recede from each other at a slow rate; and in proportion as the size of tube decreases the rate of drawing out increases. In the Venetian factories, where small tubes for beads are made, the workmen move at a smart walking pace.

Massive Glass.—Under this term may be conveniently noticed the manufacture of various familiar solid glass objects which do not acquire their form either by blowing or pressing in the ordinary sense. *Glass Rods* form the basis of many of these objects; and the formation of a plain rod of glass is accomplished by a manipulation in all respects similar to that described under the head of glass tubes, the only difference being that the rod is drawn from a solid instead of from a hollow or blown gathering as in the case with tube drawing. From solid rod glass, glass buttons of various forms are "pinched" by heating the rod till it softens, and immediately pinching it in heated moulds made and worked like ordinary pincers, but having moulds of suitable form in place of the gripping surface of the pincers. The small facets of glass lustres and girandoles and glass marbles, are made by an analogous process.

Spun Glass.—Certain qualities of glass in the plastic condition are capable of being drawn out to threads of great tenuity, which, while possessing much brilliancy and beauty of color, are perfectly flexible and elastic, and feel to the touch soft and smooth like fine wool. A good deal of attention has been given to glass spinning in Vienna and in the Bohemian glass-works, the thread produced being woven into many textiles for upholstery and wearing purposes. The material is specially useful in millinery ornaments owing to the fine colors in which it may be produced, and to the fact that it is unalterable in and unaffected by all kinds of weather.

A remarkable and novel application of glass was patented in 1878 by Mr. J. B. Hannay. It consists in making glass a cementing or binding substance in the manufacture of emery wheels, now so much used instead of files. For preparing the wheels any broken fragments of glass are utilized. These are reduced to powder, mixed with proportions of powdered flints and emery, and in the form of a cake introduced on a layer of paper into a furnace where the material is submitted to a heat sufficient to fuse it into a compact ringing mass. The resulting cake is of intense hardness and durability, and cuts through ordinary emery wheels with ease. As the glassy emery wheels can be made very much cheaper than those at present in use, there is little doubt that this material will come into extensive use, in the rapidly increasing applications of emery to grinding, smoothing, and cutting.

Colored Glass.—When to the ordinary materials in the melting pot small quantities of various metallic oxides and other mineral substances are added, colored but still transparent glass is produced. The colors yielded vary in intensity according to the proportion of oxides used; and the temperature at which the fusion is effected, the length of time the molten glass remains in the melting pot, not only modify, but actually change altogether, the resulting color. Indeed, it has been asserted by M. Bontemps that all the colors of the spectrum may be obtained by the use of one oxide alone, if employed in varying proportions and at different temperatures. The materials, temperatures, and other conditions employed by manufacturers for producing certain of their color effects in glass are kept as trade secrets; although, in a general way the substances which produce particular colors are perfectly well known. Blue is obtained by the use of cobalt,—the ordinary blue pigment smalt being a powdered cobalt glass. Yellow glass can be prepared from several sources: uranium yields a beautiful opalescent yellow; salts of silver are the source of fine shades of yellow; a different tone of the same color may also be obtained from oxide of antimony; and a dull yellow is produced from powdered charcoal. Green was at one time prepared chiefly by the use of cupric oxide and of ferrous oxide; now oxide of chromium—which produces a beautiful emerald green—is much employed, that substance being mixed with other oxides when modified colors are desired. For red glass, cuprous oxide is employed to produce an intense ruby tint; and the purple of Cassius—a compound of gold with tin oxide—yields magnificent shades of ruby, carmine, and pink, while oxide of iron also is the source of a brownish-red color. For the production of violet tints the black oxide of manganese is depended on, and a mixture of the oxides of manganese and cobalt is employed for black. The deep-black glass prepared at Venice for making glass beads contains a large percentage—about 11·40—of manganese. Avanturine, an imitation in glass of the mineral bearing that name, is a warm, brown, opaque glassy body, studded with innumerable minute spangles having a metallic lustre. It was originally made in the Venetian glass-houses, but can now be manufactured generally throughout the Continent. According to Von Pettenkofer, the metallic spangles consist of cuprous oxide, and one means of preparing the glass consists of melting equal parts of cuprous oxide and ferrous oxide with the glassy mass. The other opaque varieties of colored glass are obtained by using the various metallic oxides with the compounds that produce milky or white glass.

The uses of colored glass are various, the most obvious and usual being for ornamental windows, for signal lights, for imitation precious stones and ornamental table glass, etc. For the imitation of precious stones the strass already alluded to forms the basis, and both flint glass and Bohemian (potash) glass are much used for colored domestic glass. Window and signal colored glass are made both as rough plate and as sheet glass. In the case of plate glass the metal is, of course, uniformly colored throughout, but colored sheet glass may either be composed of "pot metal" or it may be "flashed colors." Pot metal consists of glass uniformly colored throughout; but in flashed colors the body of the glass is transparent sheet metal covered on one surface only with colored glass. It is very simply made: the workman, taking up on the end of his blowing tube a gathering of clear metal from one pot, dips this into a pot of colored metal, thus gathering over the transparent mass a uniform stratum of colored glass. The whole is then blown in the ordinary manner, and according to the original relative proportions of clear and colored metal will be the thickness of each in the finished sheet. It is obvious that this process admits of many variations, such as gathering the colored metal first, or making alternate gatherings of colored and clear metal so as to have clear within colored, colored within clear, and so on.

Iridescent Glass.—Ancient glass, which has for ages been submitted to the slow disintegrating influence of the damp of the earth and other gently operating agencies, in many instances displays an iridescent play of colors of a most magnificent description. The iridescence thus shown, it has been long known, is due to a process of decomposition resulting in the formation of excessively thin scales of glass. Numerous attempts have been made to imitate by artificial means the gorgeous display of colors thus produced by the slowly acting influences of many centuries, and a certain amount of success has attended some of these efforts. The Venetian glass workers possess the means of giving the surface of their glass a kind of metallic iridescence; and in certain Hungarian glass houses iridescent glass has been made for at least about 20 years. But in 1873, at the Vienna Exhibition, iridescent glass formed a prominent feature, and since that time it has become very common. The iridescent glass now generally seen is a plain flint glass having a slightly metallic tinge and a play of colors like a soap bubble. It is probable that several methods of producing iridescence in glass are practised, as the nacreous lustre in different examples varies considerably. The subject was investigated by MM. Fremy and Clemandot; and under a patent obtained by the latter gentleman, one method, commonly practised, has been made public. It consists in submitting the object to be iridized to the influence of a weak acid solution—such as water with 15 per cent. of hydrochloric acid—under the combined influence of heat and pressure. The effect certainly falls immensely short of the iridescence of ancient glass, but the glass assumes permanently a pearly iridescence, and, though the effect is tiresome, the process will doubtless continue to occupy a place among the methods of ornamenting table glass, etc.

Opaque Glass.—Absence of transparency in glass may be due to any of three causes—(1) to the grinding, or roughening by other means, of the surface of ordinary clear glass; (2) to devitrification or crystallization of the substance; and (3) to the mechanical intermixture of an opaque substance in the glassy mass. Obscured glass was formerly principally prepared by a process of grinding the surface,—the means employed in the case of sheet and plate glass being simply the smoothing process, which forms an intermediate stage in the operation of polishing plate glass. Now the greater part of ordinary obscured glass is prepared by the agency of Tilghman's sand blast, an apparatus by which a fine stream of sand is blown with great violence against the glassy surface. The impinging grains of sand abrade the surface with extraordinary rapidity, and by protecting certain portions with suitable stencils, elaborate patterns in clear glass are produced in a very simple manner. Alabaster glass, so called on account of its resemblance to that substance, is an opaque variety of glass which has been long known and used. Its opacity is due to a process of devitrification it readily undergoes, favored by the excess of uncombined silica used in its preparation. The material is prepared from a combination such as 100 parts of sand, 40 of potash, 5 of borax, and 5 of talc (silicate of magnesia). Into the composition of this glass it will be observed no lime enters, although sometimes bone-earth is added to the materials. For enamel glass a mixture of varying proportions of lead and tin oxides is prepared by calcining the two metals together, and using the compound in the preparation of a mixture for fusing, of which the following is an example:—sand 100 parts, pure potash 80, and mixed oxides 200 parts. The proportion of tin varies within wide limits, and oxide of antimony may be substituted for the tin. Bone glass, milk glass, and opal glass, differing in degree of opacity, are made by adding to the materials of clear glass large proportions of bone-ash, or of oxide of tin, or both together, and with these substances white arsenic may also be combined. The following is an example of a batch for opal-flint glass:—sand 100 parts, bone-ash 30, potash 30, borax 5, and red lead 5 parts. Such a glass was formerly in extensive use for the opal shades of gas lights and moderator lamps, etc.; but the ruddy glow possessed by the rays passing through the imperfectly opaque glass was an objectionable feature in the resulting material. During recent years an opal or milk glass free from such a defect has been introduced, and it is now in extensive use for globes. This preparation, which diffuses light from its surface in a clear pure white glow, owes its milky opacity to the use of cryolite—a mineral substance consisting of a double fluoride of aluminium and sodium ($Al_2F_6,6NaF$) obtained from Greenland. The cryolite glass was first brought prominently into public notice by the Hot-Cast Porcelain Company of Philadelphia, by whom it was made on a large scale, although the material had been in use in Bohemian and Silesian glass-works for some years previous to the commencement of the manufacture in America. For milk white glass the materials used are—sand 100 parts, cryolite 40, and zinc oxide 10 parts. The finished glass, which is remarkably strong, hard, and indifferent to acids contains about 15 per cent. of undecomposed cryolite, to which its opacity is due. The copious evolution of fumes of hydrofluoric acid during the melting, which continues even in the working, is the source of serious difficulty in the manufacture of cryolite glass.

TOUGHENED OR HARDENED GLASS.—In the year 1875 the announcement that a French gentleman, M. de la Bastie, had discovered a means of rendering glass practically unbreakable attracted a great amount of attention; and his statements were immediately made the subject of practical investigation throughout the glass-making community. All the experiments made in connection with M. de la Bastie's process tended to confirm his claim to have discovered a method of rendering glass capable of bearing a shock or strain variously estimated at from 30 to 100 times greater than the same material annealed in the common way. De la Bastie was led to undertake the prolonged series of experiments, which ultimately resulted in his discovery, by the consideration that the brittleness of glass arises from weak cohesion of its molecules; and his efforts were first directed to improving its molecular arrangement, by submitting glass, in a molten state, to forcible compression. This series of experiments led to no practical result; and the line of investigation he ultimately pursued, as well as the merits and defects of his process, are thus succinctly stated by Mr. H. J. Powell of Whitefriars Glass Works, with whom M. de la Bastie carried out his first practical experiments with hollow glass. Mr. Powell, writing in August, 1875, says of the process:—

> “That it consists in plunging glass heated to the melting point into a bath containing an oleaginous mixture, at a high temperature, but considerably cooler than the glass itself; and that this, according to the specification of the patentee, is effected by re-heating already manufactured and annealed glass in a kiln, and passing it thence into the bath. After a rough trial of this process, which certainly answers well for flat or solid glass, we decided that it is defective, for hollow flint glass, as hollow vessels, left to themselves in a kiln, are almost certain to collapse on reaching the required heat. To avoid this difficulty, and knowing that a vessel in course of manufacture, however hot, is always under control whilst it remains on the workman's rod, we placed a bath as near the mouth of the working-pot as possible, and directed the workman, instead of sending the finished vessel to the annealing oven, to drop it into the bath. The vessel is caught in a wire net, and is ready for removal as soon as it has acquired the temperature of the bath. For all vessels made in one piece, *e. g.*, tumblers, finger basins, etc., this process answers well; and it is obvious that if it proves to be the best way of treating hollow flint glass, the use for this description of glass, of the complicated machinery described in M. de la Bastie's specification will be done away with, and the glass will be tempered in the course of manufacture, instead of being re-heated and tempered after it has been already manufactured and annealed. We ascertained, with M. de la Bastie's aid, the right constituents and right temperature of a bath for flint glass; for although the conditions for sheet, plate, and flint glass are nearly the same, there is a difference, and it seems probable that every chemically different glass, and even every different thickness of glass, may require certain variations. In our experiments as to the hardness of the glass, we found that it could be marked, but not cut, with the diamond, and, although it could be smoothed and engraved in the ordinary way, that the disturbance caused by the wheel, when penetrating to any appreciable depth, tended to weaken, or even to cause the destruction of the entire mass. The value of the invention, as far as it concerns flint glass, is at present somewhat modified by difficulties in manipulation. 1. It seems to be impossible to heat a vessel made up of different pieces and of various thicknesses to an absolutely equal temperature throughout, so that the whole may be equally tempered. 2. It seems also impossible to displace the air from a narrow-mouthed vessel quick enough for the inside and outside to be tempered simultaneously. However, setting aside these difficulties, we come to a point which applies equally to all sorts of hardened glass. Hardened glass is not ‘unbreakable;’ it is only harder than ordinary glass, and though it undoubtedly stands rough usage better, it has the disadvantage of being utterly disintegrated as soon as it receives the slightest fracture, and up to the present, until broken, of being undistinguishable from ordinary glass. This glass is known as ‘toughened’ glass, and we have seen the terms ‘malleable’ and ‘annealed’ applied to it. Nothing can be more misleading than these unfortunate epithets. The glass is hard, and not tough or malleable, and is the very opposite to annealed glass. Annealed glass is that the molecules of which have been allowed to settle themselves; the molecules of hardened glass have been tortured into their position, and until the glass is broken are subject to an extreme tension. It is the sudden change of temperature that ‘hardens;’ glass heated up together with the oil may be annealed, but decidedly is not hardened. A piece of hardened glass is only a modified Rupert's drop, *i. e.*, it is case-hardened; the fracture of both is identical, both resist the diamond, and both can be annealed. Moreover, in the middle of imperfectly hardened glass a line is plainly visible, which seems to mark the extent of the case-hardening. This line resolves itself under the microscope into a mass of bubbles and striæ; it seems to be the nucleus of breakage, and consequently as soon as the cutting wheel approaches it, utter destruction ensues.”

The great anticipations which at first were formed as to the extended use of hardened glass have not been realized. M. de la Bastie has improved several of his processes, but the demand for his productions, at no time great, is understood to decrease rather than to increase. For a short time the process was worked by both Messrs. Powell and Messrs. Pellatt in London, but both these eminent firms have given it entirely up. Sheet glass hardened by the process does not appear ever to have come generally into the market, the most serious obstacle to its introduction being the impossibility of cutting it with the diamond, after which the utter destruction resulting from fracture is a serious defect. For laboratory purposes—as flasks and beakers, etc.—it has been suggested that the glass has great advantages, but experiments have proved that its great resistance is not absolutely reliable, and that hardened vessels submitted to a high heat lose their distinguishing peculiarities and become as common glass. Thus a glass, partially filled with water and heated considerably above the boiling point at the parts uncovered with water, broke, the bottom of the glass showing the fracture peculiar to hardened glass, while the upper uncovered part was broken into large sharp-edged fragments like common glass. A modified process of hardening, patented by Herr F. Siemens, consists in pressing and suddenly cooling the glass in moulds specially constructed to conduct away the heat with the various degrees of rapidity found to produce the best results.

STATISTICS OF THE GLASS TRADE.—According to a factory report of 1871 there were in that year 240 glass-works in the United Kingdom, employing, in addition to steam-power, 21,434 operatives, of whom 2116 were females. Of these works 213 were in England, 19 in Scotland, and 8 in Ireland. Further, there were at the same date 37 glass-cutting factories, employing 500 people, principally situated in the county of Warwick. The quantities and value of glass manufactures exported were as under in the year 1878:—

Plate glass	1,156,435 sq. ft.	£106,906
Flint glass	93,112 cwts.	239,966
Common bottles	575,160 "	308,481
Other glass manufactures	72,209 "	99,170
		£754,523

In 1878 the imports of manufactured glass were thus given:—

Window glass	652,325 cwts.	£452,202
Flint glass	143,665 "	489,518
Plate glass	91,198 "	233,602
Glass manufactures	335,751 "	879,733
	1,222,939	£2,055,055

The following table shows the comparative imports and exports of glass in the ten years ended 1877:—

	Imports, Foreign.	Exports of British Glass.	
		Plate Glass.	Other Kinds.
	Cwts.	Square Feet.	Cwts.
1868	609,806	911,330	868,950
1869	601,070	1,076,130	933,475
1870	602,376	1,357,508	799,252
1871	629,472	1,643,575	847,988
1872	688,156	2,131,924	1,002,498
1873	807,410	2,183,106	1,148,640
1874	946,903	1,411,268	1,114,253
1875	983,677	1,609,180	880,983
1876	1,060,361	1,779,628	743,495
1877	1,140,694	1,157,063	792,424

In the *Bulletin de la Société d'Encouragement pour l'industrie nationale* for 1877 there is an elaborate statistical computation of the extent and value of the glass manufacture throughout the world, based chiefly on returns applicable to 1874. The writer, M. Henry de Fontaine, arrives at the conclusion that the annual production of glass has almost doubled in the past twenty years, and estimates the total yearly production throughout the world at a value of six hundred millions of francs.

Bibliography.—The literature of glass-making of English origin is scanty and imperfect. In France and Germany the subject has received much fuller attention. The following list embraces the principal works:—Antonio Neri, *Ars Vitraria, cum Merritti observationibus*, Amst., 1668 (Neri's work was translated into English by C. Merritt in 1662, and the translation, *The Art of making Glass*, was privately reprinted by Sir T. Phillipps, Bart., in 1826); Johann Kunkel, *Vollstandige Glasmacher-Kunst*, Nuremberg, 1785; Apsley Pellatt, *Curiosities of Glass-making*, London, 1849; A. Sauzay, *Marvels of Glass-making* (from the French), London, 1869; G. Bontemps, *Guide du Verrier*, Paris, 1868; E. Peligot, *Le Verre, son histoire, sa fabrication*, Paris, 1878; W. Stein, *Die Glas-fabrikation* (in Bolley's *Technologie*, vol. iii.), Brunswick, 1862; H. E. Benrath, *Die Glasfabrikation*, Brunswick, 1875; J. Falck and L. Lobmeyr, *Die Glasindustrie*, Vienna, 1875. (J. PA.)

GLASS PAINTING.

The manufacture of colored glass, which is the basis of the beautiful and interesting art of glass painting, originated at a period of remote antiquity, and the use of enamels, to vary or ornament its surface, was known to the ancient Egyptians; but the formation of windows of mosaics of colored glass upon which the shapes of figures and ornaments are painted with an enamel fixed by fire is mediæval, and emphatically a Christian art. In all probability it was suggested by the mosaic pictures with which churches were adorned from an early period for the instruction of the illiterate, as was shown by the inscription which they bore, "sanctæ plebi Dei." The step from mosaic pictures to glass mosaic windows was merely a question of time; it is not known when the step was taken, but colored windows existed in St. Sophia at Constantinople in the 6th century, whilst the basilicas of St. John Lateran and of St. Peter at Rome were adorned about the same time in the same manner. In the year 709 Wilfrid, bishop of York, invited workers in glass from France ("artifices lapidearum et vitrearum fenestrarum primus in Angliam ascivit"). The French claim the honor of having invented the process of painting upon the mosaic windows of colored glass, and of thus transforming them into works of art, and also of teaching this to the English, who in their turn instructed the Germans; but Muratori, in the second volume of his *Antichità Italiche* of the Middle Ages, printed a treatise on mosaic and painted glass written by an anonymous Italian in the 8th century, and probably not later than the 11th was written the interesting essay *Diversarum Artium Schedula Theophili Presbyteri et Monachi*, which details with minute accuracy the process of painted glass as it has been practised with some additions and modifications, throughout the best periods of the art; it may reasonably be assumed that Theophilus describes methods invented before his time. Probably the oldest specimen of glass painting now existing is a window of the 11th century in a church at Neuwiller, in Alsace, representing St. Timothy. The figure is rudely designed, but, with the rich border of ornament, shows that the executant knew his art, which in the following century is further illustrated by windows in St. Denis, near Paris, erected by the abbot Suger, which are still preserved. It was however in the 13th century, that great age of the revival of art, that glass painting attained its first great development, and notwithstanding the claims advanced by France, it is most probable that as all art radiated from Italy as a general centre of invention and progress, as well as of faith and dogma, so glass painting partook of the general impulse. It has indeed been asserted that glass manufactured in the north was superior to that produced in Italy, and this is admitted by Vasari, but an examination of old Italian windows throws doubt upon this statement, for the Italian glass will be found to be more even in texture, more diaphanous, and certainly not inferior in color, whilst the beautiful, pearly, white glass of the earliest date in Italy is superior to the pale green representing white in northern glass, and assorts much more harmoniously with the glowing colored glass with which it is associated. Considered as a branch of fine art, Italian painted glass occupied a very high position at all periods of its history, for the designs were frequently made by some of the most famous of that long roll of immortal artists who have had so few equals elsewhere. In Germany the family of Hirschvogel of Nuremberg and other eminent artists, including, it is popularly believed, Albert Dürer, and in France Jean Cousin, Bernard Palissy, Louis Fauconnier, and others, equalled the Italian glass-painters, whilst both German and French artists excelled them in technical processes.

The late Mr. Charles Winston, author of *An Inquiry into the difference of style observable in Ancient Glass Painting, especially in England*, with his usual accuracy and profound knowledge of his subject, thus classifies the consecutive styles:—the Early English, from the date of the earliest specimens extend to the year 1280; the Decorated, which prevailed from 1280 to 1380; the Perpendicular from 1380 to 1530; and the Cinquecento from 1500 to 1550. The styles successively prevalent in Italy, although they have an affinity with those following each other in northern countries, cannot be accurately designated by the titles selected in England, the last excepted. Like other branches of painting they are most readily divided and understood by centuries; as the 13th century, a style principally influenced by Giunta Pisano and Cimabue; the 14th century, in which the spirit of Giotto and Orcagna and their followers prevailed; the 15th century, the first period of which was transitional, and the second early revival, as illustrated by the designs for windows of Lorenzo Ghiberti, Donatello, Paolo Ucello, Pietro Perugino, Andrea della Robbia, and other great artists of the time. The last age, called by Mr. Winston the Cinquecento, lasted in Italy beyond the period assigned by him for its termination, and was characterized by florid magnificence of design and splendor of color, imitative of the pictorial art of that age, and the ornament resembled that prevalent amongst the ornamentists of the schools of Raphael and Michelangelo.

In this brief analysis of the history and practice of glass painting, the Italian examples of the art are selected for description as being less known than those existing in other parts of Europe, which have been minutely and ably illustrated. Besides being classified by centuries, Italian glass painting may be appropriately arranged under the following heads or schools:—the Pisan, Florentine, Sienese, Umbrian, Lucchese, Bolognese, Lombard, and Venetian; for notwithstanding the lamentable destruction of painted glass in Italy even now in progress, specimens by artists belonging to these schools still exist, and the names of a numerous array of glass-painters of these provinces are preserved. The best examples extant of this art in Italy of the first half of the 13th century are two couplets in the apse of the famous basilica of St. Francis at Assisi. In general arrangement and design they resemble windows of the same age in other parts of Europe classed by Mr. Winston under the general head of Early English, being divided into panels of varied and admirably designed geometrical forms surrounded by diapers and borders of rich fancy and glowing color, which, however, are rather more confused than similar details in contemporary glass elsewhere. The panels are filled with scripture subjects, and Italian skill and refinement are obvious in the design of the figures; this may be readily understood when it is considered that Italian artists of this time rendered the Greek art, universally followed, with more sentiment and power than any other people. The ornament shows the influence of Byzantine conventions, but the ornamentists imitated natural forms of foliage sooner than northern artists. A remarkable peculiarity of the early painted windows at Assisi, which are here taken as the best and almost the only specimens of 13th-century glass left in Italy, is that throughout the couplets the backgrounds in each light differ in color. The subjects for instance in the right light are on a blue ground, on the left on a red ground, in other examples the grounds are alternately blue and green. It might be supposed that all unity of effect must have been destroyed in this way; but such is the skill with which the general harmony of color is arranged, that the counterchanges are less objectionable than might appear possible. Early Italian glass painting, like that of other parts of Europe, is characterized by an obvious ignorance of perspective on the part of the designers, but there are manifest indications of attempts to represent retreating surfaces and lines; that these have not the effect intended was not due, as some suppose, to the maintenance of a principle appropriate to glass painting, but simply to a want of knowledge of perspective laws common to all, even the greatest artists of the time.

Besides executing panel windows with small figures, the artists of the 13th century painted figures of comparatively large proportions under canopies of simple and primitive forms. These figure windows were placed in positions at a distance from the eye, as above in the clerestory, or at the ends of aisles. At Assisi such figures are painted at the bases of some of the windows irrespective of the idea of distance, the upper portions being filled with panels and small figures. This irrational system gave way to the entire window being filled with large figures placed over each other within canopies or geometric borders, a method of design which survived in Italy to the close of the 15th century.

The colored windows of the upper and of the lower church are associated with mural paintings which cover every available space on the walls and vaults. It might be supposed that the refulgent painted glass would either obscure the frescoes or diminish their effect by contrast; but in the first place the glass is not so thick as that of northern manufacture, nor is it made opaque by the effect of climate, whilst, as already noticed, the white glass is purer, and the brilliant sun of a southern climate illumines the frescoes sufficiently, notwithstanding the colored medium through which the rays are transmitted. Such is the case at Assisi; but at Florence the colored glass in the cathedral darkens the church too much, from causes which will be explained afterwards. The true method of combining colored glass in a building with the presence of pictures and sculpture in a less sunny climate will be illustrated in describing glass painting of the 16th century, the subject being important at the present time.

In the next great age of art, that which commences with the triumphs of the genius of Giotto, glass painting evidently shared in the general progress. No windows remain which are associated with his name as designer, but in Santa Croce at Florence, by the will of Count Alberto di Lapo, dated the 9th of July, 1348, money was provided for adorning the apse of the church with frescoes and painted windows to be completed in three years. The frescoes were painted by Angelo di Taddeo Gaddi, and it seems reasonable to suppose that he designed two of the three windows—that in the centre being of later date. The following extract from the archives of the cathedral of Florence shows that Angelo Gaddi designed for glass-painters: "A window in Santa Reparata"—the ancient name of the cathedral—"over the door towards the street of the Cassettai is commissioned of Antonio of Pisa, master glass-painter, and the design is by Angelo Gaddi." The windows illustrate the system of ranging single figures under canopies over each other. The coloring is harsh; there is too great a prevalence of dark green; and the general design of ornament is meagre and confused. This is increased by the capricious changes of the colors of the canopies, which are not white, these being rare in Italian glass painting. Thus in one of the windows the first two canopies are respectively red and green, which colors are counterchanged in those immediately over; the next two in ascent are green and yellow, the next pair brown and yellow, the fifth order shows both yellow. Thus that variety of color prevalent in the backgrounds of Italian 13th-century work is found in the canopies of windows of the next century, a custom limited to glass painting, and not found as a rule either in mural or other pictures. There are in Santa Croce several windows of the 14th century, but they are generally inferior to those of the same period extant in St. Francis of Assisi, where there are important examples of rare beauty of design and workmanship, more harmoniously colored than those at Florence, and suggesting that the Umbrian excels the Florentine school of glass painting.

Throughout the whole of the painted windows existing in Florence, of the fully developed style of the 14th century, and for a considerable portion of the 15th, the influence of the architectural design of Giotto and Orcagna is very perceptible. The graceful twisted shafts common to the works of both architects, the richly adorned niches and gablets, the dome-like covering of the famous baldacchino in the church of Or San Michele, the work of Orcagna, are features which are imitated in various ways by Italian glass-painters. The color is especially noteworthy; the canopy, somewhat squat in form, is adorned in every part with rich and diversified colors evidently imitative of the varied marbles and the infinity of marble inlay and mosaics, characteristic of so much of the mediæval architecture of Italy; whilst in northern countries the canopies in windows, with their beautiful details of form showing such rich fancy and such graceful lines, are chiefly white, not that they are altogether colorless, for it is of the perfection of mediæval architecture to associate color with form. That which in Italy was done by the help of rich stores of marbles of many hues, was effected in the north, where these were not available, by means of polychromatic painting, which was imitated in window design by the glass-painters. Thus the canopies in Italian windows differ as much from those prevalent at the same period in the rest of Europe as the campanile of Giotto differs from the spires raised by the genius of northern architecture.

In the history of painted glass in Italy during the 15th century, the windows of the cathedral of Florence, dating from 1390 to 1503, occupy an important position, not only by reason of their interest as connected with that celebrated church, but also because they were designed and executed by artists of the highest reputation. The cathedral was founded on the 8th of September, 1298, the architect being Arnolfo di Cambio di Colle di Valdelsa. In 1334 Maestro Giotto was architect, and commenced the famous belfry. In 1364 the church was vaulted over at its eastern end, and in 1420 Filippo Brunelleschi and Lorenzo Ghiberti, who built the clerestory of the nave with its round windows and Renaissance cornice, were appointed joint architects. Painted glass was introduced into the windows thirty-six years before the completion of the cupola, and thirty before that of the clerestory. These dates are an interesting testimony to the importance attached at the time to painted windows as portions of the design of so great a church. They were erected in the aisles, before the nave was finished, by Don Lionardo di Simone, monk of Vallombrosa, and Niccolo di Pietro della Magna, so early as 1390, and when the nave was roofed over by its architects, Fra Bernardino di Stefano executed the two first windows of the clerestory from designs by Lorenzo Ghiberti.[1] Ghiberti is also alleged to have designed many of the painted windows at the east end of the church; but those now existing, judging by the design and color, as well as by the technical execution, cannot be his, for they are manifestly of earlier date, whilst the authorship of some of them is recorded in the archives without reference to Ghiberti. One only, on the north side of the apse and in the lower row, suggests the design of this great artist, the suggestion being strengthened by the fact that the diapered ornament on the ruby dress of the figure is made by the wheel, which brings this window within the 15th century, whilst the diapers in the other figures of the same series are executed in an older style. It has been stated that Ghiberti advised the municipality of Florence to invite a celebrated glass-painter of Lübeck, Francesco di Domenico Lievi da Gambassi, by letters, the second being dated October 15, 1436, to settle in Florence with special privileges; he came, and it is assumed that he painted Ghiberti's designs for glass, but of this there seems to be no satisfactory evidence. We find that in 1434, before his arrival, Maestro Domenico di Pisa painted the east window of the drum, representing the coronation of the Virgin, which was designed by Donatello in competition with Ghiberti, and preferred. As it was on the 12th of January, 1434, that Brunelleschi completed the dome, evidently no time was lost in commencing the painted windows. Bernardo di Francesco del Boni is recorded in the archives as having executed in 1442 the following windows in the drum, called in Italian the tribune:—the Resurrection, designed by Paolo Uccello, and the Ascension and the Prayer in the Garden, by Lorenzo Ghiberti, although by this time Francesco di Lievi da Gambassi had been some time in Florence. Bernardo del Boni is also recorded to have painted the Annunciation designed by Uccello, removed some years ago, and the Ascension described as being either by Ghiberti or Uccello; the uncertainty is curious. In 1448 the same artist painted the Presentation in the Temple, which was designed by Ghiberti. What windows then did the artist from Lübeck really execute? Born an Italian, he was instructed from his youth in Germany, and it is reasonable to suppose that his style would be German. Now several of the upper windows of the transepts contain figures which have a decided affinity with German ideas, and it is not unreasonable to suppose that these were by the new comer. He established furnaces by special permission, and it has therefore been hastily assumed that he manufactured colored glass; but these no doubt were to burn his painted glass. The letter inviting "Francescho Dominici Livi de Ghambasso comitatus Flor., magistro in omni et quocunque genere vitreorum de musayco et de quodam alio colore vitreorum," dated 15th October, 1436, was preceded by another written on the 26th August, 1434, which is thus recorded:—"Letter written to the master glass-painter Gambassi, then in Scotland, and who made works in glass of various kinds, and was held to be the best glass painter in the world." It is now vain to express the feeling with which Scotch people must regret the destruction of the works of this excellent artist in Holyrood Chapel; the blow then inflicted upon ecclesiastical art never has been remedied.

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[1] This circumstance has led to the erroneous statement, repeated to the present time in every guide-book and by every writer on the cathedral, and to the still prevalent belief, that the three windows in the façade of the church were designed by Ghiberti, who has himself recorded:—"I designed for the front of Santa Maria del Fiore, for the central round window of the façade, the Assumption of our Lady, and I designed those on each side." The windows which Ghiberti really designed were the great circle of the façade, a noble work still in its place, and the two of the clerestory on each side of it, long since removed and lost. That they were painted by Fra Bernardino di Stefano in 1423 is thus shown in the archives of the cathedral—"Fra Bernardino di Stefano, of the order of the Preachers of Santa Maria Novella, is to execute two round windows in the nave of Sa Maria del Fiore, one to the right and the other to the left,—that to the right representing Joachim driven from the Temple, that to the left the Death of the Virgin Mary, and the designs are by Lorenzo di Bartoluccio (Ghiberti)." It is thus evident that the windows of the clerestory of the nave were to be painted with the life of the Virgin Mary, of which these two were the first and last of the series, whilst the Assumption of the Virgin appropriately occupied the centre. Those in the clerestory having disappeared, it has invariably been supposed that the two remaining at the ends of the aisles are those described by Ghiberti, although they differ in subject and entirely in style from his work. They are in fact thus mentioned in the archives:—"In 1414 Nicolo di Pietro della Magna painted the two windows on each side of the front of the cathedral," which record settles the question.

Many other glass-painters executed windows in the cathedral, the last of whom, Sandro di Giovanni Agolanti, in 1486 glazed the windows of the lantern, showing that it was finished, and in 1503 inserted glass "in an aperture for the astrologers to see the sun through." The windows of the cathedral of Florence are of rich deep colors, but unfortunately they are incrusted with dirt inside and outside. Many of them which have been broken have been wretchedly repaired, and the modern glass is toned with glazings of oil paint. They darken the church to such an extent that works of art within it are seen to disadvantage. Michelangelo's group of the Pieta is merely a dark mass, and it may be mentioned that his statue of Christ in Santa Maria sopra Minerva is similarly sacrificed to the painted glass lately introduced.

The history of glass painting is illustrated by windows in other churches in Florence; those in Santa Croce have been alluded to, with the exception of the magnificent circular window of the façade designed by Ghiberti. It is of special interest, as showing this great sculptor's ideas of color as well as of form. The subject is the Descent from the Cross, and the color strongly recalls the bright clear system of Fra Beato Angelico. In Santa Maria Novella there is another very fine circular window of the 14th century, the history of which seems to be forgotten; but in design it recalls the style of Andrea Orcagna, to whom also may be attributed the fragments of a window in the Strozzi chapel, which he partly painted in fresco, and for which he also provided the admirable altar-piece. In another Strozzi chapel in the same church, painted by Filippino Lippi in fresco, there is a very rich window which is obviously also of his design, but so completely has all critical knowledge of glass painting disappeared in Florence, that this and other noble works excite no attention and no remark, and are in danger either from removal or from the clumsiest renovation. The great window of the chancel, a large triplet, is so excellent that it places Sandro di Giovanni Agolanti in the foremost rank as a designer and glass-painter of the 15th century. He was born in 1446, and of his numerous works this superb triplet, which was erected in 1491–2, is the only example now remaining, whilst there are twenty-one records of his productions, evidently a small portion of them; the last describes him as decrepit in 1515, and mentions that Niccolo di Giovanni di Paolo, master glass-painter, took his place.

A window in St. Francis at Assisi by the Umbrian Angioletto da Gubbio, an artist of the early part of the 15th century, deserves special notice in connection with the admirable works of this great age of the art. It was erected about a century after the death of Cardinal Gentili (who built the chapel) by his heirs. The window is so full of light, so delicate in its arrangement of color, and so tenderly and skilfully painted, whilst the prevalent white ornament is so brilliant, that it is perhaps the most perfect type in existence of a painted window suitable for a building containing works of art, or where the climate is unfavorable and consequently the light imperfect. The close of the 15th century was in important respects the greatest epoch of painted glass in Italy: the general style of design of the great quattrocentista masters, their monumental and decorative methods of composition, simplicity of attitude and form, and rich unbroken color, were eminently adapted for reproduction in glass painting, whilst the prevalent style of ornament was singularly graceful and pleasing. The influence of the Italian style was felt in France, Germany, and the Low Countries, in which very noble works of glass painting rivalling the Italian were produced by eminent artists, examples of whose works may be seen at Bourges and Rouen, at Antwerp and Brussels, and in various cities in Germany, although, singularly enough, one of the finest typical examples of this great epoch of German glass painting exists at Assisi—the glazing panels of which the noble window has been composed being dispersed through two or three windows of the upper and lower church. The technical execution of the windows of this period in all these countries was superb, showing how thoroughly the artists were trained in every process of their art. In England the feeble Perpendicular style was contemporaneous, entirely devoid of good drawing, pallid in color, and weak in execution, a singular contrast in every respect to the state of the art on the Continent.

Amongst the most active and able glass-painters of the prolific 15th century in Italy the Gesuati monks, whose convent was close to Florence and was razed to the ground during the siege when Michelangelo aided in the defence of the city, were celebrated. They prepared colors for artists, supplying Michelangelo when he painted the Last Judgment, and they executed numerous windows of which there are records from 1467 to 1562. As glass-painters they painted the designs entrusted to them with forcible execution, but their drawing was less happy, and their ornamentation heavy. There are several windows by these Brethren in Florence: in Santo Spirito the great circle of the façade shows every indication of having been designed by Pietro Perugino; in San Salvatore, near San Miniato, the east window, evidently by a Gesuato, has very probably been designed by Andrea della Robbia. In another window in the same church a figure of St. John is a very fine specimen of their art. Several windows filled with small round panes of white glass, with richly colored borders and sacred monograms or heraldry in the centre, are especially noteworthy as admirable types for domestic architecture. There are also works of the same character as the above in the church of Santa Maria Maddalena dei Pazzi.

A glass-painter was now to make his appearance in Italy who was destined, although a foreigner, to eclipse in the opinion of the Italians all previous masters of the art; this was Fra Guglielmo di Marsillat, born in the diocese of Verdun in 1475. It is not known under whom he studied glass painting, but for protection from the consequences of some escapade he entered the Dominican order. Claude, an eminent French glass-painter, being summoned to Rome by Julius II. to decorate the Vatican with painted windows, induced Marsillat to accompany him. Of the numerous windows which they must have painted only two remain in the church of Santa Maria del Popolo, so complete has been the destruction of painted windows in the Eternal City. Marsillat executed a number of magnificent windows in his manner for the cathedral of Arezzo. The following is a form of contract made with him:—"The board of works of the cathedral have commissioned three windows of painted glass for the cathedral from Master William, son of Peter, Frenchman, that is, one window above the chapel of St. Francis, one window above the chapel of Matthew, one window above the chapel of St. Nicholas, for the price of fifteen livres the square braccio"—nearly 2 square feet,—"to be burnt in the fire and not painted in oil, and they are to be finished by the end of June, 1520." Marsillat, who painted well in oil and fresco, was the designer of his own windows. He was so impressed by the works of Michelangelo that he imitated his manner, and one of his windows at Arezzo, representing the Raising of Lazarus, is almost a transcript of the picture of the same subject designed by Michelangelo, and painted by Sebastian del Piombo, which is now in the National Gallery, London. The design of the Frenchman is rather more crowded, but is characterized by more life and action. He introduced into glass painting the magnificent architectural backgrounds, with figures on balconies and terraces, made familiar by the works of Paul Veronese; he drew the human figure admirably, and was very successful in the representation of motion, and his arrangement of color was perfect in harmony. It is not to be wondered at that his works produced so great an effect upon the minds of his contemporaries. They also show upon his part a consummate knowledge of technical conditions, and his windows are so perfectly executed that except where injured by violence or carelessness they are in admirable condition at the present time. Marsillat also executed some fine glass paintings at Cortona, which have been removed and are now in Florence.

Without entering upon the description of a considerable number of interesting works of glass painting in various parts of Italy, and of detailed notices of the artists, enough has been done to illustrate the history and progress of the art from the 13th century to nearly the first half of the 16th. Later much less colored glass came to be used, and a considerable change in taste took place in this art as in architecture; it is shadowed forth even as early as 1501 in the following record:—"Quod in dicto loco semper et pro omnia tempore in dicto loco et ecclesia sunt media die tenebre et ut vulgo dicitur buio et habeto colloquio cum consolibus Sancter Johannes de vietro faciat sumptibus opere unam finestram ex vitri cum ochi biacchi fregio d'allato et cum arme popoli." The desire for windows admitting more light led to the invention and adoption of a beautiful variety containing much white glass varied with yellow stain, and the introduction of a small quantity of colored glass. These windows were painted with graceful arabesques executed in enamels and burnt in, and they never have been surpassed at any time for excellence of drawing and skill of execution. Such are the windows in the Laurentian library at Florence, attributed to Giovanni da Udine, but erected after his death. Other examples might be referred to, and they are now of great value as showing the best description of ornamental window suitable for buildings of the developed Renaissance style, adorned with works of painting and sculpture. They have enough of color to harmonize them with painted decorations, and enough of white glass not to destroy the chiaroscuro of sculpture. It should be remembered that the 13th century produced beautiful windows possessing similar advantageous qualities suitable for mediæval buildings containing modern sculpture, such as the famous five sisters of York cathedral, or the white windows of the same period at Chartres.

The technical execution of the glass paintings still existing in Italy resembles that prevalent elsewhere, and the method of the old masters is clearly described by Theophilus. The glass used was either pot metal or coated; that is, the color either pervades the whole body of the metal or is applied as a film over white glass, invariably the case with ruby, which would seem black but for this contrivance. The artist employed to design a window prepared a full size working drawing, which, according to Theophilus, was executed on a whitewashed board in his time; but later these were made on paper, as is proved by the following contract from the archives of the cathedral of Florence (1437):—"To Lorenzo di Bartoluccio (Ghiberti), sculptor, seven florins, being the half of the price of his skill and labor for drawing four figures on paper of bombagia (coarse cotton) for a window to be executed by Bernardo di Francesco, glass-painter, at three livres per figure." Guided by the firmly marked outlines, the glazier cut his mosaic of glass of the requisite colors by the aid of a hot iron, the diamond not being used for this purpose till the 17th century. The pieces of glass were further reduced to the shapes and sizes needed by the aid of the grosing iron, still a familiar instrument; thus prepared they were ready for the painter, and at the present time are attached to a transparent easel formed of a large sheet of glass. Theophilus thus describes the enamel color prepared for painting with:—"Take copper beaten small, burn it in a little pipkin until it is entirely pulverized, then take pieces of green glass and sapphire" (a blue paste used in mosaic work), "and pound them separately between two porphyry stones; mix these ingredients together in the proportions of one-third powder, one-third green glass, and one-third sapphire. Grind them on the same stone with wine or urine, put them into an iron or leaden vessel, and paint the glass with the utmost care. For with the three colors" (that is, shades of one color), "if you are diligent in the work, you can make the lights and shadows of the draperies in the same manner as in colored painting. When you have laid on the first touches in the drapery with the aforesaid color, spread it in such a manner that the glass may be pure" (that is, untouched) "in that part which you are accustomed to make light in a picture, and let the touches be dark in one place and light in another" (that is, graduated), "and again yet lighter and distinguished with much care, that it may appear as if three shades of color had been applied. This order you should observe below the eyebrows, and round the eyes, and nostrils, and chin, round the naked feet and hands, and other portions of the naked body; and thus let the glass painting have the appearance of a painting composed of many colors." It must be obvious from this description of the most ancient method of glass painting, in important respects the same as that still followed, that the art is regulated by certain necessary conventions distinguishing it from painting upon opaque surfaces. The features and accessories are drawn with sharp black lines making them out clearly to be seen at a distance, and in a very different way from the representation of such details in a picture. The highest lights are the local color, that is, the pure color of the glass; the deepest shadows are solid black produced by laying on the enamel thickly; all this is precisely the reverse of the system pursued at the same early period in painting pictures in which the shadows were the local color and the lights white. As painting advanced it gradually approached more nearly to the scale of color of the glass-painter, the lights instead of being white were painted of appropriate shades of the local color, and the shadows were graduated into black in their deepest parts. It may have been that glass painting suggested this important change in ideas of color and chiaroscuro. The glass being painted as described must be burnt to fix the enamel thereon with its flux. The separate pieces with the painted side upwards are placed upon the shelves of a kiln or iron box, covered with whiting; the kiln is placed in a brick oven, and a fire kindled which surrounds it with flames. Much experience is needed to determine when the glass is sufficiently burnt to fix the enamel. When this has been done the fire is withdrawn, the oven is hermetically sealed, and the glass is left to cool gradually, so as to be annealed. From the appearance of many Italian windows as compared with those executed elsewhere, it is reasonable to infer that the Italians were less skilful than their northern contemporaries in firing their glass. The next process is to unite the numerous pieces of mosaic, thus painted and burnt, into panels of a given size, which is done by means of ribbons of lead grooved on both sides, the ribbons being soldered at all their angles, thus firmly tying the mosaic together. When the painted window is erected, the leads are seen internally in contrast with the transparent glass as intensely black lines, but externally, where they catch the light, as meandering lines of metal dividing the surface. Mistaken attempts have repeatedly been made to get rid of these lines, but they are constituent parts of the art, can only be got rid of by changing its true character, and are only disfiguring when injudiciously introduced, as for instance in some 14th-century glass in Santa Croce, in which the whites of the eyes are fixed with leads of the form of spectacles, so that all the saintly persons represented appear, ridiculously enough, to wear these aids to defective vision. The panels, which are technically called glazing panels, are inserted in their places in the windows by means of grooves prepared in the stone work, into which they are secured with cement and strengthened at intervals with cross-bars of iron called saddle bars, to which the glass is made fast by ties of copper wire. Thus fixed, experience has shown that painted windows if duly cared for will last for many centuries. Regarded in their connection with past history, no monuments of art surpass painted windows in interest; they are only equalled by the paintings still extant in the tombs of the Egyptians as illustrations of faith, history, and customs. It was almost the universal usage that persons of every rank and position, as well as corporate bodies and guilds, made offerings of painted windows to churches. Whilst they give the most vivid ideas of ancient taste and methods of decoration, the religious opinions of successive ages are interpreted by the manner in which sacred subjects are selected or represented; the actual state of art at different times, from its rudest forms to the most perfect, is admirably exemplified; and, as it was customary to introduce the donors in appropriate parts of their gifts, the prince or noble in knightly panoply, with his armorials, is seen kneeling, sometimes accompanied by his spouse. In like devout attitude the ecclesiastic appears in the robes and with the insignia of his office, or the wealthy merchant and his wife in appropriate costume. In other examples tradesmen, surrounded with the objects and materials of their commerce, sell to their customers articles of clothing or of food. Every occupation is illustrated in these ancient pictures in glass. How great then has been the loss to art and history caused by the reckless demolition of painted glass which has taken place in all parts of Europe, but especially in Italy, where the clergy have been the chief offenders! The Italians have not been impelled to this lamentable destruction of these precious records and beautiful creations by any of the convictions, changes of faith, or fanaticism, fatal to so many works of art in other countries, but by unreasoning transformations of taste, by ignorance, or by the paltry desire of gain. In northern climates ancient glass is found to have been affected by the action of the weather, its outside surface is roughened and pierced to a small depth by little pits, or is so altered as to resemble sheets of zinc; it is also covered with dirt, especially internally, the enamel rougher than the surface of the glass favoring this incrustation. These injuries and accumulations veil the glass paintings, and produce a mysterious confusion of form and color, admired by many, who to obtain in modern work such effects of age, and to conceal the inharmonious crudity of color, soil it artificially with varnish, paint, or enamel applied externally, or with dirt applied of set purpose, showing thereby their ignorance of art and their bad taste, by having recourse to processes which are outside the domain of art, for perfect harmony of color and effect of chiaroscuro ought to be the results of the artist's cultivated knowledge and skill, and nothing should be done to hasten the obscuration of the windows or to anticipate the effects of time. Important improvements have been made in the art of glass-painting, as well as in the manufacture of glass, since Theophilus wrote his treatise, but some of these have not been favorable to the art; for instance, old glass is much quieter in color than modern, and as it was less diaphanous, and less smooth in texture, it was better adapted to the operations of the glass-painter. This being observed, eminent manufacturers of colored glass in England and on the Continent have prepared imitations of the soft, pleasing hues of old glass, and of its varied texture, with considerable success. The addition of an enamel brown from iron, and much warmer in tone than that made from copper, has been an important aid to glass painting, whilst about the middle of the 16th century numerous colored enamels were invented, which, however ingenious and beautiful, subsequently modified the art unfavorably. Vehicles composed of spirits of turpentine, fat turpentine, or gum senegal have advantageously replaced the primitive distempers already alluded to. An important addition was the discovery of the yellow stain, made from silver, the only purely transparent color applicable to the surface of glass. It has been described as the invention of the Beato Giacomo of Ulm, who practised glass painting at Bologna, and died in the odor of sanctity in 1491; but the yellow stain was characteristic of glass paintings for more than a century before his time. The introduction of the system of coating white with colored glass in the same way as it had been coated with ruby glass, and the invention in the 15th century of removing portions of the colored glass by abrasion, or with the wheel so as to lay the white bare in conformity with special designs, together with the practice of staining such white portions yellow, led to important modifications in the art. Embroideries on colored garments and other ornaments were thus easily represented, and the system is very useful in painting heraldry. Instead of the wheel fluoric acid is now chiefly used to remove the film of colored glass from its white backing. The leads with which the mosaic of glass is brought together in glazing panels have undergone various changes. Early leadwork is massive; but at the beginning of the 15th century it becomes lighter in appearance but without loss of strength, for although the grooves were made shallower, the lead was increased in thickness and was rounded on the outer surfaces. Alterations also were made in the method of fixing painted windows: the saddle bars, according to climate, were made more or less robust; and, instead of crossing the windows in straight horizontal lines, they were frequently bent to suit the design. Generally speaking, horizontal bars are not objectionable unless they cross faces, or hands, and feet,—an arrangement which ought carefully to be avoided. Mosaic windows should be made waterproof, and the saddle bar should be painted at intervals of time, as otherwise the rust injures the glass.

Enamelled glass, that is to say, white glass enamelled with colors, finally took the place of mosaic glass. In England in the last century glass-painters of merit who practised enamel painting have left considerable works, amongst whom Francis Eginton, Forrest, Henry Giles, Robert S. Godfrey, Jarves, and especially Jervais, who in 1717 executed from designs by Sir Joshua Reynolds the great east window of New College, Oxford. Whatever may be thought of their method, these glass-painters were meritorious artists. Reference has been made to some of the works of the admirable glass-painters of other countries besides Italy, but the object of the present paper has been to illustrate the history and practice of the art by Italian specimens hitherto little observed, and very inadequately and generally inaccurately described.

At the present time the art of glass painting is practised in different countries with very divergent views of its character and limits. Some think that the more nearly it can be assimilated to pictures in oil or fresco the better, whilst others maintain that all such resemblance is beyond its distinctive conditions as a branch of decorative art. It is a common but erroneous belief that the art of glass painting was lost, and that it has been revived in the present century. It survived in its latest form of the enamel method, classed by Mr. Winston as the intermediate style, which is still carried out with unsurpassed skill in Germany. Undoubtedly the mosaic system had disappeared, and it has been judiciously and ably restored wherever glass painting is now common, although with different modifications and ideas of its nature. In England glass-painters possessed of much technical skill and cultivated knowledge of old forms of the art, have produced meritorious works within the limits of almost servile imitation, insisted upon by prevalent but mistaken sentiment; and in too many instances this imitation has reduced the art to the state of mere trade, so that at no period of its history have worse specimens been executed, too often found in the windows of the grandest monuments of mediæval architecture, which ought to have been preserved from such profanation. Of the great value and interest of early painted windows, as well as of those of more matured art, every one who studies them with intelligence must be sensible; and this value and interest are increased by the fact that they illustrate, with perfect truth, the tastes and ideas, the faith and customs, of the periods during which they were created, but modern counterfeits do nothing of the kind, and can convey no such impressions to future times. It is only by the restoration of the old union which existed between the great artist and the glass-painter, dwelt upon in these columns, that the beautiful art of glass painting can be really restored, nor are we without a completely successful instance of the happy results of this union. A window in the parish church at Alnwick, designed by the late William Dyce, R. A., and painted on glass at Munich, is a magnificent specimen of the art, equal in design and execution to the works of its golden age.

In Germany the arts ornamental still flourish as branches of fine art. There, as generally throughout the Continent, the acquirement of a knowledge of ornament forms part of the curriculum of study of most artists; to the entire neglect of this in England, in academies of fine art, may be attributed the low estate into which these branches have fallen. The most eminent German artists of the present century have made designs for painted windows, which have been executed by highly-trained glass-painters, with that care which is so characteristic a national attribute. Such being the case, it remains a source of wonder that artists surrounded by precious remains of ancient genius remarkable for exquisite color should, notwithstanding, show so little ability as colorists. They assimilate the colored glasses of the best qualities, with every attention to the laws of harmony, but they do not bring them into union as the old masters did by forcible painting of the shadows and half tints. The shadows generally are too transparent, and the general effect is weak. The finest work of the Munich school of glass painting, and one of the best windows produced in the present century, is in the Parliament House, Edinburgh. It is richer in color than is usual; and, having been designed by the illustrious Wilhelm von Kaulbach, the general composition is of a noble character.

In France an imitative school, resembling that which has been dominant in England, has executed skilful mimicries of ancient glass painting, and has restored successfully ancient windows broken or otherwise injured in revolutionary times or by neglect. Glass-painters of this class may be found in France, who dispute the supremacy in bad art of their island rivals. In efforts to escape from this abject imitation, trained artists have produced original works of considerable power of form and color, but too many aim at a picturesque eccentricity, and an affected design, inconsistent with the grave beauty of the art; and Jean Cousin and other great masters of the grand period of French glass-painting have no successful followers, nor has any painted window been produced in France in the present century which equals that by the Scottish artist, William Dyce, or that by the German, Von Kaulbach.

In Italy there are glass-painters whose merits as draughtsmen, designers, and executants place them in the first rank, but their windows are almost invariably laborious imitations of pictures in oil; they have undoubtedly lost the methods as well as the ideas and style of their great predecessors, whose windows they not unfrequently injure deplorably by their restorations. It is to be regretted that artists so admirably trained in many respects should so little comprehend the magnificent works of former times which would be their best models, and which they have skill enough to rival but for their vicious method of execution.

In Belgium the art is practised with considerable skill, and works of merit have been executed, but here, as elsewhere, the modern glass-painter is inferior to his predecessors, although he is surrounded by so many admirable specimens of ancient art.

The following works on glass painting may be advantageously studied:—Ferdinand de Lasteyrie, *Histoire de la peinture sur verre d'après ses monuments en France*, Paris, 2 vols. folio, 1852; Id., *Quelques mots sur la Theorie de la peinture sur verre*, Paris, 12mo, 1853; Id., *Notice sur les vitraux de l'abbaye de Rathhausen, canton de Lucerne*, Paris, 1856; A. Lenoir, *Histoire de la peinture sur verre et description des vitraux anciennes et modernes*, etc., Paris, 1803; Id., *Notice historique sur l'ancienne peinture sur verre, sur les moyens pratiques dans cet art depuis l'époque de son invention jusqu'a nos jours, et par suite sur Jean Cousin, qui a excellé dans le même art*, Paris; E. H. Langlois, *Essai historique et descriptif sur la peinture sur verre ancienne et moderne*, Rouen, 1832; Pierre le Vieil, *L'art de la peinture sur verre et de la vitrerie*, Paris, 1774; *Glass: the manner howe to anneile or paint in glass: the true receptes of the cullors*, 1616; Gessert, *Rudimentary Treatise on Painting on Glass*, London, 1851; Mrs. Merrifield, *Ancient Practice of Painting in Oil, Miniature, Mosaic, and on Glass*, etc., London, 1849; Charles Winston, *An Inquiry into the difference of style observable in ancient Glass Painting, especially in England*, Oxford, 1847; Padre L. V. Marchese, *Memorie dei piu insigni Pittori, Scultori, e Architetti Domenicani*, Florence, 1846; G. Gaye, *Carteggio inedito d'artisti dei secoli* xiv., xv., xvi., 3 vols., Florence, 1839; Gaetano Milanesi, *Le Opere di Georgio Vasari con nuove annotazioni e commente*, Florence, 1879. (C. H. W.)

GLASSIUS, Solomon (1593-1656), theologian and Biblical critic, was born at Sondershausen, in the principality of Schwarzburg-Sondershausen, in 1593, received his school education at the gymnasium of Gotha, and in 1612 entered the university of Jena, where, with the exception of some months spent at Wittenberg in 1615, he passed the following nine years of his life. As a student of theology under John Gerhard he directed his attention especially to Hebrew and the cognate dialects; in 1619 he was made an "adjunctus" of the philosophical faculty, and some time afterwards he received an appointment to the chair of Oriental languages. From 1625 to 1638 he discharged the duties of superintendent in Sondershausen; but in the latter year, shortly after the death of Gerhard (1637), he was, in accordance with the last wish of that great man, appointed to succeed him in the chair of theology at Jena. He did not, however, continue long at that university; for in 1640, at the earnest invitation of Duke Ernest the Pious, he removed to Gotha, there to act as general superintendent in the execution of important reforms which had been initiated both in the ecclesiastical and in the educational establishments of the duchy. The delicate duties attached to this office he discharged with singular tact and energy; and when called upon to take part in what is known as the "syncretistic" controversy, by which Protestant Germany was so long vexed, he manifested a combination of firmness with liberality, of loyalty to the past with a just regard to the demands of the present and the future, which unhappily have only too seldom been equalled in theological disputes. His principal work, the well known *Philologia Sacra*, published originally in 1625, was and still is regarded as a work of great value in biblical hermeneutic; and it has an historical importance as marking the transition from the earlier views on questions of biblical criticism to those of the school of Spener. It was more than once reprinted during the author's lifetime, and appeared in a new and revised form, edited by Dathe and Bauer at Leipsic, towards the close of the century (1776-1797). Glassius succeeded Gerhard also in the editorship of the Weimar *Bibelwerk*, and he wrote the commentary on the poetical books of the Old Testament for that publication. A volume of his *Opuscula* was printed at Leyden in 1700. He died in 1656.

GLASTONBURY, a market town and municipal borough of England, is situated near the middle of Somersetshire, about 22 miles S. W. of Bath, on the great western road from London to Exeter. The spot occupied by the town is a sort of peninsula formed by the windings of the river Brue, which flows west through the valley between the Poldew and the Mendip Hills; and in earlier times it was to all intents an island, as the country round was an extensive marsh, broken, however, by the Tor of St. Michael to the N. E. of the town. Of the public buildings the most important, besides the ruins of the great abbey, are the church of St. John the Baptist, in the Perpendicular style, with a tower of fine proportions; the church of St. Benedict, dating from between 1493 and 1524; the hospital of St. John, founded in 1246; and the George Inn, erected about the time of Henry VII. or Henry VIII. There was formerly in the town a remarkable cross, which is figured in Warner's *Glastonbury*; but it fell into decay, and was replaced by the present insignificant monument in 1846. Though Glastonbury has a station on the Somerset and Dorset Railway, and communicates with the estuary of the Severn by means of a canal for vessels of 70 or 100 tons burden, it has comparatively little trade. The woollen manufacture was introduced by the duke of Somerset in the first half of the 16th century, as may be seen at length in Strype's *Life of Cranmer*; but neither that nor the manufacture of silk, which was also carried on to some extent during the 18th century, is now of any importance. There are tanneries, however, and tile-works. The population of the town in 1861 was 3496, and in 1871 it was 3670.

The abbey of Glastonbury is without doubt one of the very earliest ecclesiastical foundations in England. In the words of Mr. Freeman ("King Ine," *Proc. of Somersetshire Arch. Soc.*, 1874), "it is on any showing a tie between the Briton and the Englishman, between the older Christianity of our island and the newer, the one church of the first rank which lived through the storm of English conquest, which passed into the hands of our victorious fathers as a trophy of victory undestroyed and unplundered." But unfortunately "everything relating to its early history is so enveloped in legend that one has to tread one's way with the greatest caution at every step." As Canon Stubbs remarks,[1] the extravagant claims of the monks in regard to the antiquity and celebrity of their church "doubtless provoked criticism, and criticism forced on them the need of a forged history to assert, and of forged monuments to support these pretensions. The fabrication of such evidence must have gone on at Glastonbury on a scale proportioned to the claims; and William of Malmesbury, it would almost seem, undertook to erect the story out of materials which he distrusted. This did not content his employers, and they interpolated his work to a degree which makes it impossible to rely with confidence on any part of it."

Though Glastonbury is not mentioned either by Bede or by the authors of the Saxon Chronicle as one of the early foundations, its existence (continues Prof. Stubbs) is proved by the incontrovertible authority of the letters of St. Boniface and the life of the same by S. Willibald. The name of Glastonbury, however, is of comparatively modern origin, being a corruption of the Saxon *Glæstingaburh* or town of the Glæstings. By the Britons the spot seems to have been called Ynys yr Avallon (Latinized as Avallonia), the Island of Apples, or Ynyswitrin, the Glassy Island; and it became the local habitation of various fragments of Celtic romance.

According to the legends which grew up under the care of the monks, the first church of Glastonbury was a little wattled building erected by Joseph of Arimathea as the leader of the twelve apostles sent over to Britain from Gaul by St. Philip. About a hundred years later, according to the same authorities, the two missionaries Phaganus and Deruvianus who came to king Lucius from Pope Eleutherius established a fraternity of anchorites on the spot, and after three hundred years more St. Patrick introduced amongst them a regular monastic life. About 546 David of Menevia is said to have built a new church near the old one, and in the 7th century the old one was encased with boards and covered with lead by the care of Paulinus of York. In the early part of the 8th century the great West Saxon king Ine (*cf.* charter in Kemble, *Codex diplomaticus ævi Saxonici*, vol. i. No. lxxi.) built and endowed a monastery at Glastonbury, which, in spite of the preceding establishments, may almost be considered as a new foundation. From the decadent state into which, like other monasteries, Glastonbury was brought by the Danish invasions, it was brilliantly recovered by the powerful hand of Dunstan, who had been educated within its walls and was appointed its abbot about 946. The church and other buildings of his erection remained till the installation, in 1082, of the first Norman abbot, who inaugurated the new epoch by commencing a new church. His successor Herlewin (1101–1120), however, dissatisfied with the meanness of the edifice, pulled it down to make way for a finer structure. Henry of Blois (1126–1172) added greatly to the extent of the monastery, building a bell tower, a chapter-house, a cloister, a dormitory, a refectory, a palace, a brew-house, etc. In 1184 (on 25th May) the whole of the buildings were laid in ruins by fire; but Henry II. of England, in whose hands the monastery then was, entrusted his chamberlain Rudolphus with the work of restoration, and caused it to be carried out with much magnificence. The great church of which the ruins still remain was then erected. In the end of the 12th century, and on into the following, Glastonbury was distracted by a strange dispute, caused by the attempt of Savaric the ambitious bishop of Bath to make himself master of the abbey. The conflict, carried on alternately by blows and bribes, was brought to a close by the decision of Innocent III., that the abbacy should be merged in the new see of Bath and Glastonbury, and that Savaric should have a fourth of the property. On Savaric's death his successor gave up the joint bishopric and allowed the monks to elect their own abbot. From this date to the Reformation the monastery continued to flourish, the chief events in its history being connected with the maintenance of its claims to the possession of the bodies or tombs of King Arthur and St. Dunstan. As early at least as the beginning of the 11th century the tradition that Arthur was buried at Glastonbury appears to have taken shape; and in the reign of Henry II., according to Giraldus Cambrensis and others, the abbot Henry de Blois, causing search to be made, discovered at the depth of 16 feet a massive oak trunk with an inscription "Hic jacet sepultus inclitus rex Arthurus in insula Avalonia." After the fire of 1184 the monks asserted that they were in possession of the remains of St. Dunstan, which had been abstracted from Canterbury after the Danish sack of 1011 and kept in concealment ever since. The Canterbury monks naturally denied the assertion, and the contest continued for centuries. In 1508 Warham and Goldston having examined the Canterbury shrine reported that it contained all the principal bones of the saint, but the abbot of Glastonbury in reply as stoutly maintained that this was impossible. The day of such disputes was, however, drawing to a close. On 1539 the last and 60th abbot of Glastonbury, Robert Whyting, was, in the words of a contemporary letter (MS. Cotton, Cleop. E., iv. fol. 996), "arraigned, and next day put to execution for robbing of Glastonbury church." His body was quartered, and his head fixed on the abbey gate. A darker passage does not occur in the annals of our English Reformation than this murder of an able and high-spirited man, whose worst offence was that he defended as best he could from the hand of the spoiler the property of his charge.[1]

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[1] *Introduction to Memorials of St. Dunstan, Rolls Series*, 1874.

The ruins of the abbey are now comparatively few, and as the work of destruction has in many places descended to the very foundations it is impossible to make out the details of the plan. Of the vast range of buildings for the accommodation of the monks almost nothing remains except the abbot's kitchen, noteworthy for its octagonal interior, the porter's lodge, and the abbey barn. Considerable portions are still standing of the so-called chapel of St. Joseph at the west end, which Mr. Willis has identified with the lady chapel, occupying the site of the old wicker church. This chapel, which is the finest part of the ruins, is transition work of the 12th century. It measures about 66 feet from east to west and about 36 from north to south. Below the chapel is a crypt which Professor Willis shows to be a construction of the 15th century inserted in a building which had no previous crypt. Between the chapel and the great church is an Early English building which appears to have served as a Galilee porch. The great church itself was a cruciform structure with a choir, a nave, and transepts, and a tower surmounting the centre of intersection. From east to west the length was 410 feet, and the breadth of the nave was about 80 feet. The nave had ten severies, and the choir six. Of the nave three bays of the south side are still standing, and the windows have pointed arches externally and semi-circular arches internally. Two of the tower piers and a part of one arch give some indication of the grandeur of the building. The old clock, presented to the abbey by Adam de Godbury (1322–1335), and noteworthy as the first recorded example of a clock striking the hours automatically with a count-wheel, is still preserved, although not in its entirety, in the cathedral at Wells.

The Glastonbury thorn, planted, according to the legend, by Joseph of Arimathea, has been the object of considerable comment. According to Loudon (*Arboretum et Fruticetum*) it was probably *Cratægus præcox*, and he reports that he received from Glastonbury, in December, 1833, a thorn branch in full blossom, having also on it ripe fruit. The actual thorn visited by the pilgrims was destroyed about the Reformation time, but specimens of the same variety are still extant in various parts of the country.

See William of Malmesbury, "De Antiq. Glastoniensis Ecclesiæ," in *Rerum Anglicarum Script. Vet.*, tom. i., 1684 (also printed by Hearne and Migne); John of Glastonbury, *Chronica sive de Hist. de Rebus Glast.*, ed. by Hearne, Oxford, 1726, 2 vols.; Adam of Domerham, *De Rebus Gestis Glast.*, ed. by Hearne, Oxford, 1727, 2 vols.; *Hist. and Antiq. of Glast.*, London, 1807; *Avalonian Guide to the Town of Glastonbury*, 1839, 8th ed.; Warner, *Hist. of the Abbey and Town*, Bath, 1826; Rev. F. Warre, "Glastonbury Abbey," in *Proc. of Somersetshire Archæol. and Nat. Hist. Soc.*, 1849; Rev. F. Warre, "Notice of Ruins of Glastonbury Abbey," *ibid.*, 1859; Rev. W. A. Jones, "On the Reputed Discovery of King Arthur's Remains at Glastonbury," *ibid.*, 1859; Rev. J. R. Green, "Dunstan at Glastonbury," and "Giso and Savaric," *ibid.*, 1863; Rev. Canon Jackson, "Savaric, Bishop of Bath and Glastonbury," *ibid.*, 1862, 1863; E. A. Freeman, "King Ine," *ibid.*, 1872 and 1874; Dr. W. Beattie, in *Journ. of Brit. Archæol. Ass.*, vol. xii., 1856; Rev. R. Willis, *Architectural History of Glastonbury Abbey*, 1866. Views and plans of the abbey building will be found, says Mr. Willis, in Dugdale's *Monasticon*, 1655; Stevens's *Monasticon*, 1720; Stukeley, *Itinerarium Curiosum*, 1724; Grose, *Antiquities*, 1754; Carter, *Ancient Architecture*, 1800; Storer, *Antiq. and Topogr. Cabinet*, vols. ii., iv., v., 1807, etc.; Britton's *Architectural Antiquities*, vol. iv., 1813; *Vetusta Monumenta*, vol. iv., 1815; and *New Monasticon*, vol. i., 1817.

GLATZ (Slav. *Kladsko*), a fortified town of Prussian Silesia, chief town of a countship in the government district of Breslau, is situated 50 miles S. S. W. of the town of that name. It stands in a narrow valley on the left bank of the Neisse, not far from the Austrian frontier. It is strongly walled, and is further defended by an old castle built on a high hill on one side of the town, and by a regular modern fortress erected on a hill on the opposite side. Before the town on both banks of the river there is also a strongly fortified camp, by which its bombardment from the neighboring heights may be hindered, and which affords accommodation for as many as 10,000 men. The town is the seat of a circle court and of an agricultural union, and possesses one Lutheran and three Catholic churches, one of which is very old and contains several monuments of Silesian dukes. Among the other buildings the principal are the nunnery, the royal Catholic gymnasium, the asylum for destitute children, and the military hospital. The industries include the manufacture of spirits, linen, damask, broadcloth, hosiery, beads, and leather. Glatz existed as early as the 11th century. In the Thirty Years' War it was several times besieged and taken. It surrendered to Frederick the Great in 1742, was retaken by the Austrians in 1760, and was restored to Prussia at the peace of 1763. The population in 1875 was 12,553.

GLAUBER, JOHANN RUDOLPH (1603–1668), alchemist and medicinal chemist, was born at Carlstadt in 1603, and died at Amsterdam in 1668. There is no authentic record of details concerning his life; his name has been somewhat marred by tradition, but it is not unreasonable to suppose that this originated with persons who did not heed the warning given by the chemist himself, in one of his more important memoirs, "let no one rashly judge of this work, until he be thoroughly informed concerning the same." Commencing his career as a chemist at the time he did, it was not unnatural that he imbibed the notion, prevalent among his contemporaries, of the existence of "alkaheat," a liquid which was to be universal in its uses as a solvent and a medicine, and of the "philosopher's stone." But whatever the motive which induced him to toil in his laboratory, it is certain that he, by ascertaining the preparation of many valuable medicines, contributed largely to pharmacy. He undoubtedly was the first, in 1648, to procure hydrochloric acid by the action of oil of vitriol on common salt, and also in all probability to obtain nitric acid by means of oil of vitriol and nitre. Sodium sulphate, discovered by him, and commonly therefore termed Glauber's salt (see below), he obtained by the action of oil of vitriol on salt.

His treatises, about thirty in number, were published at Frankfort in 2 vols. 4to, in 1658–1659; at Amsterdam, in 1661, in 7 vols. 8vo; and at London, translated into English by Parke, in 1689, 1 vol. folio.

GLAUBER'S SALT, the popular term for neutral sulphate of sodium (Na_2SO_4), discovered by the chemist whose name it bears, and formerly known as "sal mirabile Glauberi." It occurs in nature in combination with calcium sulphate as the mineral glauberite, and uncombined in right rhombic prisms, as thenardite, being found in this form in Bolivia and Peru, and near Madrid; or in monoclinic prisms, with ten molecules of water as glauberite or ordinary Glauber's salt, in Austria, Hungary, Italy, and in great quantity as a deposit from the hot springs of Carlsbad. It is also a constituent of sea-water, and the chief active principle of medicinal waters, and occurs in minute traces in the blood. It has a bitter but not acrid taste. It is somewhat anomalous in its solubility, the maximum occurring at about 34° C. According to Löwel, it exists in aqueous solution at temperatures as high as 34° C. as a decahydrate, but above that temperature as an anhydride, the solubility of the former increasing, and of the latter decreasing, with a rise of temperature (see Chemistry, vol. v. p. 438). Under ordinary circumstances it crystallizes from solution in large colorless prisms; these, when exposed to the air or heated, effloresce, giving a white powder, which melts at a strong red heat, and on cooling forms a transparent mass. The salt has also been the subject of some interesting experiments made by Guthrie, who at −7° C. procured it in combination with 166 molecules of water. From his investigation of this and other substances, he concluded that the solution of a solid body consists in the formation of a liquid hydrate which ultimately diffuses into the rest of the solvent. In the manufacture of sodium carbonate from salt and sulphuric acid, this sulphate is prepared in large quantities. In medicine it is employed as a purgative.

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[1] A curious relic of Abbot Whyting, his watch, was purchased in 1837 at the sale of T. Bowen's effects, and presented by C. K. Tynte to the duke of Sussex.

GLAUCHAU, one of the most important manufacturing towns of Saxony, circle of Zwickau, is situated on the right bank of the Mulde, 7 miles north of Zwickau and 17 west of Chemnitz. It is the seat of a royal administrative commission, of a district court, and of the ecclesiastical and secular courts of the countship of Schönburg. Its principal manufactures are woollen and half-woollen goods, in regard to which it occupies the first position in Germany. Besides 3000 hand-looms and 1000 power-looms in the town, the trade gives employment to many others in the neighboring districts. There are also dyeworks, printworks, and manufactories of paper, linen, thread, and machinery. Glauchau possesses a real school, an elementary school, a weaving school of the higher grade, an orphanage, and an infirmary. Some portions of the extensive old castle date from the 12th century, and the Gottesacker church contains interesting antiquarian relics. Glauchau was founded by a colony of Sorbs and Wends, and belonged to the lords of Schönburg as early as the 12th century. The mineralogist Agricola was born at Glauchau in 1494. While the population in 1834 was only 6292, it was 14,357 in 1858, and 21,743 in 1875.

GLAUCUS (*Γλαῦκος, i. e. γλαυκός*, "silvery" or "sheeny"), in Greek mythology, the name of several figures, the most important of which are the four described below :—

(1.) Glaucus, surnamed Pontius (*ὁ πόντιος*, equivalent to *ὁ θαλάσσιος*), according to the common legend had originally been an expert fisherman and diver at Anthedon (Bœotia), but having eaten of the magical herb sown by Cronos, had leapt into the sea, where ultimately he was changed into a god, and endowed with the gift of unerring prophecy. A principal seat of his cultus was Anthedon, where the inhabitants claimed to be descended from him; but he was also worshipped extensively, not only on the coasts of Greece, but also on those of Sicily and Spain, it being customary for fishermen and sailors at certain seasons to watch during the night for the moment when he should come on his periodical rounds accompanied by his train, in order that they might consult him as an oracle. He is generally represented as endowed with most of the attributes of Nereus, but occasionally he is identified with Melicertes. He is sometimes said to have instructed Apollo in prophecy. In art he is depicted as a vigorous old man with long hair and beard, his body terminating in a scaly tail. The *Argonautica* represent Glaucus as having been builder and steersman of the "Argo," as having alone remained unhurt in the fight of Jason with the Tyrrhenians, and as having afterwards become a sea-god, in which capacity he was able in various ways to assist the expedition. A poetical account of his metamorphosis is given by Ovid (*Met.*, xiii. 906), and his story has been also treated by Pindar and by Æschylus, the latter of whom is known to have made Glaucus Pontius the subject of one of his satyr-dramas (see Pausanias, ix. 22, 6; and compare Hermann, *De Æschyli Glaucis*). Allusions to the loves of Glaucus with Ariadne, Scylla, the Nereids, and Melicertes are frequently to be met with in ancient literature; and a considerable quantity of folklore concerning him will be found in the scholiast on Plato's *Republic*, p. 536, and also in Athenæus, *Deipnosoph.* vii. 47, 48. See also Gädechen's monograph (*Glaukos der Meergott*, 1860).

(2.) Glaucus, usually surnamed Potnieus (*ὁ ποτνιεύς*), from Potniæ near Thebes, a deity worshipped chiefly in Corinth, is to be carefully distinguished from Glaucus Pontius. He was the son of Sisyphus by Merope, and the father of Bellerophon. According to the legend he was destroyed by his own mares,—the most common form of the story being that he was torn to pieces by them. Accounts differ as to the place of his violent death, and also as to the immediate occasion of it. Sometimes it is represented as having happened at Iolcus, at the funeral games of Pelias, but usually the scene is laid at Potniæ. He is most frequently represented as having offended Aphrodite by having kept his mares from breeding; but other versions of the myth are that he had fed them on human flesh to make them more spirited, or that they had been suffered to drink at a sacred well at Bœotia, or that they had eaten the herb hippomanes. On the isthmus of Corinth, and also at Olympia and Nemea, he was worshipped as *ταράξιππος*; and he was the subject of a lost tragedy of Æschylus. His affinities with Poseidon Hippius are obvious; and it may be taken for granted that the frantic horses of Glaucus Potnieus represent the stormy waves of the sea, just as Glaucus Pontius is himself a personification of the ocean in its friendlier and calmer moods.

(3.) Glaucus, the son of Minos by Pasiphae, when a child, playing at ball or pursuing a mouse, fell into a honey pot and was smothered. His father, after a vain search for him, consulted the oracle, and was referred for an answer to the person who should suggest the aptest comparison for one of the cows of Minos which had the power of assuming three different colors. Polyidus (Πολύϊδος) of Argos, who had likened it to a mulberry (or bramble), which changes from white to red and then to black, soon afterwards discovered the child. Minos then desired him to restore young Glaucus to life; and on his failure in this, he was sentenced to be entombed alive along with the corpse. Having in the sepulchre killed a serpent by which he had been attacked, he saw its companion revivify it by laying upon it a few leaves of a certain herb. The same herb he successfully applied to Glaucus. This curious myth is now very generally admitted to be of a solar character; but interpreters are far from unanimous as to the significance of the various details. The story, which is related by Apollodorus (iii. 3. 1), and also by Ælian, was a favorite subject with poets and artists. Æschylus, Sophocles, and Euripides are each of them said to have treated it dramatically; and, according to Lucian, it was often represented in mimic dances (Lucian, *De Saltatione*, 49; Welcker, *Die Griech. Tragoedie*). In some of its features at least the mythus is found to be very widely diffused See Cox, *Aryan Mythology*, i. 161; Baring-Gould, *Myths of the Middle Ages*, ii. 145.

(4.) Glaucus, son of Hippolochus, and grandson of Bellerophon, mythical progenitor of the kings of Ionia, was a Lycian prince who, along with his brother Sarpedon, assisted Priam in the Trojan war. The incident between Glacus and Diomede, as related in the *Iliad*, is well known. He was afterwards slain by Ajax; but his body was carried back to Lycia, as that of his brother had been. It seems probable that these two sons of the Lycian land—the land of light—who leave it in youth, but are carried thither again (by Hypnos and Thanatos) when their course is done, originally were meant to represent respectively the creeping light of the early dawn (Sarpedon) and the brightness of the open day (Glaukos).

GLEBE, in ecclesiastical law, is the land devoted to the maintenance of the incumbent of a church. Burn (*Ecclesiastical Law, s. v.* "Glebe Lands") says:—"Every church of common right is entitled to house and glebe, and the assigning of them at the first was of such absolute necessity that without them no church could be regularly consecrated. The house and glebe are both comprehended under the word *manse*, of which the rule of the canon law is, *sancitum est ut unicuique ecclesiæ unus mansus integer absque allo servitio tribuatur.*" In the technical language of English law the fee-simple of the glebe is said to be in *abeyance*, that is, it exists "only in the remembrance, expectation, and intendment of the law." But the freehold is in the parson, although at common law he could alienate the same only with proper consent,—that is, in his case, with the consent of the bishop. The disabling statutes of Elizabeth (1 Eliz. c. 19, and 13 Eliz. c. 10) made void all alienations by ecclesiastical persons, except leases for the term of twenty-one years or three lives. As to exchange of glebe lands see 5 and 6 Vict. c. 54, and 17 and 18 Vict. c. 84. In Scotch ecclesiastical law, the manse now signifies the minister's dwelling-house, the glebe being the land to which he is entitled in addition to his stipend. All parish ministers appear to be entitled to a glebe, except the ministers in royal burghs proper, who cannot claim a glebe unless there be a landowner's district annexed; and even in that case, when there are two ministers, it is only the first who has a claim. See Bell's *Dictionary and Digest.*

GLEE is a musical term for a part song of a particular kind. The word, as well as the thing, is essentially confined to England. The technical meaning has been explained in different ways; but there is little doubt of its derivation from the Anglo-Saxon "gleov, gleo," *gaudium delectamentum,* and hence *ludus musicus.* Glee-man, Anglo-Saxon, "gleoman," is translated simply as "musicus" or "cantor," to which the less distinguished titles of "mimus, jocista, scurra," are frequently added in old dictionaries. The accomplishments and social position of the gleeman seem to have been as varied as those of the Provençal "joglar." To return to the word "glee," there are early examples of its being used as synonymous with harmony or concerted music. The former explanation, for instance, is given in the *Promptorium Parvulorum,* a work of the 15th century. Glee in its present meaning signifies, broadly speaking, a piece of concerted vocal music, generally unaccompanied, and for male voices, though exceptions are found to the last two restrictions. The number of voices ought not to be less than three. As regards musical form, the glee is little distinguished from the catch,—the two terms being often used indiscriminately for the same song; but there is a distinct difference between it and the madrigal—one of the earliest forms of concerted music known in England. While the madrigal does not show a distinction of contrasted movements, this feature is absolutely necessary in the glee. In the madrigal the movement of the voices is strictly contrapuntal, while the more modern form allows of freer treatment and more compact harmonies. Differences of tonality are fully explained by the development of the art, for while the madrigal reached its acme in Queen Elizabeth's time, the glee proper was little known before the Commonwealth; and its most famous representatives belong to the last century and the first quarter of the present. Among the numerous collections of the innumerable pieces of this kind, only one of the earliest and most famous may be mentioned, *Catch that Catch can, a Choice Collection of Catches, Rounds, and Canons, for three and four voices,* published by John Hilton in 1652. The name "glee," however, appears for the first time in John Playford's *Musical Companion,* published twenty-one years afterwards, and reprinted again and again, with additions by later composers—Henry Purcell, William Croft, and John Blow among the number. The father of the glee in its modern form is Dr. Arne, born in 1710. Among more recent English musicians famous for their glees, catches, and part-songs, the following may be mentioned:—Attwood, Boyce, Bishop, Crotch, Callcott, Shield, Stevens, Horsley, Webb, and Knyvett. The convivial character of the glee led, in the last century, to the formation of various societies, which offered prizes and medals for the best compositions of the kind, and assembled for social and artistic purposes. The most famous amongst these—The Glee Club—was founded in 1783, and at first used to meet at the house of Mr. R. Smith, in St. Paul's Churchyard. This club was dissolved in 1857. A similar society—The Catch Club—was formed in 1761, and is still in existence. A short historic survey of the subject is contained in Mr. W. A. Barrett's *The English Glee and Madrigal Writers.*

GLEIG, George (1753–1839), bishop of Brechin, Scotland, was the son of a farmer, and was born at Boghall, Kincardineshire, May 12, 1753. He received his early education at the school of Arbuthnott, and at the age of thirteen entered King's College, Aberdeen, where he especially distinguished himself in mathematics and the moral and physical sciences. In his twenty-first year he took orders in the Scottish Episcopal Church, and was ordained to the pastoral charge of a congregation at Pittenweem, Fife, whence he removed in 1790 to Stirling. His pastoral duties allowing him considerable leisure for literary pursuits, he became a frequent contributor to the *Monthly Review,* the *Gentleman's Magazine,* the *Anti-Jacobin Review,* and the *British Critic.* He also wrote several articles for the third edition of the *Encyclopædia Britannica,* and on the death of the editor, Colin Macfarquhar, in 1793, was engaged to edit the remaining volumes. One of his principal contributions to this work was the article Metaphysics. He was twice chosen bishop of Dunkel, but the opposition of the primus rendered the election on both occasions ineffectual. In 1808 he was consecrated assistant and successor to the bishop of Brechin, in 1810 was preferred to the sole charge, and in 1816 was elected primus of the Episcopal Church of Scotland, in which capacity he greatly aided in the introduction of many useful reforms, in fostering a more catholic and tolerant spirit, and in cementing a firm alliance with the sister church of England. He died at Stirling in February, 1839.

Besides various sermons, Gleig was the author of *Directions for the Study of Theology,* 1827; an edition of *Stackhouse's History of the Bible,* 1817; and a life of Robertson the historian, prefixed to an edition of his works. See *Life of Bishop Gleig* by the Rev. W. Walker, 1879.

GLEIM, Johann Wilhelm Ludwig (1719–1803), a minor German poet, was born April 2, 1719, near Halberstadt, and died there February 18, 1803, after having occupied, during half a century, the situation of secretary to the chapter of Halberstadt. "Father Gleim" was the title accorded to him throughout all literary Germany on account of his kind-hearted though inconsiderate and undiscriminating patronage alike of the poets and poetasters of the period. He wrote a large number of feeble imitations of Anacreon, Horace, and the minnesingers, a dull didactic poem entitled *Halladat oder das rothe Buch* (Halberstadt, 1774, 4th ed. 1812), and collections of fables and romances (*Fabeln,* Berlin, 1756–57; *Romanzen,* Berlin and Leipsic, 1756; *Lieder, Fabeln, und Romanzen,* Berlin, 1758). Of higher merit are his *Preussische Kriegslieder eines Grenadiers* (Berlin, 1758). These, which were inspired by the campaigns of Frederick II., are often distinguished by genuine feeling and vigorous force of expression. They are also noteworthy as being the first of that long series of noble political songs in which later German literature is so rich. With this exception, Gleim's writings are for the most part tamely commonplace in thought and expression. His very best odes have only a certain feeble prettiness to recommend them. A few, as *Das Hüttchin* and *An Leukon,* have still some popularity, and appear in most collections of German poetry.

See Gleim's *Sämmtliche Werke* (7 vols., Halberstadt, 1811–1813), and Körte's *Gleim's Leben aus seinen Briefen und Schriften* (Halberstadt, 1811).

GLEIWITZ, a town in the Prussian province of Silesia, chief town of the circle of Tost-Gleiwitz, government district of Oppeln, is situated on the Klodnitz, and on the railway between Oppeln and Cracow, 40 miles S. E. of the former town. It is the seat of a royal mining board, a provincial court of justice, and a tax office. It possesses one Protestant and two Catholic churches, a synagogue, a gymnasium, a school of industry, two female schools of a higher grade, a convent, a hospital, an infirmary, two orphanages, and a barracks. Gleiwitz is the centre of the iron industry of Upper Silesia. Besides the royal foundry, with which are connected machine manufactories and boiler works, there are other two foundries, meal mills, and manufactories of wire, gas-pipes, cement, and paper. The population in 1875 was 14,156.

GLENDOWER, or Glyndwr, Owen, the last native who assumed the title of Prince of Wales, and the leader of the only formidable attempt made by the Welsh to regain their freedom, after they had been subjugated by Edward I., was born most probably at Glyndwrdy in Montgomeryshire, whence his name, about the year 1354. He was the son of Gruffydd Vychan, sprung from the lords of Bromfield, and through his mother he claimed descent from a daughter of Llywelyn, the last crowned prince of Wales. He was entered a member of one of the inns of court, and brought up to the profession of the law, but he does not seem to have practised. In 1385, in the great dispute between the Grosvenors and the Scropes as to their right to bear a certain coat of arms, he was a witness for Grosvenor —one of the witnesses for Scrope being the poet Chaucer. He found his way to court, where he became a favorite with King Richard, and was made an esquire of his body. When Richard went to Ireland Owen accompanied him, as he did also on his return to Wales. He was present when Richard placed himself in the hands of the treacherous Northumberland, and at Flint, where his deposition was decided upon. Owen thereupon retired into private life. He had the misfortune to have for a neighbor Reginald de Grey, earl of Ruthin; and between him and De Grey a feud existed, occasioned by a dispute about a piece of waste land. In the time of Richard, Owen was successful in a lawsuit; but no sooner was the king deposed than De Grey took forcible possession of the land. Owen in vain appealed to parliament, although the bishop of St. Asaph entreated them to grant his request, and warned them that if they did not, Wales would rise in rebellion; and a little later Henry IV., on the ground that Owen, as a crown tenant, had neglected to join an expedition to Scotland (while the fact was that the summons, which had been entrusted to De Grey to give to Owen, was not delivered until it was too late), declared a forfeiture of his land held of the crown, and granted some of it to De Grey. With armed retainers De Grey took possession; but Owen mustered his followers, and after regaining his own, devastated the lands of De Grey. Henry took De Grey's part, and Owen set both at defiance. On the 20th September, 1400, Owen struck the first blow for the freedom of his country at Ruthin, where a fair was being held. The town was burnt down. During that and the following year Owen steadily added to his strength, and the king, although he thrice invaded Wales at the head of a large army, failed to get at the enemy, who retired to the mountain fastnesses. This, and the stormy weather which the English seem to have invariably experienced, so awed them that they thought the Welsh chieftain was allied with the powers of darkness. Harsh laws were enacted against the Welsh, who thereby were only the more goaded to rebellion. The lord-marchers sided with the king, and Sir Edward Mortimer, uncle of the earl of March, gave Owen battle at Brynglas in Radnorshire, on June 22, 1402. 1100 Herefordshire men were left dead on the field, and Mortimer himself was made prisoner. It was at this battle that the Welsh women were guilty, as Shakespeare says, of inhuman conduct to the dead. This so alarmed the king that he invaded Wales in the autumn with three armies, but nothing came of it. At a parliament held at Machynlleth, at the close of this year (1402), Owen was formally proclaimed Prince of Wales. About this time it was that the first steps were taken which secured the league between Owen, Mortimer, and Percy. Early in 1403 Prince Henry —Falstaff's Hal—was appointed lieutenant of the king in Wales. He led an army into North Wales and destroyed Owen's residences, "and laid waste a fine and populous country." The next great event was the battle of Shrewsbury, at which Percy was defeated. Glendower has been accused of having neglected aid to his ally at this battle, but letters recently discovered exonerate him from blame in this respect, as he was elsewhere at the time. Meanwhile Owen was committing terrible ravages in the districts under the sway of the marchers, or where Norman castles overawed the natives; and in 1404 he sent ambassadors—his chancellor Griffith Young, and his brother-in-law John Hanmer—to Charles of France, who entered into treaty to aid Owen. In pursuance of this treaty, a large force, under the command of Hugueville, landed at Milford Haven at the end of July, 1405. But meanwhile Owen had sustained two crushing defeats from the army under Prince Henry, the first at Grosmont in Monmouthshire on the 11th March, and the second at Mynyddpwllmelin in Brecknockshire four days later. Still he was able to muster a force to join the French contingent, and with them he pushed on to the neighborhood of Worcester, where the king met them but did not fight, and the French returned home. Owen's power appears to have suffered irrevocably at the defeats of the spring. For years afterwards he carried on a desultory warfare, but defections from his ranks so weakened his power that he was no longer the dangerous enemy he had been. But he never submitted. In July, 1415—fifteen years after the first outbreak—the king, now Henry V., authorizes Sir Gilbert Talbot to treat with Owen, and to offer him and his followers free pardon, "in case they should desire it." A similar offer was made in February, 1416. His death is believed to have taken place at the house of one of his daughters in Monmouthshire, but there is no certainty as to either the date or the place of his death.

GLEYRE, Marc Charles Gabriel (1806–1874), a celebrated French painter, was of Swiss origin, having been born at Chevilly, in the canton of Vaud, May 2, 1806. His father died, and then his mother, while he was yet a boy of some eight or nine years of age; and he was brought up by an uncle at Lyons, who sent him to the industrial school of that city. Going up to Paris a lad of seventeen or nineteen, he spent four years in close artistic study—in Hersent's studio, in Suisse's academy, in the galleries of the Louvre. To this period of laborious application succeeded four years of meditative inactivity in Italy, where he became acquainted with Horace Vernet and Léopold Robert; and six years more were consumed in adventurous wanderings in Greece, Egypt, Nubia, and Syria. At Cairo he was attacked with ophthalmia, and in the Lebanon he was struck down by fever; and he returned to Lyons in shattered health. On his recovery he proceeded to Paris, and, fixing his modest studio in the Rue de Université, began carefully to work out the conceptions which had been slowly shaping themselves in his mind. Mention is made of two decorative panels—Diana leaving the Bath, and a Young Nubian—as almost the first fruits of his genius; but these did not attract public attention till long after, and the painting by which he practically opened his artistic career was the Apocalyptic Vision of St. John, sent to the Salon of 1840. This was followed in 1843 by Evening, which at the time received a medal of the second class, and afterwards became widely popular under the title of the Lost Illusions. It represents a poet seated on the bank of a river, with drooping head and wearied frame, letting his lyre slip from a careless hand, and gazing sadly at a bright company of maidens whose song is slowing dying from his ear as their boat is borne slowly from his sight. In spite of the success which attended these first ventures, Gleyre retired from public competition, and spent the rest of his life in quiet devotion to his own artistic ideals, neither seeking the easy applause of the crowd, nor turning his art into a means of aggrandizement and wealth. After 1845, when he exhibited the Separation of the Apostles, he contributed nothing to the Salon except the Dance of the Bacchantes in 1849. And yet he labored steadily and was abundantly productive. He had an "infinite capacity of taking pains," and when asked by what method he attained to such marvellous perfection of workmanship, he would reply, "En y pensant toujours." A long series of years often intervened between the first conception of a piece and its embodiment, and years not unfrequently between the first and the final stage of the embodiment itself. A landscape was apparently finished; even his fellow artists would consider it done; Gleyre alone was conscious that he had not "found his sky." Happily for French art this high-toned laboriousness became influential on a large number of Gleyre's younger contemporaries; for when Delaroche gave up his studio of instruction he recommended his pupils to apply to Gleyre, who at once agreed to give them lessons twice a week, and characteristically refused to take any fee or reward. By instinct and principle he was a confirmed celibate: "Fortune, talent, health—he had everything; but he was married," was his lamentation over a friend. Though he lived in almost complete retirement from public life, he took a keen interest in politics, and was a voracious reader of political journals. For a time, indeed, under Louis Philippe, his studio had been the rendezvous of a sort of liberal club. To the last—amid all the disasters that befell his country—he was hopeful of the future, "la raison finira bien par avoir raison." It was while on a visit to the Retrospective Exhibition, opened on behalf of the exiles from Alsace and Lorraine, that he suddenly dropped down and expired May 5, 1874. He left unfinished the Earthly Paradise, a noble picture, which Taine has described as "a dream of innocence, of happiness, and of beauty—Adam and Eve standing in the sublime and joyous landscape of a paradise enclosed in mountains"—a worthy counterpart to the Evening. Among the other productions of his genius are the Deluge, which represents two angels speeding above the desolate earth, from which the destroying waters have just begun to retire, leaving visible behind them the ruin they have wrought; the Battle of the Lemanus, a piece of elaborate design, crowded but not cumbered with figures, and giving fine expression to the movements of the various bands of combatants and fugitives; the Prodigal Son, in which the artist has ventured to add to the parable the new element of mother's love, greeting the repentant youth with a welcome that shows that the mother's heart thinks less of the repentance than of the return; Ruth and Boaz; Ulysses and Nausicaa; Hercules at the feet of Omphale; the Young Athenian, or, as it is popularly called, Sappho;

Minerva and the Nymphs; Venus *πάνδημος*; Daphnis and Chloe; and Love and the Parcæ. Nor must it be omitted that he left a considerable number of drawings and watercolors, and that we are indebted to him for a number of portraits, among which is the sad face of Heine, engraved in the *Revue des Deux Mondes* for April, 1852. In Clément's catalogue of his works there are 683 entries, including sketches and studies. Gleyre is in great favor in Switzerland; and a special exhibition of his works was held at Lausanne in the Arland Museum, August and September, 1874.

See Fritz Berthoud in *Bibliothèque Universelle de Genève*, 1874; Albert de Montet, *Dict. Biographique des Genevois et des Vaudois*, 1877; and *Vie de Charles Gleyre*, 1877, written by his friend Charles Clément, and illustrated by 30 plates from his works.

GLINKA, FEDOR NIKOLAEVICH, (1788–1849), a Russian poet and author, was born at Smolensk in 1788, and was specially educated for the army. In 1803 he obtained a commission as an officer, and two years later took part in the Austrian campaign. His tastes for literary pursuits, however, soon induced him to leave the service, whereupon he withdrew to his estates in the government of Smolensk, and subsequently devoted most of his time to study or travelling about Russia. Upon the invasion of the French in 1812, he re-entered the Russian army, and remained in active service until the end of the campaign in 1814. Upon the elevation of Count Milarodovich to the military governorship of St. Petersburg, Glinka was appointed colonel under his command. On account of his suspected revolutionary tendencies he was, in 1826, banished to Petrozavodsk, but he nevertheless retained his honorary post of president of the Society of the Friends of Russian Literature, and was after a time allowed to return to St. Petersburg. Soon afterwards he retired completely from public life, and died on his estates in 1849.

Glinka's martial songs have special reference to the Russian military campaigns of his time. He is known also as the author of the descriptive poem *Kareliya*, etc. (*Carelia, or the Captivity of Martha Joanovna*), 1830, and of a metrical paraphrase of the book of Job. His fame as a military author is chiefly due to his *Pisma Russkago Ofitsera* (*Letters of a Russian Officer*), 8 vols., 1815–16.

GLINKA, MICHAEL IVANOVICH (1804–1857), a celebrated Russian composer, was born at Novospassky, a village in the Smolensk government, in 1804, and not, as stated generally in the dictionaries, in 1803. His early life he spent at home, but at the age of thirteen we find him at the Blagorodrey Pension, St. Petersburg, where he studied music under Carl Maier and John Field, the celebrated Irish composer and pianist, settled in Russia. We are told that in his seventeenth year he had already begun to compose romances and other minor vocal pieces; but of these nothing now is known. His thorough musical training did not begin till the year 1830, when he went abroad and stayed for three years in Italy, to study the works of old and modern Italian masters. His thorough knowledge of the requirements of the voice may be connected with this course of study. His training as a composer was finished under Dehn, the celebrated contrapuntist, with whom Glinka stayed for several months at Berlin. In 1833 he returned to Russia, and devoted himself to operatic composition. On November 27, 1836, took place the first representation of his *Life for the Czar*. This was the turning point in Glinka's life—for the work was not only a great success, but in a manner became the origin and basis of a Russian school of national music. Subject and music combined to bring about this issue. The story is taken from the invasion of Russia by the Poles early in the 17th century, and the hero is a peasant who sacrifices his life for the czar. Glinka has wedded this patriotic theme to inspiring and in some places admirable music. His melodies, moreover, show distinct affinity to the popular songs of the Russians, and for that reason the term "national" may be justly applied to them. His appointment as imperial chapel-master and conductor of the opera of St. Petersburg was the just reward of his dramatic successes. His second opera, *Russlan and Lyudmila*, founded on Poushkin's poem, did not appear till 1842; but in the meantime he wrote an overture and four entreactes to Kukolnik's drama *Prince Kholmsky*. In 1844 he went abroad for a second time, and lived chiefly in Paris and Spain. On his return to St. Petersburg he wrote and arranged several pieces for the orchestra, amongst which the so-called *Kamarinskaya* has achieved popularity beyond the limits of Russia. He also composed numerous songs and romances. In 1857 he went abroad for the third time, and died suddenly at Berlin, on February 14th of that year.

GLINKA, SERGY NIKOLAEVICH (1774–1847), Russian author, the elder brother of Fedor N. Glinka (noticed above), was born at Smolensk in 1774. In 1796 he entered the Russian army, but after three years' service retired with the rank of major. He afterwards employed himself in the education of youth and in literary pursuits, first in the Ukraine, and subsequently at Moscow, where he died in 1847. His poems are spirited and patriotic; he wrote also several dramatic pieces, and translated Young's *Night Thoughts*.

Among his numerous prose works the most important from an historical point of view are—*Russkoe Chtenie* (*Russian Reading: Historical Memorials of Russia in the 18th and 19th Centuries*), 2 vols., 1845; *Istoriya Rossii*, etc. (*History of Russia for the use of Youth*), 10 vols., 1817–19 (2d ed. 1822; 3d ed. 1824): *Istoriya Armyan*, etc. (*History of the Migration of the Armenians of Azerbijan from Turkey to Russia*), 1831; and his contributions to the *Russky Vyestnik* (*Russian Messenger*), a monthly periodical, edited by him from 1808 to 1820.

GLOBE. With the exception of illuminated portolani, the most interesting monuments of geography are globes. Celestial globes are much more ancient than terrestrial ones. The earliest of these with which we are acquainted is one made of copper engraved in the Arab-Cufic character of the 11th century. It is preserved in the Bibliothèque Nationale de Paris, Sect. Géog., No. 396 (see fig 1). In Italy the emperor Frederick II. (1197–1250) possessed a celestial globe of gold, probably also of Arab manufacture, on which the stars were indicated by pearls; from the scanty information that has come down to us respecting it we should imagine that it partook somewhat of the nature of an armillary sphere, as representations of the planets were to be seen in the interior of it. To these succeed a series of globes ranging from the 15th to the 17th century.

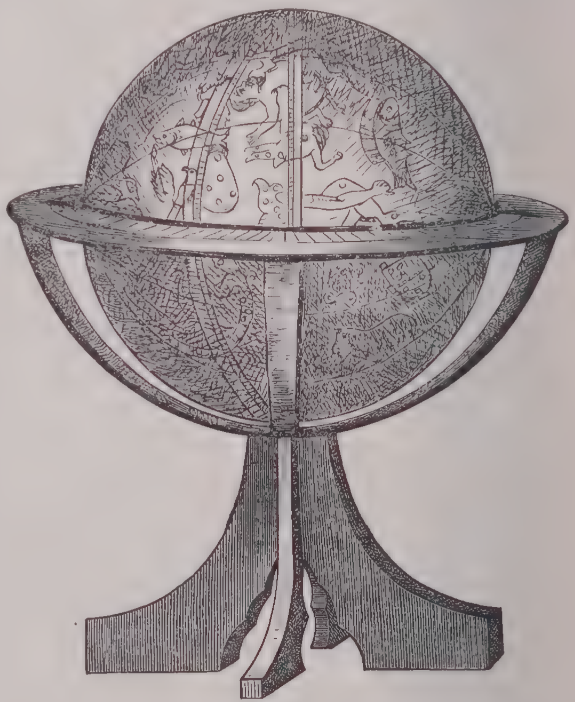

FIG. 1.—Globe in Bibliothèque Nationale, Paris.

One might suppose that many specimens of these globes would exist in public libraries, but diligent research has shown that the majority of those not made of metal are more perishable than maps, and much more so than books. The earliest terrestrial globe of any importance known to geographers is the well-known one of Martin Behaim, of Nuremberg, bearing the date of 1492. It is about 21 inches in diameter, and is made of pasteboard covered with parchment, on which are designed historical pictures with their legends written in Old German in various colors. The first meridian passes through Madeira, and the only other lines on it are those of the equator, the two tropics, and the polar circles. It has also a meridian of iron and an horizon of brass, but these were not added until 1500, which date they bear. As a monument of geography it is of the highest importance, being the only original document that has come down to us in this form embodying the geographical views of its author with those of his gifted contemporaries, Toscanelli, Columbus, etc. This globe represents with some slight modifications most of the disproportions of the Ptolemaic geography, into which is incorporated information evidently derived from the travels of Marco Polo and Sir J. Maundeville. It was executed by Behaim, assisted by Holtzchuer, while on a visit to his native city (1491–3), after a sojourn of five years at the Azores. It is still preserved in the house of his ancestors at Nuremberg. An exact and authenticated facsimile of it, mounted on a stand, is preserved in the Bib. Nat. de Paris, Section Géographique, No. 393.[1]

The Laon globe of 1493, in the possession of M. Leonce Leroux, of the Administration Centrale de la Marine à Paris, is made of red copper engraved, about the size of a 36-pounder cannon ball, and pierced by a socket which at a former period held an axis. It has all the appearance of having formed part of the apparatus of an astronomical clock. On the globe are engraved many circles. The first meridian, as in the globe of Behaim, passes through Madeira. In the northern hemisphere meridian lines are drawn at every 15th degree; these meridians are again crossed by certain parallels of latitude corresponding somewhat to the seven climates usually found on maps of the period. Neither meridians nor parallels are to be traced on the southern hemisphere. Although this globe bears a legend upon it dated 1493, it is evident that the general geographical information recorded upon it is earlier than that on Behaim's globe by five or six years. In all probability it was that current in Lisbon between the voyage of Diego Cam to the Zaire or Congo river, 1484–5, and that of Bartholomeu Diaz to the Cape of Good Hope in 1487. The author is unknown. A heart-shaped projection of this globe was published in the *Bulletin de la Soc. de Géog. de Paris*, 4me. série, tom. 20te, 1860.

In all probability the earliest post-Columbian globe extant is the one now preserved in the Lenox Library, New York. It was found in Paris some twenty-five years ago by Mr. Richard M. Hunt, who, upon learning its value, presented it to the Lenox Library, of which he is the architect. This globe is of copper, about 4½ inches in diameter, and engraved. It is pierced for an axis, and probably, like the Laon sphere, formed the principal feature of an astronomical clock or armillary sphere. The date assigned to the Lenox globe by Mr. Henry Stevens, who first recognized its importance, and had an accurately drawn projection made of it in the Coast Survey Bureau at Washington in 1869, is about 1506–7. A comparison of that projection, now published in reduced facsimile for the first time (see fig. 2), with several contemporary maps and globes, serves to show the accuracy of the date assigned to it, as also to suggest its French origin. The author is unknown.

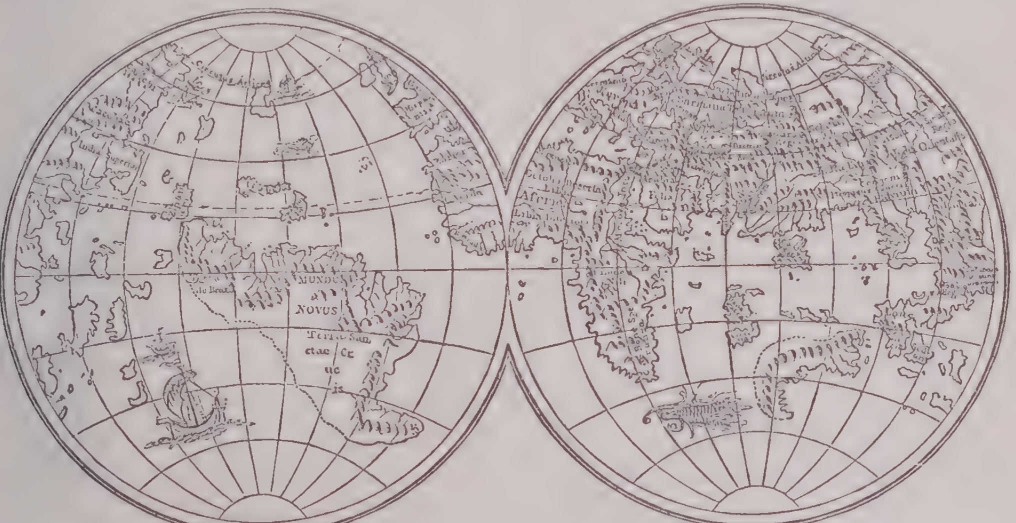

Fig. 2.—Lenox Globe.

The next globe that demands attention is the famous one made at Bamberg in 1520 by Johann Schöner, at the cost and charges of his friend Johann Sayler. It was afterwards taken to Nuremberg by Schöner, where it is still preserved in the town library. The importance attached to this globe is that hitherto it has always been regarded as the first of its kind to portray the discoveries in the New World, in combination with the notions that had previously prevailed of the space intervening between Europe and Africa on one side, and the eastern ends of Asia on the other. Schöner in this globe breaks up America into as many islands as possible. Thus North America is shown as one large island. He also represents South America as a large island, to which he applies several names, among which we observe, for the first time on a globe, the name "America." North America was not comprised under the name until a later date. Schöner's globe indicates two great series of North American discoveries, of which one, commencing with the Cabots in 1497, extended by degrees to Canada and Nova Scotia, while the other, commencing with Columbus in 1492, advanced from the Bahamas slowly northwards to Virginia and New England. Between these two points there remained a region more or less known which on this globe is indicated by open water. In depicting the east coast of Asia and the many islands there, including Japan and Java-major, the author follows the globe of Behaim. By some it has been regarded as a new edition of Behaim. There are in Germany several globes which depict the world nearly in the same manner as Schöner's. One, preserved in the city of Frankfort, bearing the same date (1520), is about 10½ inches in diameter, and has been reproduced by M. Jomard in his *Monuments de la Géographie*, pl. 15 and 16. There is also another in the library of the grand-duke of Weimar. As all these globes give to North and South America the configuration they have in Schöner, Humboldt was of opinion that they all are, with respect to America, copies of an older chart "hidden perhaps in the archives of Italy or Spain."

There is at Nancy a terrestrial globe which is also a geographical curiosity. It is of chased silver gilt, about 6 inches in diameter; the land portions are represented in fine gilding, the water by azure blue enamel. One of the hemispheres opens outwards horizontally, the interior being also gilt. It formerly served the purpose of a pyx on the altar of the church of Notre-Dame-de-Sion, to which church it was offered by Charles IV., duke of Lorraine, on his return in 1663. It is now preserved in the town library. It has all the appearance of having been made at a period immediately following the execution of the curious heart-shaped map by Oronce Finé of 1531, found in the Paris edition of Grynæus, 1532. In this map and the globe at Nancy we find the New World still regarded as an extension of eastern Asia or the Indies, the geography of Marco Polo being apparently mixed up with that of Cortez in Mexico. A stereographic projection of this globe was published in *Mem. de la Soc. Roy. de Nancy*, vol. viii., 1836.

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[1] For other reproductions of it see J. C. Doppelmayr, *Historische Nachricht von den Nürnbergischen Mathematicis und Künstlern*, Nuremberg, 1730; Dr. F. W. Ghillany, *Geschichte des Seefahrers Ritter Martin Behaim*, Nuremberg, 1853; and Jomard, *Monuments de la Géographie*, Paris, 1854.

There is another globe somewhat larger than the preceding, made of copper engraved, known as the De Bure globe. It has no date, but its geographical features in the main bear a close resemblance to the globe at Nancy. It is supposed to be of Spanish origin. It is preserved in the Bib. Nat. de Paris, Section Géographique, No. 427.

In the same section, No. 394, is preserved the Ecuy globe, made of brass. The word "Rhotomagi" (Rouen) is appended to the title, whence it seems to be of French origin. We have on this globe the first indications of a separation between East Asia and North America. The date appears to be about 1540.

In 1541 the illustrious Gerard Mercator constructed and published at Louvain a terrestrial globe, and in 1551 a companion celestial globe.[1] These are without doubt the most important monuments of the kind of the 16th century. They were to be found in nearly all the universities and libraries of Europe, in the private libraries of the rich, and the class-room of the teacher of navigation. We also know from Blundeville's *Exercises* that up to the date of 1592 they were in common use in England. Six pairs at least of these globes were sold for Mercator by Camerarius of Nuremberg; others we know were sold at the book-fairs of Frankfort-on-the-Main; and Mercator himself presented one pair to the university of Louvain, of which he was a student and a master of arts. Yet only two sets of the original globes are known now to exist in Europe—one in the royal library at Brussels, discovered in 1868, the other in the imperial court library at Vienna, discovered in 1875. These globes are about 2 feet high, and when first mounted on stands with all their accessories of meridians, horizons, etc., must have presented a noble appearance. They are only known to us by facsimiles of gores reproduced from the originals in their natural size, published at Brussels in 1875, with an introduction to their history by Dr. J. Van Raemdonck. A comparison of the terrestrial globe with all those that preceded it shows it to be a monument at once of learning and of science, worthy of the greatest scientific geographer of his age.[2] The authors used by Mercator in his configurations of the continents of the Old World were chiefly Ptolemy and Marco Polo. For representing the New World he evidently acquainted himself with the narratives of all the most recent voyages, maps, and charts that were to be had in his time. These were used with the greatest possible skill and discrimination; and in consequence we have the best delineation of the world on a globe that it was possible to produce at the period. In Mercator's time the imperfect knowledge of pilots in general, and the defects of their charts in plano, made terrestrial globes much more useful to navigators than we can well realize to-day. Convinced of their importance Mercator neglected nothing in order to adapt them to the use of seamen; he therefore added to his globes the rhumbs hitherto found only on plain charts. He added yet another improvement, delineating about thirty leading stars of the principal constellations according to their magnitudes and their positions in the heavens. These important improvements appear to be quite peculiar to the globes of Mercator.

An examination of the celestial globe of 1551 also reveals many improvements introduced by Mercator in his delineation of the heavens. Without counting a great number of stars as yet unresolved into symbolical groups, Mercator gives us 934 fixed stars, distributed in 51 constellations. Two of the latter are entirely new, and are not met with on later celestial globes. These are Antinous, formed of six stars on the equator below the Eagle, and Cincinnus, or the Lock of Hair, formed of one star and two nebulæ in the north hemisphere, under the tail of the Great Bear.[3]

The Globe of Euphrosynus Ulpius of 1542.—This globe, apparently made in Rome, is now preserved in the museum of the New York Hist. Soc. It is 15½ inches in diameter, made of copper, and is divided into two hemispheres on the line of the equator, and fastened together with iron pins. The normal position of the globe in its stand being vertical, the north pole with its hour-circle is surmounted by an iron cross. It is encompassed by a horizon, upon which are engraved the signs of the zodiac. The height of the whole apparatus, with its stand of oak, is 3 feet 8 inches. It was executed by Euphrosynus Ulpius, a name unknown to geographers, and is dedicated to Cardinal Marcellus Cervinus, D.D., who thirteen years later, was elevated to the Roman see, under the title of Marcellus II., and survived his election only twenty-two days. The first meridian line passes through the Canaries; the remaining ones are repeated at intervals of 30 degrees. Great prominence is given to the line of demarcation between Spain and Portugal in the New World, laid down by Pope Alexander VI. The geographical features peculiar to this globe are two, evidently copied from the Verrazano map of 1529,—the legend found upon it recording the voyage made by Verrazano on behalf of Francis I. in 1524, and the rude line drawn south-east from about 57° to 36° N. lat. The latter, common to both map and globe, gave rise to the curious conception of the "Mare Verrazano," the origin of which has exercised the minds of geographers from Hakluyt down to our day.[4]

In the South Kensington Museum is a celestial globe 7½ inches in diameter, made of gilt metal (it is supposed for Rudolph II.), by G. Roll and J. Reinhold at Augsburg, dated 1584.

Mollineux Globes of 1592.—The true successor of Mercator in the art of globe-making was neither J. F. Van Langren, Jodocus Hondius, nor W. J. Blaeu, as has been supposed, but an Englishman named Emerie Mollineux, the friend of Hakluyt, and of John Davis of Arctic fame. The earliest notice we have of the terrestrial globe made by him is the prospective one of its intended publication, to be found at the end of the preface to the 1st edition of Hakluyt's *Voyages* of 1589. The "comming out of the very large and most exact terrestriall globe" of Mollineux there referred to, with its companion celestial one, was accomplished in 1592. At the same time appeared a manual in English for their use, by Thomas Hood of Trinity College, Cambridge; and in 1594 appeared another manual, written expressly for them in Latin by Robert Hues, entitled *Tractatus de Globis et eorum usu*. Two years afterwards this latter was translated by J. Hondius, and published in Amsterdam, giving rise to the notion, apparently still prevalent in Holland, that Hues wrote this book expressly for Hondius,—a bibliographical blunder involving injustice to the memory of Mollineux. The only examples of these once famous globes known to exist are now preserved in the library of the Middle Temple, London. They are both 2 feet in diameter, mounted on stands, with the usual accessories of horizon, meridian, etc. The celestial globe still bears the date of 1592, but the terrestrial appears to have received additions, and the date has been altered by the pen to 1603. The best description of these two globes is a contemporary one to be found in Blundeville's *Exercises*, London, 1594, which enables us to realize the difference between these globes and Mercator's:—

> "The mappe which covereth Mr. Molineux his terrestriall globe differeth greatly from Mercator his terrestriall globe, by reason that there are found out divers new places, as well towards the North Pole as in the East and West Indies, which were unknowne to Mercator. They differ also greatly in names, longitudes, latitudes, and distances of such places set down not only in Mercator's globe but also in divers maps more lately made. As touching the map of the stars which covereth the celestiall globe of Mr. Molineux, I do not find it greatly to

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[1] At a later period Mercator also made for Charles V. a pair of globes, the terrestrial one of wood, the celestial one of glass; these were destroyed in the subsequent troubles in the Low Countries.

[2] According to Dr. F. Wieser, a third example of it is preserved at Weimar.

[3] A pair of Mercator's globes reproduced in facsimile, natural size, were conspicuous features in the Belgian section of the exhibition connected with the geographical congress held in Paris in 1875.

[4] The history of this curious geographical puzzle will shortly be dealt with by Mr. Henry Stevens, to whom we are indebted for much information respecting this globe. A projection of a portion of it is to be seen in the *Mag. of American History*, vol. iii. p. 17, Jan., 1879.

> differ from that of Mercator, saving that Mr. Molineux hath added to his celestiall globe certain southern images, as the Crosse, etc. In the great terrestriall globe the voyage, as well of Sir F. Drake as of Mr. Th. Candish, is set down and showed by help of two lines, the one red, and the other blew, whereof the red line doth show what course Sir Francis observed in all his voyage, as well outward as homeward; and the blew line showeth in like manner the voyage of Master Candish, and in that globe is also set down how farre Sir Martin Furbisher discovered towards the north parts. Nothing is set down in this globe but only the outermost end of his voyage, named Forbisher's Straights, having in N. lat. about 63 degrees." [1]

From a later inscription on the terrestrial globe we learn that it was still further repaired in 1818 by Messrs. J. & W. Newton, globe makers, of Chancery Lane. These globes are of special interest as the first of the kind made in England and by an Englishman.

In the same year J. Van Langren, and Jodocus Hondius five years later (1597), put upon record their intention of bringing out pairs of globes; but no globes of their manufacture are known to exist of a date anterior to the 17th century. To Mollineux succeeds William Jansson Blaeu (1571–1638), a celebrated mathematician, map-drawer, and publisher of Amsterdam, who secured a considerable reputation by publishing terrestrial and celestial globes, which excelled in beauty and accuracy everything that had preceded them. He was succeeded by his son John, editor of the well-known *Atlas Major* in 11 vols. folio. The elder Blaeu constructed globes in three sizes, the largest measuring 27 inches, the next about 14½ inches, the smallest about 7½ inches in diameter. The bodies of the globes were usually made of wood, covered with plastic composition upon which the maps were pasted in gores, thus admitting of corrections being made from time to time. In consequence of this no examples of his globes are known to exist without additions of the 17th century. Mr. P. J. K. Baudet, who wrote the *Life and Works of W. J. Blaeu*, Utrecht, 1871; notwithstanding his utmost exertions, could find in Holland only two pairs, one in the astronomical observatory at Leyden, the other in the physical museum at Amsterdam, the latter being of the smallest size. Another pair, however, of the smallest size, dated 1603, are in the possession of Mr. Henry Stevens; and a pair of the medium size, belonging to Mr. Fred. Müller of Amsterdam, were exhibited at the geographical congress held in Paris in 1875. Of the last pair, the celestial globe bears the date of 1603. The terrestrial globe, though still bearing the date of the first edition of 1599, has received corrections of a much later date, embodying the geographical results of the first Dutch expedition to the East Indies under Houtman in 1598, and those of Oliver Van Noort in the same year, and of Le Maire in 1616. From a report presented to the French minister of public instruction by M. E. Cortambert in 1855, we learn that a pair of fine globes by Blaeu is preserved in the Bibliothèque de Bourges. Two pairs of the 27-inch globes of Blaeu's heirs have recently been found, the first in the library of Trinity House, Tower Hill, the second in the British Museum, of date about 1645. In their main features the globes of Blaeu coincide more or less with several well-known maps published at this period, and with others to be found in the atlases of Mercator and Hondius.

The only remaining globes of the 16th century known to us are two pairs by A. F. Van Langren; the first, preserved in the Bib. Nat. de Paris, Sect. Géog., No. 405; the second in the Bibliothèque de Grenoble, found by M. E. Cortambert in 1855. In the latter library is also to be seen a curious terrestrial globe in MS., made by some monks of the Grande Chartreuse; it is undated, but is supposed to be of the 17th century.

It remains to notice briefly the few globes of a later period that are remarkable either for their historical interest, peculiar form, or great size. In the Academy of Sciences at St. Petersburg there are or were four that call for notice. The first is a terrestrial one, 3 feet in diameter, made at Pleskow by a deacon named Karpow Maximow. It is supposed to have been the first made in Russia. This is accompanied by a planetary 2½ feet in diameter, presented to Peter the Great by the company of English merchants established in Russia. Here is also preserved a large terrestrial globe of copper, made in 1664 by the heirs of W. J. Blaeu; it is 7 feet in diameter, and was brought from Moscow about 1747. In the same academy is preserved the famous Gottorp globe; it is a hollow sphere 11 feet in diameter, containing a table and seats for twelve persons. It was made by A. Bush in 1654, under the direction of Olearius, from designs found among the papers of Tycho Brahe, and was not finished until 1664. The outside represents the terrestrial globe, the interior showing the heavens; the stars are distinguished according to their respective magnitudes by gilt nails of various sizes. It was presented to Peter the Great by Frederick IV. of Denmark in 1713. The Czar was so pleased with his acquisition that he had it transported by water to Revel, and thence on rollers and sledges to his new capital. Being partly burnt in 1747, it was repaired again 1751, and adjusted to the horizon of St. Petersburg, the meridian and horizon being made by an English mechanic named Scott.

The two largest complete globes existing are those preserved in the "Salle des Globes" in the Bibliothèque Nationale of Paris. They are each 12 feet in diameter, and were made under the direction of the famous Italian geographer Coronelli in 1683, by order of Cardinal d'Estrées, the Spanish ambassador, and presented by him to Louis XIV. They are made of wood, very solid, and are covered with cloth or canvas on which the configurations have been drawn by an able artist, particularly those on the celestial globe. The meridians and horizons are of bronze, the latter are sustained by eight columns of the same material, and the former by two bronze feet highly ornamented. Between the brackets that form the feet of the meridians is placed, under each globe, a compass in marble and bronze; the ascent to these is by five steps which encircle each globe. On the celestial globe painted blue are marked all the fixed stars, and their constellations with the paths of the comets, also the places of all the planets at the moment of the birth of Louis XIV. This last event is alluded to also in a hyperbolical inscription to be seen on a copper plate to be found on it. The geography of the terrestrial globe is based upon that of Sanson; the sea being painted in deep blue, and the land portions being white, the inscriptions upon it are very legible. There is also to be seen on it a bust of the king placed above a dedication somewhat like that on the celestial globe. Although these globes are without any great scientific value, they serve to indicate the astronomical and geographical knowledge prevalent in France at the end of the 17th century. A good illustration of these globes, accompanied by a detailed account of their history, by M. C. Letort of the Bibliothèque Nationale, will be found in *La Nature*, No. 116, August 21, 1875. In the Bib. Mazarine is preserved a terrestrial globe 8 feet in diameter, known as the Louis XVI. globe. It is made of copper engraved, the names of places being inlaid with black, and is mounted on a temporary wooden structure, the beautiful accessories of bronze cast for it never having been finished or utilized; they are, however, to be seen in another part of the library. We learn from a MS. description of this globe, also preserved here, that it was made for Louis XVI., himself no mean geographer, by the direction of Vergennes in 1784. The geography of it is based upon that of D'Anville, corrected by Robert de Vaugondy and Le Clerc; it also indicates the net results of all the voyages round the world made up to this period.

About 1764 Dr. Roger Long of Cambridge, professor of astronomy and master of Pembroke, erected in an outbuilding of his hall a sphere 18 feet in diameter. The concave interior was lined with tin, upon which was depicted all the stars and constellations visible in England on the horizon of Cambridge. The lower part of the sphere was cut off at the diameter of 13 feet, and the truncated meridians were screwed down on to a circle which ran on rollers of lignum vitæ, the whole being movable by simple machinery provided for the purpose. It was capable of holding thirty persons, and had an entrance by six steps placed over the South Pole. In the centre was placed a planetarium. Although it is said funds were left for its preservation, it appears to have fallen into neglect and decay.

To these succeed in order of size the globes known as "Georamas." One exhibited in Paris in 1844 was 30 feet in diameter; another by Delanhard erected in 1823 was 40 feet in diameter; of the last the proprietor published a description. Then follows Wyld's well known "great globe," erected in Leicester Square, London, 60 feet in diameter. The largest appears to have been the one erected by Colonel Langlois, in Paris, in 1825, on the Champs Élysées. This was 120 feet in diameter. As has been truly said, these structures served more to satisfy curiosity than to impart scientific instruction. (C. H. C.)

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[1] This last remark does not appear to be quite accurate, as John Davis says:—"How far I proceeded doth appear upon the globe made by Master Emery Mullineux" (*Hydrographical Description*, London, 1595).

Manufacture.—The manufacture of artificial globes has changed but little in character during the last hundred years. Such improvements as have been introduced have reference either to the quality of the maps or to the mode of mounting the globes. The number of sizes manufactured has also been increased. The diameter has always been used to indicate the size of the globes, and those now produced by the various makers vary from 1 to 36 inches.

The process of manufacture differs little if at all in the sizes of globes ranging between 3 and 25 inches. Thus supposing, for example, a 12-inch globe (the ordinary school globe) is required to be made, a spherical mould measuring some quarter of an inch less in diameter is prepared on which to form hemispherical caps that are to constitute a hollow foundation for the globe. This mould, made preferably hollow for lightness, and having a central axle terminating in poles, is well greased on the surface to enable it to resist damp. To form the caps, strips of white paper, damped in water, are first applied to the mould to form a coating thereon. Upon this coating is applied brown paper saturated with paste, and alternate layers of white and brown paper are added, until the required thickness of paper, say $\frac{1}{16}$th of an inch, is obtained. The change of color is adopted simply as a guide to the workman, that he may know when he has completed a coating of paper. The mould thus covered is put aside to dry, and after two or three days the paper covering is severed into two hemispherical caps, which are then drawn off from the mould.

A wooden axle furnished with poles (which will eventually form the north and south poles of the globe) is provided, of such a length as will enable the caps, when fitted over the poles, to meet at their severed edges. By means of glue these edges are joined up, and the caps are firmly attached to the ends of the axle. Thus a hollow sphere of rude outline is formed, measuring somewhat less than 12 inches in diameter. The next operation is to bring this sphere to the required diameter for the globe, and to make it perfectly true. For this purpose the ball is coated with a plastic composition of whiting, boiled oil, and glue, and passed under the action of a steel semicircle fitted with bearings for receiving the poles of the ball, and retaining the same in place while the ball is being slowly rotated. By applying to the ball repeated coatings of this composition, and removing all superfluities by means of the gauging edge of this steel semicircle, a smooth spherical surface is eventually obtained. When the ball is finished and hard, it is tested in loose bearings to see whether it will remain quiescent in all positions. If it shows a tendency to run round, the ball is balanced by the introduction of a counterweight at the highest part of its periphery. When the ball is balanced, and the hole made good by which the counterweight was introduced, the surface is polished, after which it is ready to receive the map. For 12-inch globes the maps of the earth and of the heavens are engraved on steel or copper plates in 12 gores, measuring each 30 degrees in width, and extending from pole to pole, or more usually to the 70th degree of latitude, the remaining portion of the maps being made up by north and south pole plates. This arrangement is somewhat modified for larger globes. Thus, for globes above 15 inches in diameter, the gores are divided in the line of the equator, and they are also divided longitudinally for say one-fourth of their length at the 15th degree, in order to facilitate the laying down of the maps evenly upon the spherical surface. Preparatory to covering the sphere with the map, it is marked with lines corresponding to the equator, parallels of latitude, and lines of longitude on the map, such lines serving as a guide for the workman. The gores of the map having been carefully cut out, they are damped and laid down in proper order in a pile upon a pasting board. The workman then covers his polished ball, for the length and breadth of a gore, with paste, or, more properly, a preparation of starch, and having coated with starch the uppermost gore of the pile, he with an ivory knife lifts that gore, and lays it upon the pasted portion of the ball, fitting it to the lines marked thereon, and smoothing down creases, at the same time taking care that the latitude and longitude lines of the gore correspond exactly with the lines on the ball. Having laid down this gore in place, he next applies a second gore in like manner, taking care that the two gores shall join each other, and not expose any portion of the underlying surface. In this way the workman proceeds until all the gores are in place, and he finishes the pasting of the ball by applying the pole papers which fit respectively on to the opposite ends of the gores. The map has next to be sized, preparatory to its being colored, in order to form a resist to the varnish which is subsequently to be applied to the globe. The map is tinted and outlined with water colors, and a coat of varnish is then applied. When this is dry the globe is ready for mounting; after which the varnishing operation is completed by the application in a heated room of several coats of spirit varnish following quickly the one on the other. Some skill is requisite in laying on the varnish, so as to obtain a surface as clear and smooth as glass. This result is unfortunately evanescent, as the best varnish is liable to discolor and to crack, and thereby obscure to some extent the legibility of the underlying map. After varnishing the globe will be fit to handle in from four to six days. For the purpose of mounting the globe a flat ring, termed the brazen meridian, is provided, and bearings are formed thereon to receive the poles of the globe. This ring is divided on its face into 360 degrees, the numbering of these degrees being from 0 (which corresponds with the equator) to 90 at the poles on one half of the ring, and on the other half the numbering starts from the poles at 0, running up to 90, which corresponds with the equator. Fitted to the poles, and capable of turning thereon, are hour circles, which underlie the brazen meridian, and are divided and numbered to correspond with the 24 hours of the day and night. The frame for the reception of the globe and ring is formed with a wooden horizon, which constitutes an imaginary line dividing the globe into two equal parts, the portion above the horizon being the visible half, and that below the horizon the invisible half of the sphere. This horizon is covered, like the globe, with papers which are varnished to protect them from injury. The horizon papers near their inner edge are divided into 360 degrees, by which are reckoned the azimuth and the amplitude; they also indicate the points of the compass in the space called the circle of the winds. The horizon of the frame is notched to receive the brass meridian, which rests in a step-bearing fitted to the central pillar or block of the frame, and is held therein by a screw stop, which, entering an annular groove in the back of the meridian, leaves the ring free to turn round in the frame, for the purpose of rectifying the globe, or bringing its axis to any desired angle with the horizon. The fitting of the globe is completed by the quadrant of altitude, consisting of a thin flexible slip of brass, jointed to a clamping nut, which is intended to embrace the brass meridian, and may be adjusted thereon by a tightening screw. This flexible strip or blade is divided off into 90 degrees, corresponding to those on the equator, and is intended to measure distances between any two places upon the curved surface of the earth, or the altitude of the sun, a star, or any planetary body in the heavens, and for this purpose its graduations are numbered from 0 to 90. A useful appendage to the globe frame is a mariner's compass, which facilitates the adjustment of the globes to their true polar position.

The value of a globe, whether terrestrial or celestial, depends mainly on the quality of the map with which it is covered. Before the present century, English globes were not only poor specimens of the engraver's art, but they showed little attention to accuracy of detail. Now, however, they rank in quality with, if they do not surpass, the best foreign maps, notwithstanding that little encouragement is given to their manufacture. Specimens of globe plates published at the latter end of the 17th century in Italy are yet to be seen, which are a marvel of the cosmographer's art. Under the patronage of the Venetian republic, P. Coronelli, cosmographer to the republic, published a terrestrial and celestial globe of the unprecedented size of 4 feet in diameter, which embodied the utmost scientific knowledge of the time, and in the constellations of the celestial globe showed the finest quality of line engraving at its best period. The composition of these figures served as a basis for the remodelling of the constellations on English globes some 40 years since, at which time the drawing of the figures was not merely barbarous, but absurd. Whether these fine globes were ever manufactured it is now difficult to ascertain, but none are known to exist except a celestial globe produced by the late Mr. William Newton, to whom the globe manufacture is indebted for such improvements as have been introduced during the present century, and another which is preserved in the Bibliothèque Nationale of Paris, bearing the name of Deuvez as the maker.

An amusing illustration of the difficulties which attend the delineator of globe plates is to be found in the preface of a book published in 1686, for its author, Mr. J. Moxon, entitled *A Tutor to Astronomy and Geography*. Moxon appears to have been a globe-maker, and in expatiating on the improvements to be found in his new terrestrial globe, he says:—"California is found to be an island, though formerly supposed to be part of the main continent, whose north-west shore was imagined to thrust itself forth close to the coasts of Cathaio, and so make the supposed straits of Anian." On his globe, therefore, the peninsula was converted into an island. Precisely the same difficulties are now experienced by globe-makers; and those who have watched, for example, the varied forms which the lakes in Central Africa have taken during the last 25 years will understand at what risk the globe-maker corrects his costly plates, to bring them up to the current geographical knowledge.

The inconvenience attendant on the transport of large globes, manufactured as above explained, not to speak of their excessive cost, led to the introduction of flexible or compressible globes, both on the Continent and in the United States. It does not appear that they have been extensively manufactured, for at the best they were but toys, but they certainly displayed great ingenuity in their construction. A French manufacturer used a spherical bladder as a base for his globe, affixing to it rigid poles, and covering it with a map printed on soft white leather, which map was applied in the same way as the maps on the ordinary globe. By inflating the bladder through a mouth-piece which was fitted with a stop-cock and constituted also one of the poles, the spherical form of the globe was obtained; and by discharging the air, the globe could be compressed into a small space. A frame composed of detached pieces was also provided for this globe, to permit of its being used for working problems thereon. When not required for use, the globe and its fittings could be packed into a very small compass. The best globes of this class were to be seen in the American department of the 1851 Exhibition. These measured 24 inches in diameter, and were manufactured by the late Mr. Goodyear, of india-rubber fame; but they never obtained a market in England, and were evidently intended for reference globes only.

Some 50 years ago, the late Mr. William Newton designed a pocket globe of some merit. It was mounted in a spherical case, which, opening at a centre line, disclosed the globe mounted in a brass ring, and within a fixed horizon. Upon this globe, measuring 3 inches in diameter, numerous problems could be worked with tolerable accuracy. His last and best improvement was what he termed the "Newtonian Globe." It was designed chiefly for common schools, and was set upon an iron pillar, which avoided the cost of a wooden frame. The principal object, however, of the author was to convey to children, in the most simple manner, an elementary acquaintance with the construction and movements of the heavenly bodies. The author's design may be thus briefly explained. The Newtonian globes are hung in stationary rings or meridians, and are capable of turning upon their axes or poles for the purpose of showing the real diurnal motion of the earth and the apparent diurnal motion of the heavens, according to the Newtonian system or real structure of the universe. In place of a wooden horizon, a sliding annular plate is substituted. On the terrestrial globe this plate acts as a terminator to indicate the line of demarcation between day and night. The globe is so mounted upon its pedestal that the axis always lies in its true inclined position, and points to the north polar star in the heavens. A small brass ball representing the sun is made to slide upon the meridian, and it is carried by an arched arm, which connects it with the annular terminator. This ball is adjustable to correspond to the declination or perpendicular position of the sun north or south of the equator, according as the sun's declination varies from day to day throughout the year; and the terminator follows the motions of the sun. Upon the celestial globe a similar sliding annular plate marks the visible horizon of any place on the earth's surface, and shows what part of the heavens would be there seen at a given time; it also assists in illustrating the rising and setting of the sun and moon at different seasons and periods of the year, and the apparent diurnal rotation of the planets and fixed stars. These globes have been well appreciated in the north of Europe, but as they are not in conformity with English school books, they have had little success in the United Kingdom. (A. V. N.)

GLOBE-FISH or **Sea-Hedgehog.** By these names some sea-fishes are known, which have the remarkable faculty of inflating their stomachs with air. They belong to the genera *Diodon* and *Tetrodon.* Their jaws resemble the sharp beak of a parrot, the bones and teeth being coalesced into one mass with a sharp edge. In the Diodonts there is no mesial division of the jaws, whilst in the Tetrodonts such a division exists, so that they appear to have two teeth above and two below. By means of these jaws they are able to break off branches of corals, and to masticate other hard substances on which they feed. Usually they are of a short, thick, cylindrical shape, with powerful fins (fig. 1). Their body is covered with thick skin, without scales, but provided with variously formed spines, the size and extent of which vary in the different species. When they inflate their capacious stomachs with air, they assume a globular form, and the spines protrude, forming a more or less formidable defensive armor (fig. 2). A fish thus blown out turns over and floats belly upwards, driving before the wind and waves. Many of these fishes are highly poisonous when eaten, and fatal accidents have occurred from this cause. It appears that they acquire poisonous qualities from their food, which frequently consists of decomposing or poisonous animal matter, such as would impart, and often does impart, similar deleterious qualities to other fish. They are most numerous between the tropics and in the seas contiguous to them, but a few species live in large rivers, as, for instance, the *Tetrodon fahaka*, a fish well known to all travellers on the Nile. Nearly 100 different species are known.

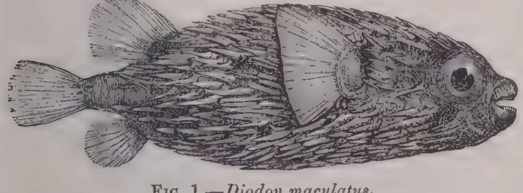
Fig. 1.—*Diodon maculatus.*

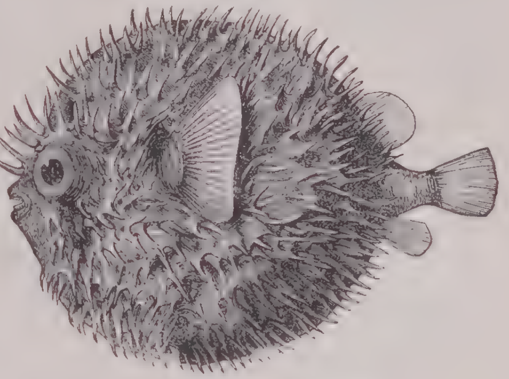
Fig. 2.—*Diodon maculatus* (inflated).

GLOBIGERINA. See Foraminifera.

GLOGAU (sometimes called Gross or Great Glogau, to distinguish it from Klein or Little Glogau, in the government of Oppeln) is a fortified town of Prussia at the head of a circle in the Lower Silesian government of Liegnitz, situated partly on an island and partly on the left bank of the Oder, about 80 miles S. E. of Frankfort. Among its more important buildings are the cathedral, in the Gothic style, and a castle in the Renaissance style, now used as a courthouse; and it also possesses a new town-house, a synagogue, a poorhouse, an orphanage, a military hospital, two gymnasia, and several libraries. Situated as it is on a navigable river and at a junction of two or three railway lines, Glogau carries on an extensive trade, which is fostered by a variety of local industries, dealing with tobacco, beer, oil, sugar, vinegar, bone-meal, earthenware, etc. One of its publishing firms—that of Flemming & Company—has attained a wide reputation for maps. In 1871 the population of Glogau, inclusive of the garrison, amounted to 18,266,—of whom 6039 were Roman Catholics, and 947 Jews; and in 1875 it was stated at 18,062.

In the beginning of the 11th century Glogau, even then a populous and fortified town, was able to withstand a regular siege by the emperor Henry V.; but in 1157 the duke of Silesia, finding he could not hold out against Frederick Barbarossa, set the place on fire. In 1252 the town, which had been raised from its ashes by Henry the Bearded, became the capital of a principality of Glogau, which continued till 1506, when town and district were united to the Bohemian crown. In the course of the Thirty Years' War Glogau suffered greatly. The inhabitants, who had become Protestants soon after the Reformation, were dragooned into conformity by Wallenstein's soldiery; and the Jesuits received permission to build themselves a church and a college. Captured by the Protestant allies in 1632, and recovered by the Imperialists in 1633, the town was again captured by the Swedish general Torstenson in 1642, and continued in Protestant hands till the peace of Westphalia in 1648. In 1741 the Prussians took the place by storm, and during the Seven Years' War it formed an important centre of operations for the Prussian forces. After the battle of Jena it fell into the hands of the French; and they have reason to be proud of the gallant defence made by Laplane, who held out against the Russian and Prussian besiegers, after the battle of Katzbach (August 26, 1813), till the 17th of the following April.

GLOSS, GLOSSOGRAPHER, GLOSSARY, GLOSSATOR. The Greek word γλῶσσα, meaning originally a tongue, hence a language or dialect, gradually came to denote especially any obsolete, foreign, provincial, technical, or otherwise peculiar word or use of a word (see Arist. *Rhet.* iii. 3, 2); and the making of collections and explanations of such *γλῶσσαι* was at a comparatively early date a well-recognized form of literary activity. Even in the 5th century, among the many writings of Democritus of Abdera was included a treatise entitled *Περὶ Ὁμήρου ἢ ὀρθοεπείης καὶ γλωσσέων.* It was not, however, until the Alexandrian period that the *γλωσσογράφοι* became very numerous. Of many of these it is probable that even the names have perished; but in the writings of Athenæus alone (*c.* 250 A. D.) allusions are to be found to no fewer than thirty-five. Among the earliest may be mentioned Philetas of Cos (d. *c.* 290 B. C.), the elegiac poet, to whom Aristarchus dedicated the treatise *πρὸς Φιλητᾶν*; he was the compiler of a lexicographical work, arranged probably according to subjects, and entitled *Ἄτακτα* or *Γλῶσσαι* (sometimes *ἄτακτοι γλῶσσαι*). Next came his disciple Zenodotus of Ephesus (*c.* 280 B. C.), one of the earliest of the Homeric critics and the compiler of *Γλῶσσαι Ὁμηρικαί*; Zenodotus in turn was succeeded by his greater pupil Aristophanes of Byzantium (*c.* 200 B. C.), whose great compilation *περὶ λέξεων* (still partially preserved in that of Pollux), is known to have included *Ἀττικαὶ λέξεις Λακωνικαὶ γλῶσσαι*, and the like. From the school of Aristophanes issued more than one glossographer of name—Diodorus, Artemidorus (*γλῶσσαι*, and a collection of *λέξεις ὀψαρτυτικαί*), Nicander of Colophon (*γλῶσσαι*, of which some twenty-six fragments still survive), and Aristarchus, the famous critic, whose numerous labors included an arrangement of the Homeric vocabulary (*λέξεις*) in the order of the books. Contemporary with the last named was Crates of Mallos, who, besides making some new contributions to Greek lexicography and dialectology, was the first to create at Rome a taste for similar investigations in connection with the Latin idioms. From his school proceeded Zenodotus of Mallos, the compiler of *Ἐθνικαὶ λέξεις* or *γλῶσσαι*, a work said to have been designed chiefly to support the views of the school of Pergamus as to the allegorical interpretation of Homer.[1] Of later date were Didymus (Chalkenteros, *c.* 50 B. C.), who made collections of *λέξεις τραγωδουμέναι κωμικαί*, etc.; Apollonius Sophista (*c.* 20 B. C.), whose Homeric *Lexicon* has come down to modern times; and Neoptolemus, known distinctively as *ὁ γλωσσογράφος*. Coming down to the beginning of the first century of the Christian era we find Apion, a grammarian and rhetorician at Rome during the reigns of Tiberius and Claudius, following up the labors of Aristarchus and other predecessors with *γλῶσσαι Ὁμηρικαί*, and a treatise *περὶ τῆς Ῥωμαϊκῆς διαλέκτου*; Heliodorus or Herodorus was another almost contemporary glossographer; Erotian also, during the reign of Nero, prepared a special glossary for the writings of Hippocrates, still preserved. To this period also Pamphilus, the author of the *λειμών* from which Diogenian and Julius Vestinus afterwards drew so largely, most probably belonged. In the following century one of the most prominent workers in this department of literature was Ælius Herodianus, whose treatise *περὶ μονήρους λέξεως* has been edited in modern times, and whose *ἐπιμερισμοί* we still possess in an abridgment; other names are those of Pollux, of Diogenian (*λέξις παντοδαπή*), of Julius Vestinus (*ἐπιτομὴ τῶν Παμφίλου γλωσσῶν*), and especially that of Phrynichus, who flourished towards the close of the 2d century. His *Eclogæ nominum et verborum Atticorum* has frequently been edited. To the 4th century belongs Ammonius of Alexandria (*c.* 389), who wrote *περὶ ὁμοίων καὶ διαφόρων λέξεων*, a dictionary of words used in senses different from those in which they had been employed by older and approved writers. Of somewhat later date is the well-known Hesychius, whose often-edited *Λεξικόν* rightly superseded all previous works of the kind; Cyril, the celebrated patriarch of Alexandria, also contributed somewhat to the advancement of glossography by his *συναγωγὴ τῶν πρὸς διάφορον σημασίαν διαφόρως τονουμένων λέξεων*; the names of Orus and Orion, of Philoxenus, and of the two Philemons also belong to this period. The works of Photius, Suidas, and Zonaras, as also the *Etymologicum Magnum*, to which might be added the *Lexica Sangermansia* and the *Lexica Segueriana*, have already been referred to (DICTIONARY, vol. vii. p. 158). In Latin lexicology the most prominent name is that of Festus, whose only extant work, however, is but an epitome of the treatise of Verrius Flaccus *De Verborum Significatu.* This last-named author had himself been preceded by Varro (*De Lingua Latina*) who in turn makes allusion to several before him, "qui glossas scripserunt." The introduction of grammatical and linguistic studies into Rome is usually attributed to Crates of Mallos (*c.* 267 B. C.) mentioned above.

To a special category of technical glossaries belongs a large and important class of works relating to the law-compilations of Justinian. Although the emperor forbade, under severe penalties, all commentaries (*ὑπομνήματα*) on his legislation (*Const. Deo Auctore*, sec. 12; *Const. Tanta*, sec. 21), yet indices (*Ἴνδικες*) and references (*παράτιτλα*), as well as translations (*ἑρμηνείαι κατὰ πόδα*) and paraphrases (*ἑρμηνείαι εἰς πλάτος*), were expressly permitted, and lavishly produced. Among the numerous compilers of alphabetically arranged *λέξεις Ῥωμαϊκαί* or *Λατεινικαί*, and *γλῶσσαι νομικαί* (Glosse nomicæ), Cyril and Philoxenus are particularly noted; but the authors of *παραγραφαί*, or *σημειώσεις*, whether *ἔξωθεν* or *ἔσωθεν κειμεναι*, are too numerous to mention. A collection of these *παραγραφαί τῶν παλαιῶν*, combined with *νέαι παραγραφαί* on the revised code called *τὰ βασιλικά*, was made about the middle of the 12th century by a disciple of Michael Hagiotheodorita. This work is known as the *Glossa Ordinaria τῶν βασιλικῶν*.[2]

In Italy also, during the period of the Byzantine ascendency, various glossæ (glosæ) and scholia on the Justinian code were produced;[3] particularly the Turin gloss (reprinted by Savigny), to which, apart from later additions, a date prior to 1000 is usually assigned. After the total extinction of the Byzantine authority in the West the study of law became one of the free arts, and numerous schools for its cultivation were instituted. Among the earliest of these was that of Bologna, where Pepo (1075) and Irnerius (1100–1118) began to give their expositions. They had a numerous following, who, besides delivering exegetical lectures ("ordinariæ" on the *Digest* and *Code*, "extraordinariæ" on the rest of the *Corpus Juris Civilis*), also wrote Glossæ, first interlinear, afterwards marginal.[4] The series of these glossators was closed by Accursius (see ACCORSO) with the compilation known as the *Glossa ordinaria* or *magistralis*, the authority of which soon became very great, so that ultimately it came to be a recognized maxim, "Quod non agnoscit glossa, non agnoscit curia."[5] For some account of the glossators on the canon law, see vol. v. p. 19 (CANON LAW).

Bible Glosses.—With the decay of learning and originality during the dark ages grew the necessity for making and the custom of transcribing on manuscript copies of the Vulgate various notes, explanatory or otherwise, of the text. Ultimately collections of these glosses or sets of glosses came to be made. They are distinguished as either marginal or interlinear. The most famous collection of *Glossæ marginales* was that made by Walafridus Strabus in the 9th century; it consists of notes grammatical, historical, and theological, culled from the writings of Augustine, Ambrose, Jerome, Gregory, Isidore, Bede, Alcuin, and Hrabanus Maurus, with additions by himself. The interlinear glosses (which as a rule were not so full as the marginal) were sometimes theological but more generally purely philological. A somewhat important collection of interlineal glosses belonging to the former class was made by Anselm of Laon (*c.* 1100). The philological glosses have considerable value to the linguistic student, especially those which originated in Germany during the Carolingian period. The MS. vocabularies in the libraries of St. Gall, Munich, Vienna, etc., have been frequently examined of late years with results which have been fully indicated by Raumer in his treatise on the influence of Christianity upon Old High German (*Einwirkung des Christenthums auf die althochdeutsche Sprache*).[6] Some interlinear vernacular translations of portions of the Bible into the Anglo-Saxon, of the 9th and following centuries, have also been recently reprinted (see ENGLISH BIBLE).

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[1] See Matthæi, *Glossaria Græca*, Moscow, 1774–5.

[2] See Labbé, *Veteres glossæ verborum juris quæ passim in Basilicis reperiuntur* (1606); Otto, *Thesaurus juris Romani*, vol. iii. (1697); Stephens, *Thesaurus linguæ Græcæ*, vol. viii. (1825).

[3] See Biener, *Geschichte der Novellen*, p. 229 *sqq.*

[4] Irnerius himself is with some probability believed to have been the author of the BRACHYLOGUS (*q. v.*).

[5] Thus Villani (*De origine civitatis Florentinæ*) says of the Glossæ that "tantæ auctoritatis gratiæque fuere, ut consensu omnium publice approbarentur et spretis abolitisque penitus aliis solæ juxtus textus legum oppositæ sunt et ubique terrarum sine controversia pro legibus observantur, ita ut propemodum nefas sit, non secus quam textui, Glossis Accursii contraire, sicut antiqua fama referente comperi." For similar testimonies see Bayle's *Dictionnaire*, *s. v.* "Accursius," and Rudorff, *Röm. Rechtsgeschichte*, i. p. 338 (1857).

[6] Considerable interest of a similar kind attaches to the so-called *Glossæ malbergicæ* upon the Latin text of the Salic law. It was at one time held that in these glosses we have some relics of the ancient

GLOSSOP, a municipal borough of Derbyshire, is situated on the extreme northern border of the county, 14 miles E. S. E. of Manchester. It is the chief seat of the cotton manufacture in Derbyshire, and it has also woollen and paper mills, dye and print works, and bleaching greens. The town has for several years been rapidly increasing in size, and now consists of three main divisions, viz., the Old Town (or Glossop proper), Howard Town (or Glossop Dale), and Mill Town. The principal buildings are the town hall and market-house, the temperance hall, the grammar school, and the mechanics' institution. In the immediate neighborhood is Glossop Hall, the seat of Baron Howard, lord of the manor, a picturesque old building with extensive terraced gardens. On a hill near the town is Milandra Castle, the site of a Roman station.

Glossop was granted by Henry I. to William Peverel, on the attainder of whose son it reverted to the crown. In 1157 it was gifted by Henry II. to the abbey of Basingwerk. Henry VIII. bestowed it on the earl of Shrewsbury, and it now belongs to the Howards. It was made a municipal borough in 1866. The population in 1871 was 17,046.

Plate VII. GLOUCESTER, a county in the west midland district of England, bounded on the N. by Worcester and Warwick, on the S. by Somerset, on the E. by Oxford and Wilts, and on the W. by Hereford and Monmouth. The river Wye forms the western boundary line, the Stratford Avon part of the northern, the Bristol Avon the south-western, and the Thames for some miles the south-eastern. The shape of the county is irregularly elliptical, its greatest length in direct line from Bristol to Clifford Chambers (N. E.) being 54 miles, its greatest width from Down Ampney to Preston, near Ledbury, at right angles, 33 miles. The area, according to the tithe surveys—deducting 3000 acres of detached land incorporated by an Act of 1844 with the counties of Worcester, Warwick, and Wilts, by which they were surrounded, and 17,688 acres of water—amounts to 805,102 acres, mostly cultivable. The county contains 29 hundreds, among which are grouped 351 parishes, 227 tithings, liberties, and hamlets; and the parishes are arranged in 17 poor law unions for the relief of the poor, and 21 petty sessional divisions for the administration of justice and sanitary purposes. Electorally Gloucestershire is divided into the two divisions of East and West Gloucestershire, each returning two members. The latter comprises Dean Forest to the Severn bank (the "Eye between Severn and Wye" of the local proverb), and the country S. of the former river to S. E. and N. E. of Dursley, the chief polling place of the division. East Gloucestershire, comprehending the rest of the county, has its chief polling places at Gloucester and Cheltenham, and besides these boroughs, the former of which returns two members and the latter one, has within its limits the boroughs of Stroud with two members, and Tewkesbury and Cirencester with one each. West Gloucestershire, sharing with North Somerset the city of Bristol, sends two more members to parliament, so that the total representation of the county is 13 members. Gloucestershire contains 28 market-towns and 2 cities.

The population of the county in 1851 was 458,805 (218,187 males and 240,618 females); in 1861 it was 485,770 (229,009 males and 256,761 females); and in 1871 it had increased to 534,320 (251,943 males and 282,377 females). Since the first census in 1801 the population has increased by 283,917 persons, or 113 per cent.

The population of the principal towns at the census of 1871 was as follows:

Bristol city	182,552	Tetbury	3,349
Cheltenham	41,923	Newent	3,168
Gloucester	18,341	Dursley	2,617
Stroud	7,082	Wotton-under-edge	2,314
Cirencester	6,096	Newnham	1,483
Tewkesbury	5,409		

The county has three natural divisions, the hill, the vale, and the forest, parallel to each other north and south. (1.) The hill country, which, except the high ground of the Forest of Dean, consists wholly of the Coteswolds, a range extending from Broadway near Chipping-Campden on the north to Bath on the south, and from Birdlip hills on the west to Burford on the east, and traversing the eastern side of the county at an average elevation of 700 feet, though in parts, as at Cleeve Hill near Prestbury, it is 1134 feet above the level of the sea. It covers nearly 300,000 acres of undulating table-land, locally subdivided into the Southwolds betwixt Bath and Badminton, the Stroudwater hills betwixt Tetbury and Woodchester, and the Coteswolds proper, or the rest of the hill country northward. (2.) The Vale, or that level tract extending from the base of the Coteswolds to the east bank of the Severn, the upper or northern part of which expanse is known as the vale of Gloucester, and embraces Gloucester, Cheltenham, Tewkesbury, and some 50,000 acres; whilst the lower is the vale of Berkeley, a tract of similar area reaching from Aust Cliff on the Severn opposite the mouth of the Wye to Robin's Wood hill, two miles south-east of Gloucester. The vale of Gloucester is a continuation of the vale of Evesham. (3.) The Forest division is the peninsula lying between the Wye and the Severn, in modern times limited to the Forest of Dean, but anciently occupying all Gloucestershire west of Severn, and covering some 43,000 acres. The area of the present forest is 23,015 acres, 11,000 of which are enclosed. Its length from north to south is 20 miles, its breadth (east to west) 10 miles.

Geology.—Though the igneous rocks are little developed, the great variety of sedimentary deposits makes Gloucestershire a rich field for the geologist. At Damory, Charfield, and Woodford is a patch of greenstone, the cause of the upheaval of the Upper Silurian basin of Tortworth, in which are the oldest stratified rocks of the county. Of these the Upper Llandovery is the dominant stratum, exposed near Damory mill, Micklewood chase, and Purton passage, wrapping round the base of May and Huntley hills, and re-appearing in the vale of Woolhope. The Wenlock limestone is exposed at Falfield mill and Whitfield, and quarried for burning at May hill. The Lower Ludlow shales or mudstones are seen at Berkeley and Purton, where the upper part is probably Aymestry limestone. The series of sandy shales and sandstones which, as Downton sandstones and Ledbury shales, form a transition to the Old Red Sandstone, are quarried at Dymock. The "Old Red" itself occurs at Berkeley, Tortworth Green, Thornbury, and several places in the Bristol coal-field, in anticlinal folds forming hills. It forms also the great basin extending from Ross to Monmouth and from Dymock to Mitcheldean, Abenhall, Blakeney, etc., within which is the Carboniferous basin of the Forest. It is cut through by the Wye from Monmouth to Woolaston. This formation is over 8000 feet thick in the Forest of Dean. The Bristol and Forest Carboniferous basins lie within the synclinal folds of the Old Red Sandstone; and though the seams of coal have not yet been correlated, they must have been once continuous, as further appears from the existence of an intermediate basin, recently pierced, under the Severn. The lower limestone shales are 500 feet thick in the Bristol area, and only 165 in the Forest, richly fossiliferous, and famous for their bone bed. The great marine series known as the Mountain Limestone, forming the walls of the grand gorges of the Wye and Avon, are over 2000 feet thick in the latter district, only 480 in the former, where it yields the brown hematite so largely worked for iron even from Roman times. It is much used too for lime and road metal. Above this comes the Millstone Grit, well seen at Brandon hill, where it is 1000 feet in thickness, though but 455 in the forest. On this rest the Coal-measures, consisting in the Bristol field of two great series, the lower 2000 feet thick with 36 seams, the upper 3000 feet with 22 seams, 9 of which reach 2 feet in thickness. These two series are divided by over 1700 feet of hard sandstone (Pennant Grit), containing only 5 coal-seams. In the Forest coal-field the whole series is not 3000 feet thick, with but 15 seams. At Durdham Down a Dolomitic conglomerate, of the age known as Keuper or Upper Trias, rests unconformably on the edges of the Palæozoic rocks, and is evidently a shore deposit, yielding dinosaurian remains. Above the Keuper clays come the Penarth beds, of which classical sections occur at Westbury, Aust, etc. The series consists of grey marls, black paper shales containing much pyrites and a celebrated bone bed, the Cotham landscape marble, and the white Lias limestone, yielding *Ostrea Liassica* and *Cardium Rhæticum.* The district of Over Severn is mainly of Keuper marls. The whole Vale of Gloucester is occupied by the next formation, the Lias, a warm sea deposit of clays and clayey limestones

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Celtic tongue; but their truly Germanic character was afterwards conclusively established by Jacob Grimm.

characterized by ammonites, belemnites, and gigantic saurians. At its base is the insect limestone bed. The pastures producing Gloucester cheese are on the clays of the Lower Lias. The more calcareous Middle Lias or marlstone forms hillocks flanking the Oolite escarpment of the Coteswolds, as at Wotton-under-Edge, and Churchdown. The Coteswolds consist of the great limestone series of the Lower Oolite. At the base is a transition series of sands, 30 to 40 feet thick, well developed at Nailsworth and Frocester. Leckhampton hill is a typical section of the Lower Oolite, where the sands are capped by 40 feet of a remarkable pea grit. Above this are 147 feet of freestone, 7 feet of oolite marl, 34 feet of upper freestone, and 38 feet of ragstone. The Painswick stone belongs to lower freestone. Resting on the Inferior Oolite, and dipping with it to S. E., is the "fuller's earth," a rubbly limestone about 100 feet thick, throwing out many of the springs which form the head waters of the Thames. Next comes the Great or Bath Oolite, at the base of which are the Stonesfield "slate" beds, quarried for roofing, paling, etc., at Sevenhampton and elsewhere. From the Great Oolite Minchinhampton stone is obtained, and at its top is about 40 feet of flaggy Oolite with bands of clay known as the Forest Marble. Ripple marks are abundant on the flags; in fact all the Oolites seem to have been near shore or in shallow water, much of the limestone being merely comminuted coral. The highest bed of the Lower Oolite is the Cornbrash, about 40 feet of rubble, productive in corn, forming a narrow belt from Siddington to Fairford. Near the latter town and Lechlade is a small tract of blue Oxford Clay of the Middle Oolite. The county has no higher Secondary or Tertiary rocks; but the Quaternary series is represented by much northern drift gravel in the Vale and Over Severn, by accumulations of Oolitic detritus, including post-Glacial extinct mammalian remains on the flanks of the Coteswolds, and by submerged forests extending from Sharpness to Gloucester.[1]

Agriculture.—In the soil of the hill country is so much lime that a liberal supply of manure is required. This is provided by folding sheep, and by paring and burning the turf and strewing the ashes on the surface. Good crops of barley and oats are thus obtained, and even of wheat, if the soil is mixed with clay. But the poorest land of the hill country affords excellent pasturage for sheep, the staple commodity of the district; and the sainfoin, which grows wild, yields abundantly under cultivation. The Coteswolds have been famous for the breed of sheep named from them since the early part of the 15th century,—a breed hardy and prolific, with lambs that quickly put on fleece, and become attempered to the bracing cold of the hills, where vegetation is a month later than in the vale. Improved of late years by judicious crossing with the Leicester sheep, the modern Coteswold has attained high perfection of weight, shape, fleece, and quality. The ewes are good mothers; the wool produce, of which the staple is long and mellow to the hand though rather coarse in quality, is an important item, averaging from 7 to 8 ℔ a head in a Coteswold flock. An impulse has been given to Coteswold farming since the chartering in 1845 of the Royal Agricultural College at Cirencester, to instruct young men in farming and the kindred sciences. The pupils engage in the cultivation of a farm of 700 acres attached to the college, a Gothic structure near Cirencester, which has hitherto accommodated on an average 100 inmates. Yet, despite the march of improvement, the aspect of the district is somewhat barren, owing to the absence of trees and hedgerows in the so-called "stone wall" country, and to the size of the farms, sometimes exceeding 1000 acres. Cattle are kept for home needs and to improve the soil. Oats and barley are the chief grain crops. In the Vale the deep rich black and red loamy soil is well adapted for cattle, and a moist mild climate favors the growth of grasses and root crops. A great proportion of the Vale is in permanent pasture, and its farmers look largely to hay as the winter food of their stock. The cattle, save on the frontier of Herefordshire, are mostly shorthorns, of which many are fed for distant markets, many reared and kept for dairy purposes. The rich grazing tract of the Vale of Berkeley is said to produce annually 1200 tons of the famous double Gloucester cheeses, and the Vale in general has long been celebrated for its cheese and butter. The Vale of Gloucester is the chief corn district. Its aspect is generally pastoral, characterized by grass-lands hemmed in with hedgerows and hedgerow timber, and dotted with apples, pears, and orchard fruit as if to compensate for the comparative barrenness of the Coteswolds. The Vale, from its position and climate, is subject to violent storms of wind and rain.

Statistics of Agriculture for Gloucestershire as returned on 4th of June, 1878.

Total area	804,977	acres.
Total acreage under crops, bare fallow, and grass	648,795	"
Corn crops (nearly one-half wheat and one-fourth barley)	172,515	"
Green crops (about two-thirds turnips and swedes)	62,679	"
Grasses under rotation	94,279	"
Permanent pasturage	307,026	"
Bare and fallow	12,263	"
Flax and hops	33	"

Live Stock.

Horses	25,725
Cattle	107,236
Sheep	416,853
Pigs	69,331

According to the Owners and Heritages Return 1872–73, the county was divided among 37,705 proprietors, holding land whose acreage was 733,640, and whose gross estimated rental was £2,556,543. The estimated extent of commons and waste lands was 7429 acres. Of the owners 76 per cent. possessed less than one acre, and the average value all over was £3 8s. 11¾d. There were 10 proprietors who possessed upwards of 5000 acres, viz.:—Lord Fitzhardinge, 18,264; Duke of Beaufort, 16,610; Lord Sherborne, 15,773; Earl Bathurst, 9967; Crown Property, 9575; R. S. Holford (Weston Birt), 9332; Thomas W. C. Master (Cirencester), 7226; Earl Eldon (Encomb), 6664; Lord Sudeley (Winchcomb), 6620; Earl Ducie, 5193.

Forest District.—The surface of this district is agreeably undulating to the height of from 120 to 1000 feet, and its sandy peat soil renders it most suitable for the growth of timber, which is the cause of its having been a royal forest from time immemorial. John Evelyn records that the commanders of the Armada had orders not to leave in it a tree standing. In the reign of Charles I. the Forest contained 105,537 trees, and, straitened for money, he granted it to Sir John Wyntour for £10,000, and a fee farm rent of £2000. The grant was cancelled by Cromwell; but at the Restoration only 30,000 were left, and Wyntour, having got another grant, destroyed all but 200 trees fit for navy timber. In 1680 an Act was passed to enclose 11,000 acres and plant with oak and beech for supply of the dockyards; and the present forest, though not containing very many gigantic oaks, has six "walks" covered with timber in various stages of growth. The two finest oaks of the Forest are a headless giant 45 feet in girth just outside the village of Newland, to the left of the road from Coleford to Monmouth, and "Jack of the Yat," with 19 feet of girth, on the right of the roadside from Coleford to Mitcheldean.[2]

Botany.—The flora of the county, representing that of the two main hydrographical areas of the kingdom and of various geological formations, is extremely rich. Its distinct forms of phanerogams number more than half the British flora. But there is little bog land in the county, and no true sea coast. Hence certain gaps in the list of indigenous plants. There are only some 25 species of ferns; but the rare flowers mentioned below are worthy of note as indigenous.[3] The quantity of mistletoe on the numerous apple trees in the cider orchards of the Vale is another botanical feature of the county, a parasite occurring on other trees also, notably on the Badham Court oak, Sedbury Park, Chepstow, and on the Frampton-on-Severn oak. The elm, used at Bristol for shipbuilding, the willow, and the maple form the chief hedge timber of the Vale, while in the Forest some fine hollies, 6 feet round, are found amongst the oaks. The Spanish chestnut at Tortworth, Piff's elm, Boddington, near Cheltenham, and the Lassington oak are the most notable trees of the county. Mustard was once much cultivated in the Vale, "few houses being without a cannon ball and bowl in which the seeds were bruised" (see Rudge's *General Views of Agriculture of Gloucester*, London, 1807).[1]

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[1] *Authorities.—Geology of East Somerset and Gloucester Coal-fields*, H. B. Woodward, F.G.S.; *Memoirs of Geol. Survey*, London, 1876; "Geology of Country round Cheltenham," E. Hull, A.B., F.G.S., in *Memoirs of Geol. Survey*, 1857; "Geology of Part of Wilts and Gloucester," *ib.*, 1852; *The Coteswold Hills*, John Lycett, London, 1857; papers by Mr. Lycett in *Quart. Journ. of Geol. Soc.*, vol. iv., and by Dr. Wright in vols. xii. and xvi.

[2] The Forest is locally governed by two crown-appointed deputy gavellers to superintend the woods and mines, and four verderers elected by the freeholders, whose office, since the extermination of the deer in 1850, is almost purely honorary. From time immemorial all persons born in the hundred of St. Briavel's, who have worked a year and a day in a coal mine, become "free miners," and may work coal in any part of the Forest not previously occupied. At the present time the Forest laws are administered at the Speech-House by the queen's officers and the free miners.

[3] *Anemone Pulsatilla; Arabis stricta; Thlaspi perfoliatum; Hutchinsia petræa; Polygala oxyptera* and *calcarea; Cerastium pumilum; Lotus angustissimus; Pyrus pinnatifida; Epilobium lanceolatum; Sedum rupestre; Trinia vulgaris: Limnanthemum nymphæoides; Veronica hybrida; Orobanche Hederæ; Cynoglossum montanum; Utricularia neglecta; Daphne Mezereum; Buxus sempervirens; Cephalanthera rubra; Galanthus nivalis.*

Communication and Trade.—Gloucestershire is, in virtue of its two city ports, Bristol and Gloucester, a maritime county. The approach to the first is by the Somerset Avon, to the second by the Severn, or, more strictly, by the Gloucester and Berkeley canal, for which, owing to the dangerous navigation of the Severn, an Act was obtained in 1793, though the works were not completed and opened for traffic till 1827. They consisted of a small tidal basin and lock at Sharpness Point, on the Severn, near Berkeley, connecting the estuary of the river by a ship canal 16 miles long with the city of Gloucester, where there was a suitable discharging dock, and where the canal was again connected with the river Severn by a lock. The gradual extension of the trade necessitated a corresponding extension of the works, and in 1869 a new and enlarged entrance, half a mile further down the river, was projected, with suitable discharging and repairing docks, which last form one large sheet of water on the same level as the old canal connecting them also with Gloucester. These were completed and opened in 1874. Through the river Severn from Gloucester to Worcester and Stourport the port is brought into direct communication with the great system of internal canals throughout the kingdom, and both at Sharpness docks and Gloucester is in direct communication with the Midland and Great Western railway systems. The following are the trade statistics of the year ending September 25, 1878:

	Tons.	Tons.
Foreign imports	428,532	
Coasting	105,224	533,756
Foreign exports	51,047	
Coasting	112,176	163,223
Total traffic		696,979

Of the foreign imports 253,643 tons, amounting to about 1,200,000 quarters, were grain and seed. The port is well situated for a corn port, its corn warehouses at Sharpness accommodating 100,000 quarters, and those of Gloucester about 130,000 quarters. The new works at Sharpness will accommodate vessels up to 2500 tons burden.

The Severn Bridge railway—5 miles in length—commences at Lydney by a junction with the Great Western Railway and the Severn and Wye railway, crosses the Severn at Purton Passage, and terminates at the Berkeley new docks by a junction with the Midland, thus forming a long-needed connection between the two sides of the river, and shortening the distances from South Wales to London by 14 miles, and from South Wales to Bristol by 20. Its great local importance consists in providing a communication from South Wales and Dean Forest and their coal-fields to the Berkeley new docks and the south of England, as is evidenced by the various competing schemes introduced in the same session of 1872 for bridges having the same object. The great iron bridge itself consists of girders constructed on a modification of the bow-string principle, and rests on piers composed of cast iron cylinders sunk down in the rock and filled with concrete. Commencing with the Lydney shore, the spans are as follows:—one of 134 feet, two of 327, five of 171 feet, thirteen of 134, and one of 196 feet (inclusive of swing bridge over canal), making in all 22. The width of the river is 1186 yards, and the total length of the bridge, including the masonry viaduct and swing span, 1387 yards. While the main object of this stupendous undertaking is the transit of coal, arrangements are also contemplated for passenger traffic across the river.

Another canal, once of great importance to the commerce of Gloucestershire, is the Thames and Severn Canal, connecting the navigation of these two great rivers, the first of which rises at the back of Leckhampton Hill, at Seven Springs. The Thames and Severn canal begins at Lechlade on the former river, and joining the Stroudwater canal, which crosses the Gloucester and Berkeley, enters the Severn at Framilode. But this canal, though of considerable engineering skill, is now but little used, the Great Western railway having almost entirely superseded it; and it is the same with another canal running from the Severn at Gloucester to Newent and Ledbury.

Manufactures.—Gloucestershire is also an important manufacturing county. In the time of Edward III. the manufacture of woollen cloth was introduced into its hill country by the Flemings, attracted probably by the facilities offered for felting by the numerous streams of water flowing from the Coteswolds. The manufacture gradually increased in spite of vexatious legislation, enacted with the view of encouraging native industry, but really tending to hamper the trade. Cirencester is mentioned as its seat in Henry IV.'s reign, and Stroud in 1553. The raw material for the manufacture was long obtained from the produce of English flocks, but afterwards a better description of wool was imported from Spain, and towards the close of the last century a still finer quality was got from Germany. The main supply is now obtained from the British colonies in the southern hemisphere. The description of cloth for which Gloucestershire and the west of England have been and still are most famous is broad-cloth, dressed with teazles to produce a short close nap on the face, and made of all shades of color, but chiefly black, blue, and scarlet. The most prosperous time of the Gloucestershire woollen trade was from 1800 to 1820, during which period the water-power of the various streams was keenly utilized, and a very large proportion of the population was engaged early and late on the several processes, either in their cottages or at the mills. The commercial crisis of 1825 very seriously crippled the trade; and though it afterwards recovered, it is probable that fewer persons have since been employed in it. The further introduction of machinery, enabling manufacturers to dispense with much manual labor, the passing of the factory laws, and the increased facilities of obtaining education, have greatly improved the social habits of the manufacturing population.

History.—Gloucestershire has not been unnoted in the annals of England. At Gloucester Henry III. was crowned; at Berkeley Castle Edward II. was murdered; the Wars of the Roses were ended at the battle of Tewkesbury, where in May, 1471, Queen Margaret and Prince Edward were taken prisoners; the repulse which Charles I. sustained at Gloucester, when the earl of Essex compelled him to raise the siege, was the climax of his fortunes. The county is strewn with relics of antiquity. Four Roman roads intersect it; Roman pavements and vestiges are found at Cirencester, Gloucester, Woodchester, and Lydney, and camps—British, Saxon, Danish, and Roman—in numerous places, with many interesting relics of the Middle Ages. Among these are the restored castle of Sudeley, near Winchcombe, a manor house before the Conquest, a baronial castle in the days of Stephen, and the home in succession of the Botelers, Seymours, Queen Katherine Parr, and the Chandos family; Thornbury Castle, an interesting ruin instead of a castellated palace, as it would have been had not its pretensions provoked the jealousy of Wolsey against its builder, Edward Stafford, duke of Buckingham, who was beheaded in 1521; St. Briavel's Castle, to the south of the Forest of Dean, an ancient seat of the Norman kings, if not the Saxon, which became the residence of the chief officer of the Forest, and retains in its ruined state a decorated chimney shaft surmounted by a horn, the warder's badge. Berkeley Castle, built prior to Henry II., is an almost unique specimen of a feudal residence in the actual occupation of a descendant of its founder, Baron Fitzharding. Edward II. was murdered in a detached upper chamber of the square tower. The chief mansions of the county are Badminton House (Duke of Beaufort); Oakley Park, Stroud (Earl Bathurst); Tortworth Park, with a chestnut measuring 52 feet, a boundary tree in King Stephen's reign (Earl Ducie); Sherborne Park, Northleach (Lord Sherborne); Clearwell Court, Coleford (Earl of Dunraven); Highnam Court (T. Gambier Parry); Sudeley Castle (J. Coucher Dent); Southam House, the oldest residential house in the county, built in the time of Henry VII., a timber and stone mansion of two stories (Earl of Ellenborough); and Prinknash Park, a 15th century residence of the abbots of Gloucester (B. St. John Ackers). Besides these there are various other seats of somewhat lesser size. Among the eminent persons born in the county are the chronicler Robert of Gloucester, Sebastian Cabot, William Cartwright the poet, Thomas Chatterton, Robert Southey, the Rev. John Eagles, and George Whitfield.

Education.—According to the parliamentary returns of public elementary schools for the year ending 31st August, 1876, there were in Gloucestershire 408 day schools, 34 of which were also used as night schools. Of these schools 314 were in connection with the Church of England, or the National Society or parochial; 15 were board schools, 9 Roman Catholic, 36 British and Foreign, and 13 Wesleyan Methodist Conference schools.

See Atkyns's *Gloucestershire*, 1769; Rudder's *Gloucestershire*, a republication of Atkyns, with additions, 1779; Fosbrooke's *Abstract of Records and Manuscripts respecting the County of Gloucester*, 1807, 2 vols. 4to; *The Forest of Dean, an Historical and Descriptive Account*, by H. G. Nicholls, M.A., 1858.

GLOUCESTER, the capital city of the county named after it, 106 miles from London by road and 114 by railway, derives its name from the British Caer-Gloui, near which at Kingsholm the Romans formed their camp of Glevum, vestiges of which remain in four principal streets running N., S., E., and W., and crossing at the centre, as well as in Roman pavements, altars, coins, and pottery. A Roman station under Aulus Plautius, it became a city of Mercia, by name Gleauanceastre, under the Saxons, and is named by Bede as one of the noblest cities in the land. A monastery was founded here in 679, in which in 1022 Bishop Wulstan of Worcester established the Benedictine rule. In the 8th century the city was repeatedly ravaged and burnt by the Danish invaders, and endured ruinous conflicts up to the time of the settlement between Canute and Edmund Ironside. The abbey throve from the time of Canute, the foundations of the present church having been laid by Abbot Serlo (1072–1104), and Walter Frocester, its historian, becoming its first mitred abbot in 1381. Edward the Confessor often resided at Gloucester, and it was a favorite resort of the Norman kings, of whom Henry I. met with his death from a surfeit of lampreys, for which he acquired a taste there. Henry II. held a great council there, and Henry III. was crowned in the abbey, and "loved Gloucester better than London." The "statutes of Gloucester" were passed in parliaments held there in succeeding reigns; but the tide of royal favor experienced an ebb when Charles I. subjected the city garrisoned by the Parliamentarians, to a critical siege, which was eventually raised in September, 1643, by the earl of Essex. Until 1541 the whole of Gloucestershire lay in Worcester diocese, but in that year it was constituted the see of Gloucester, with the abbey church for its cathedral, and John Wakeman, last abbot of Tewkesbury, for its first bishop. The cathedral may be succinctly described as "a Norman carcase," altered by additions in every style of Gothic architecture. It is 420 feet long, and 144 broad, with a beautiful central tower rising to the height of 225 feet, and topped by four graceful pinnacles. The nave is massive Norman with Early English roof; the crypt also, under the choir, aisles, and chapels, is Norman, as is also the chapter house. The south porch is Perpendicular, with fan-tracery roof, as also is the north transept, the south being transitional Decorated. The choir has Perpendicular tracery, and an apsidal chapel on each side, and the triforium carried under the east window in a curve, so as to form a whispering gallery, is very noteworthy. Between the apsidal chapels is a cross lady-chapel, and north of the nave are the cloisters with very early example of fan-tracery, the carols or stalls for the monks' study and writing lying to the south. The beautiful tower is 15th century work. For several years an extensive process of restoration has been in progress. The finest monument is the canopied shrine of Edward II., who was brought hither from Berkeley. By the visits of pilgrims to this the building and sanctuary were enriched. At the step of the altar, too, is a monument in colored bog oak of Robert Curthose, a great benefactor to the cathedral, the eldest son of the Conqueror, who was interred there; and those of Bishop Warburton and Dr. Edward Jenner are also worthy of special mention. One of the oldest houses in the city is the "New Inn in the Northgate Street," a strong and massive timbered house with external galleries and court yards, built in 1450 for the pilgrims to Edward II.'s shrine, by Abbot Sebroke, a traditional subterranean passage leading thence to the cathedral. The timber is principally chestnut.

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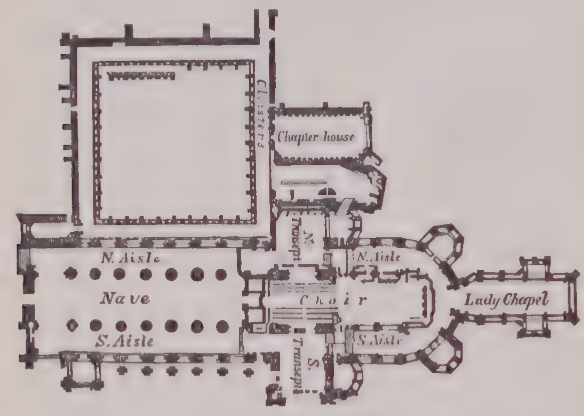
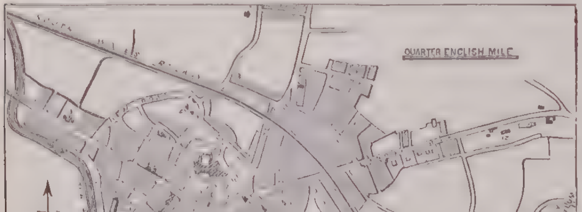
[1] *Authorities.*—Swete's *Flora Bristoliensis*, 1854; Buckman's *Botany of Cheltenham*, 1844; Marshall's *Rural Economy of Gloucestershire*, 1789; H. G. Nicholl's *Forest of Dean*, 1858; and MS. Floras of Gloucestershire, by Messrs. Harker and Boulger.



Gloucester Cathedral.



Plan of Gloucester.

1. St. Mark's Church.
2. Ruins of St. Catherine's Abbey.
3. St. Bartholomew Hospital.
4. St. Mary de Lode Church and Hooper's Monument.
5. Statue of Queen Anne.
6. St. Nicholas Church.
7. Gas Works.
8. County Hall.
9. Theatre.
10. St. John's Church.
11. Wesleyan Chapel.
12. New Hospitals.
13. Blue Coat School.
14. St. Michael's Church.
15. Post Office.
16. Corn Exchange.
17. Meat and Vegetable Market.
18. St. Mary de Crypt.
19. County Jail.
20. Custom House.
21. City Jail.
22. St. Luke's Church.

Gloucester is situated on a gentle eminence overlooking the Severn, and sheltered by the Coteswolds on the east, while the Malverns rise prominently to the west. The Tolsey or Guildhall stands at the cross, the point of intersection of the four principal streets, in each of which are various quaintly gabled and timbered houses, helping to preserve the ancient aspect of the city. The most modern quarter of it is in the region of the spa, to the south, where a chalybeate spring was discovered in 1814. The principal public buildings are the shire hall, the town hall or Tolsey (occupying the site of the ancient Roman capitol), the county jail and penitientiary, the East-gate market, the corn market, the infirmary, the lunatic asylum, and the hospital erected in 1861 in place of the four old almshouses. There are 14 churches and several dissenting chapels, and it may have been the olden proverb, "as sure as God's in Gloucester," which provoked Oliver Cromwell to declare that the city had "more churches than godliness." Of the churches four are of special interest: St. Mary de Lode, which is very old, and contains a monument of Bishop Hooper; St. Mary de Crypt, a cruciform structure of the 12th century, with a beautiful and lofty tower; the church of St. Michael, said to have been connected with the ancient abbey of St. Peter, and from whose tower the curfew bell is still rung every evening; and St. Nicholas church, originally of Norman erection, and possessing a tower and other portions of later date. A new episcopal palace was erected in 1862. There are three endowed schools: the College school, founded by Henry VIII., as part of the cathedral establishment; the Crypt school, founded by Dame Joan Cooke in the same reign; and Sir Thomas Rich's Blue Coat Hospital for 30 boys (1666). The first Sunday school was held in Gloucester, being originated by the Rev. Richard Raikes. Gloucester has returned two members to parliament since the 23d year of Edward I. The city was chartered by Richard III., and is now governed by a mayor,

six aldermen, and eighteen burgesses. Its ancient industries were iron-founding, cloth-making, pin-making, and bell-founding, but the last two have been for some time discontinued. It now possesses iron and brass foundries, marble and slate works, chemical works, soap works, rope works, flour mills, manufactories of engines, machines, and agricultural instruments, and boat and ship-building yards. In 1877 the number of British ships that entered the port was 3762, with a tonnage of 272,391, and of foreign ships 549, with a tonnage of 167,200; the number of British ships that cleared was 3992, with a tonnage of 278,773, and of foreign ships 488, with a tonnage of 144,581. The principal imports are timber, corn, wine, and spirits, and the principal exports iron, coals, malt, salt, bricks, and pottery. The town is celebrated for its Severn salmon and lampreys. Near the canals and docks are the remains (a gateway and some walls) of Llanthony Priory, a cell of the mother abbey in the vale of Ewyas, Monmouthshire, which in the reign of Edward IV. had become the secondary establishment. The famous bore of the Severn attains its great height just below Gloucester. The area of the municipal borough is 415 acres, and of the parliamentary borough 1606 acres. The population of the municipal and parliamentary borough in 1861 was 16,512; that of the municipal borough in 1871 was 18,330, and of the parliamentary borough (extended since 1861) 31,804.

See *Handbook to the Cathedrals of England, Western Division*, 1864; *General Architectural Description of the Cathedral Church at Gloucester, with Plans and Sketches*, by Frederick S. Waller, F.R.I.B.A., 1856. (J. DA.)

GLOUCESTER, a city and port of entry of Essex county, Massachusetts, United States, is beautifully situated near the southern extremity of the peninsula of Cape Ann, 30 miles N. N. E. of Boston by rail. It includes six villages—Gloucester village, East Gloucester, West Gloucester, Annisquam, Bay View, and Lanesville. The harbor, opening out into Massachusetts bay, is one of the best on the coast, and is defended by a fort. The prosperity of Gloucester depends mainly on its cod and mackerel fisheries, which employ nearly 400 vessels, with upwards of 3500 men, and have an annual value of about 4,000,000 dollars. For the year ending June 30, 1878, the total value of imports was 81,450 dollars, of domestic exports 36,172 dollars, and of foreign exports 384 dollars. Steamers ply daily between the city and Boston. There are a number of manufactories connected chiefly with the fisheries, and in the neighborhood there are extensive granite quarries. Gloucester possesses a fine city hall, a high school, seven grammar schools, and a free library. On account of its attractive situation, and the fine scenery of the neighborhood, it is a favorite summer residence. About two miles from it is Norman's Woe, the scene of the wreck of the "Hesperus," celebrated in Longfellow's poem.

Gloucester received its name from the fact that many of its early settlers came from the county of Gloucester in England. It was occupied as a fishing station in 1624, was incorporated as a town in 1642, and was made a city in 1874. It was attacked by the English in 1775 and in 1814, in both cases unsuccessfully. The population in 1800 was 5313; in 1850, 7786; in 1860, 10,904; and in 1870, 15,389, of whom 4007 were foreigners.

GLOUCESTER, ROBERT OF. See ROBERT OF GLOUCESTER.

GLOVE (Saxon *glof*), a covering for the hand, with a separate sheath for each finger. Among our ancestors, to throw down the glove or gauntlet was equivalent to a challenge to single combat, and the person thus defied signified his acceptance of the challenge by taking up the glove, and casting down his own,—which ceremony was regarded as a mutual compact to meet at the time and place specified. This custom, according to Favyn (*Théâtre d'Honneur et de Chevalerie*), was derived from the Oriental mode of contracting sales of land and the like by giving the purchaser a glove, by way of delivery or investiture; and to this effect he quotes Ruth iv. 7, and Psa. cviii. 9, passages where the word commonly translated "shoe" is by some rendered "glove." Du Cange quotes from a charter of the 13th century an instance of re-investiture or restitution symbolized by the person depositing his glove on the earth. The use of gloves is of high antiquity. There is reason to believe the ancient Persians wore them, since it is mentioned in the *Cyropædia* of Xenophon that on one occasion Cyrus went without his gloves; and we know that some kind of protecting coverings for the hands were used by the Greeks and Romans in certain kinds of manual labor, although their precise form is unknown.

The word *gantus*, used for a glove in mediæval Latin, is obviously of Teutonic derivation. In the life of St. Columbanus, written by Jonas, abbot of Bobbio, in the 7th century, gloves for protecting the hands in manual labor are spoken of as "tegumenta manuum quæ Galli *wantos* vocant." A pair of gloves are mentioned in the will of Bishop Riculfus, who died 915 A. D. Gloves did not become articles of ecclesiastical vestment till the 12th century. They do not appear in the Bayeux tapestry, and they did not come into general use in England till the 13th century. Matthew Paris, noticing the burial of Henry II. (1189), mentions that he was buried in his coronation robes, with a golden crown on his head and gloves on his hands. Gloves were also found on the hands of King John when his tomb was opened in 1797, and on the hands of Edward I. when his tomb was opened in 1774. In the 14th century they were in common use among the better classes. In the 16th century they were frequently embroidered with great elaboration, and in the reign of Charles II. the short sleeves of the ladies' dresses brought in long gloves reaching almost to the elbow. It is an old custom in England that a pair of gloves are given by the sheriff to the judge who presides at a maiden assize; and in Scotland white gloves are given to the judges on a maiden circuit,—that is, when there are no cases for trial.

The manufacture of gloves was early introduced into the British Islands, and such was the dignity of the craft that, as early as the reign of King Robert III., the incorporation of glovers of Perth was chartered—a wealthy guild still existing, although the calling has long ceased to characterize that town. The glovers' company of London received its armorial bearings as early as 1464, but the body was not chartered till 1638; and in Worcester, which has long been the principal British centre of the trade, a company was incorporated in 1661.

The glove industry of the present day is both extensive and diversified, seeing that gloves are now almost universally worn, and made of various classes of material and in several different ways. Of yarn, thread, silk, and cloth gloves it is unnecessary to speak, as these varieties are, in comparison with leather gloves, of comparatively little importance. The leather employed by glovers is prepared from the skins of deer, sheep and lambs, goats and kids—the last being by far the most important. The skins are prepared either by the ordinary processes of shamoying for wash-leather and doe or buck leather gloves, or by a special method of tawing in the case of ordinary dress gloves. The kid-skins are principally collected by hawkers in the South European countries, and sold in the Leipsic and Naples fairs. The tawing industry is conducted on a great scale at Annonay, Paris, and Milhau in France. The tawing process differs from ordinary tanning in the greater care and cleanliness of all the operations, in the submission of the dressed skins to a brief fermentation by piling them under the influence of heat, which increases the softness and flexibility of the leather, and in tawing with a mixture of flour, the yellow of eggs, and alum. On the completion of this operation, they are stretched by hand and dried as rapidly as possible. Thereafter they are damped, placed in dozens between linen cloths, and worked about to render them soft and pliable, after which they are planed on the flesh side, dried, and again planed. They are then polished by rubbing with a heavy glass disc or other smooth substance, and dyed by brushing liquid dyes over one side. Finally they are stretched on a marble table, and smoothed with a blunt knife. From a kid skin so prepared the materials of three gloves are obtained. The skins are moistened and stretched, and the various parts are cut out by a machine having steel punches the shape and size desired. The thumb piece, the quirks and the fourchettes inserted between the fingers, and the wrist welt—the latter frequently white—are cut out separately. Machine sewing, in which a kind of button stitch is made, is to a small extent utilized in the manufacture of gloves; but the greater part of the sewing is done by hand. The pieces to be sewn together are placed in a machine between a pair of jaws, the holding edge of which is composed of fine saw teeth, between each of which the sewer passes back and forward her needle, and in this way a neat uniform stitch is secured. There are three kinds of hand-sewing in the glove trade—round sewing or ordinary glove stitch, piqué stitch, and prick seam. After sewing, the backs are stitched or tamboured, the button-hole is formed, the wrist attached, and the button sewed on, thus finishing the glove. After damping and stretching to its utmost length, the glove is ready to be stamped and put up for use.

Paris is, beyond question, the most important centre of glove-making, and for delicacy of material and beauty of workmanship the productions of some Parisian manufacturers are without any rivals; but it is at Grenoble that French gloves are most extensively manufactured. English gloves, of unfailing excellence of material and workmanship, are principally made at Worcester; and in one specialty—"dogskin" gloves made from Cape sheep-skin, having a warm tan color—English makers have no competitors. A very large quantity of cheap but useful gloves are made at Brussels and Copenhagen. During the year 1876, 1,084,400 dozen pairs, of a value of £1,380,884, were imported into the United Kingdom from France; from Belgium there were 301,305 dozen pairs, valued at £345,174; and the total imports from all quarters amounted to 1,497,437 dozen pairs, of a value of £1,840,956. In 1878 the total imports were 1,060,040 dozen pairs, valued at £1,302,060.

Buckskin gloves are largely made in the United States, and that branch, together with a limited production of kid and other gloves, is chiefly centred in the village of Gloversville, Fulton co., N. Y. It is estimated that from about 140 separate glove factories in that village not less than two-thirds of the gloves made in the United States are sent out. Kid gloves are made to some extent in New York city.

GLOVER, Richard (1712–1785), an English poet, was born in 1712. He was the son of a London merchant, and received his education at Cheam in Surrey. While there he wrote in his sixteenth year a poem to the memory of Sir Isaac Newton, which was appended by Dr. Pemberton to his *View of Newton's Philosophy*, published in 1728. Though Glover followed the business of his father, he devoted much of his attention to literary pursuits, and he acquired the reputation of being one of the best Greek scholars and most famous poets of his day. In 1737 he published an epic poem, *Leonidas*, written in celebration of the defence of Thermopylæ. As the praise of liberty formed the subject matter of the poem, it was thought to have a special reference to the politics of the time; and being warmly commended by the regent and his court, by Lord Lyttelton, and the novelist Fielding, it soon passed through several editions. Though exhibiting a well-cultivated taste and some skill in versification, it possesses, however, little poetical merit, and is totally wanting in the higher qualities of epic poetry. A continuation of the *Leonidas*, entitled *Atheniad*, subsequently appeared, but had little or no popularity. In 1739 Glover published a poem entitled *London, or the Progress of Commerce;* and in the same year, with a view to excite the nation against the Spaniards, he wrote a ballad, *Hosier's Ghost*, which is spirited and effective, and was one of the most popular of its day. He was also the author of two tragedies, *Boadicea* (1753) and *Medea* (1761), which, however, on account of their close imitation of Greek models, are unsuited for the modern stage. The success of Glover's *Leonidas* led him to take considerable interest in politics, and in 1760 he entered parliament as member for Weymouth, in which capacity his abilities as a speaker, and his knowledge of commercial questions, acquired for him considerable influence. He died in November, 1785. His diary, entitled *Memoirs of a distinguished literary and political Character from 1742 to 1757* was published in 1813. Glover is one of the reputed authors of *Junius;* but his claims—which were advocated in an *Inquiry concerning the author of the Letters of Junius with reference to the Memoirs, etc.*, published in 1815—rest on very slight grounds.

GLOWWORM. See Coleoptera, vol. vi. p. 120.

GLUCINUM, or Beryllium (Greek γλυκύς, sweet, from the taste of its salts), is a metal related most nearly in its physical properties to zinc and mercury, symbol G, atomic weight 9·3. It occurs in the beryl and emerald, $G_3Al_2Si_6O_{18}$, or $3GO,Al_2O_3,6SiO_2$ (see vol. iii. p. 530, and vol. viii. p. 156), from which its oxide was earliest obtained by Vauquelin in 1798; also in the minerals euclase ($H_2G_2Al_2Si_2O_{10}$, or $H_2O,2GO,Al_2O_3,2SiO_2$), phenacite (G_2SiO_4), chrysoberyl (GO,Al_2O_3), gadolinite, leucophanite, and helvite. Glucinum was first obtained by Wöhler and Bussy in 1828, in an impure pulverulent form, by the fusion of its chloride with potassium; and by Debray in 1854, in the compact state, by the decomposition in an atmosphere of hydrogen of the vapor of the chloride by that of sodium (*Ann. Chim. Phys.*, ser. iii. vol. xliv. 5). Heated in air the metal oxidizes superficially, or, if in a state of fine division, burns with brilliancy. The spark-spectrum of glucinum presents two brilliant blue lines. Glucinum may be estimated in minerals, after removal of their silica, in the insoluble form or as fluoride, by the separation of aluminium mostly as alum, what remains being then thrown down, with iron, by means of warm solution of ammonium carbonate; to the filtrate excess of hydrochloric acid is added; and finally the glucinum is precipitated as hydrate, $G(OH)_2$, which is washed, dried, and ignited. An alloy of glucinum with iron has been obtained by Davy and by Stromeyer.

On the chemistry of glucinum see further vol. v. pp. 456–8 and 470; also Watts, *Dict. of Chemistry*, ii.; W. Crookes, *Select Methods in Chemical Analysis*, pp. 45, 46, 66; and Roscoe and Schorlemmer, *Treatise on Chemistry*, ii. pt. 1, pp. 231–6.

GLUCK (not, as frequently spelt, Glück), Christopher Willibald (1714–1787), a celebrated operatic composer, was born at Heidenwang, near Neumarkt, in the Upper Palatinate, on July 2, 1714. He belonged to the lower middle class, his father being gamekeeper to Prince Lobkowitz; but the boy's education was not neglected on that account. From his twelfth to his eighteenth year he frequented the Jesuit school of Kommotow in the neighborhood of Prince Lobkowitz's estate in Bohemia, where he not only received a good general education, but also had lessons in music. At the age of eighteen Gluck went to Prague, where he continued his musical studies under Czernhorsky, and maintained himself by the exercise of his art, sometimes in the very humble capacity of fiddler at village fairs and dances. Through the introduction of Prince Lobkowitz, however, he soon gained access to the best families of the Austrian nobility, and when in 1736 he proceeded to Vienna, he was hospitably received at his protector's palace. Here he met Prince Melzi, an ardent lover of music, who invited Gluck to accompany him to Milan, where the young musician continued his education under Giovanni Battista San Martini, an interesting composer who, although self-taught, was one of the most accomplished musicians of the 18th century, and has been called the model of Haydn. His works belong chiefly to the class of chamber music. In this respect, however, the master's example was not followed by the pupil. Gluck's dramatic instinct was irrepressible, and soon we find him producing operas at the rapid rate necessitated by the omnivorous taste of the Italian public in those days. Eight of these works were produced at various Italian theatres between 1741 and 1745. Although favorably received, they were not much above the ordinary operatic level of the day, and it would be needless even to give their names. Only the first may be mentioned here, *Artaserse*, libretto by Metastasio, first performed at Milan in 1741. To the reputation thus acquired Gluck owed an invitation to London, where in 1745 he became composer for the opera house in the Haymarket. The first opera produced there was called *La Caduta dei Giganti*, 1746, words by Metastasio), followed by one of his earlier operas, re-written for the purpose. It is stated that he also appeared as a performer on the musical glasses. The success of the two operas, as well as that of a so-called *pasticcio*, or dramatic medley entitled *Piramo e Tisbe*, was anything but brilliant, and Gluck accordingly left London. But his stay in England, although not accompanied by immediate success, was not without important consequences for his subsequent career. Gluck at this time was neither more nor less than an ordinary producer of Italian opera. Handel's well-known saying that Gluck knew no more counterpoint than his (Handel's) cook, whether true or not, was unfair, for the reason that, if Gluck had known as much counterpoint as the author of *Israel in Egypt* himself, it would have been difficult to make use of it in the style of music then exclusively cultivated by him. Had the young composer been successful in the ordinary *opera seria*, there is every reason to fear that the great dramatic reform, initiated by him, would never have taken place. The critical temper of the London public fortunately averted this calamity. It may also be assumed that the musical atmosphere of the English capital, and especially the great works of Handel, were not without beneficial influence upon the young composer. But of still greater importance in this respect was a short trip to Paris, where Gluck became for the first time acquainted with the classic traditions and the declamatory style of the French opera—the future scene of his own triumphs. Of these great issues little trace, however, is to be found in the works produced by Gluck during the fifteen years after his return from England. His first opera written for Vienna, called *La Semiramide reconosciuta* (1748), is again an opera seria of the ordinary kind, and little more can be said of *Telemacco* (Rome, 1749), *La Clemenza di Tito* (Naples, 1751), and numerous occasional pieces of a more or less serious kind written for the court at Vienna, where Gluck settled permanently in 1756, having two years previously been appointed court chapel-master, with a salary of 2000 florins, by the empress Maria Theresa. On a previous occasion he had received the order of knighthood from the pope, consequent upon the successful production of two of his works in Rome. During the long interval from 1756 (the date of his opera *Il Rè Pastore*) to 1762, Gluck seems to have matured his plans for the reform of the opera; and, barring a ballet named, like Mozart's opera, *Don Giovanni*, and some *airs nouveaux* to French words with pianoforte accompaniment, no compositions of any importance have to be recorded. His *pièce d' occasion, Il Trionfo di Clelia*, produced at Bologna in 1762, is still written in the old manner. But his *Orfeo ed Euridice*, played in October of the same year at Vienna, shows that the composer had entered upon a new career. It is significant that in the original score the work is described as a "dramma per musica" or music-drama, the title opera seria being avoided. Gluck also for the first time had deserted Metastasio, and Raniero Calzabigi furnished the highly dramatic book of *Orpheus*. Quite apart from its significance in the history of dramatic music, *Orpheus* is a work which, by its intrinsic beauty, commands the highest admiration, and does not fail to impress an audience, even now, wherever an adequate representative of the title-part can be found. Orpheus's air, "Che farò," is known to every one; but finer even is the great *scena* in which the poet's song softens even the *ombre sdegnose* of Tartarus. The ascending passion of the entries of the solo (Deh! placatevi; Mille pene; Men tiranne), interrupted by the harsh but gradually-softening exclamations of the Furies, is of the highest dramatic effect. These melodies, moreover, as well as every declamatory passage assigned to Orpheus, are made subservient to the purposes of dramatic characterization; that is, they could not possibly be assigned to any other person in the drama, any more than Hamlet's monologue could be spoken by Polonius. It is in this power of musically realizing a character—a power all but unknown in the opera of his day—that Gluck's genius as a dramatic composer is chiefly shown. After a short relapse into his earlier manner, Gluck followed up his *Orpheus* by a second classical music-drama named *Alceste*, and first produced in December, 1767, at Vienna. In his dedication of the score to the grand-duke of Tuscany, Gluck has fully expressed his aims, as well as the reasons for his total breach with the old traditions. "I shall try," he writes, "to reduce music to its real function, that of seconding poetry by intensifying the expression of sentiments and the interest of situations without interrupting the action by needless ornament. I have accordingly taken care not to interrupt the singer in the heat of the dialogue, to wait for a tedious *ritornel*, nor do I allow him to stop on a sonorous vowel, in the middle of a phrase, in order to show the nimbleness of a beautiful voice in a long *cadenza*." Such theories, and the stern consistency with which they were carried out, were little to the taste of the pleasure-loving Viennese; and the success of *Alceste*, as well as that of *Paris and Helena*, which followed two years later, was not such as Gluck had desired and expected. He therefore eagerly accepted the chance of finding a home for his art in the centre of intellectual and more especially dramatic life—Paris. Such a chance was opened to him through M. Bailli du Rollet, attaché of the French embassy at Vienna, and a musical amateur who entered into Gluck's ideas with enthusiasm. A classic opera for the Paris stage was accordingly projected, and the friends fixed upon Racine's *Iphigénie en Aulide*. After some difficulties, overcome chiefly by the intervention of Gluck's former pupil, the dauphiness Marie Antoinette, the opera was at last accepted and performed at the Académie de Musique, on April 19, 1774. The great importance of the new work was at once perceived by the musical amateurs of the French capital, and a hot controversy on the merits of *Iphigénie* ensued, in which some of the leading literary men of France took part. Amongst Gluck's opponents were not only the admirers of Italian vocalization and sweetness, but also the adherents of the earlier French school, who refused to see in Gluck the legitimate successor of Lulli and Rameau. Marmontel, Laharpe, and D'Alembert were opponents, the Abbé Arnaud and others the enthusiastic friends of the German master. Rousseau took a peculiar position in the struggle. In his early writings he is a violent partisan of Italian music, but when Gluck himself appeared as the French champion he willingly acknowledged the great composer's genius. In a letter to Dr. Burney, written shortly before his death, Rousseau gives a close and appreciative analysis of the *Alceste*, the first Italian version of which Gluck had submitted to him for suggestions; and when, on the first performance of the piece not being received favorably by the Parisian audience, the composer exclaimed, "*Alceste* est tombée," Rousseau is said to have comforted him with the flattering *bonmot*, "Oui, mais elle est tombée du ciel." The contest received a still more personal character when Piccini, a celebrated and by no means incapable composer, came to Paris as the champion of the Italian party. Into the details of the historic battle between Gluckists and Piccinists this is not the place to enter. Volumes have been written on the subject, and the whole affair has been denounced as a sign of the frivolity of the eighteenth century. But to those interested in music and in the drama, the question whether the vocal virtuoso or the true dramatic artist should reign on the lyrical stage is by no means without importance; although, perhaps, the gentlemen of the queen's court, and their friends who applauded her countryman and protegé Gluck from "le coin de la reine," hardly looked upon the matter in so serious a light. The victory at last remained, by common consent (including, it is said, Piccini's own), with Gluck. The succession of the operas written for Paris is the following:—*Orphée et Eurydice* (the *Orfeo* rewritten), 1774; *Alceste* (also an adaptation of the earlier work), 1776; *Armide*, 1777; *Iphigénie en Tauride*, 1779. Some minor compositions, written partly by desire of the queen for the court festivals, it would be needless to mention. Gluck was engaged upon an opera, *Les Danaides*, when an attack of apoplexy compelled him to relinquish all thoughts of work. He left Paris for Vienna, where he lived for several years in dignified leisure, disturbed only by his declining health. He died on November 18, 1787.

To the general character of Gluck's music some allusion has already been made. He was essentially a dramatic composer, and no notice need be taken of the few works belonging to a different sphere. In connection with its dramatic purpose his music ought always to be judged. He never was a great contrapuntist in the sense that Bach and Handel were. But neither was there much room for polyphonous display in the music-drama as he understood it. The chorus of Scythians in the second *Iphigenia* ("Il nous falloit du sang") would not gain in effect if it contained an elaborate fugue. This and other choruses in the same great work at the same time illustrate Gluck's power of rendering musically national as well as individual characteristics. As a masterly trait of psychological characterization may further be cited the accompaniment to Orestes's air, also in *Iphigénie en Tauride* ("Le calme rentre dans mon cœur"), where the unfortunate man in vain tries to find relief from the pangs of conscience, distinctly heard in the unceasing semiquavers of the orchestral accompaniment. The severe censure passed on Gluck for drowning the voices by the instruments posterity has converted into one of the composer's highest claims to fame. Not only has Gluck developed the orchestra as regards mere beauty and volume of sound, but he also has made it an important factor in the dramatic organism. Instances from the second *Iphigénie* alone might again be multiplied. The savage Scythians, for instance, are characterized by the noise of brass and percussion: while Iphigénie's simple prayer is accompanied by the strings and two oboes. The care bestowed by Gluck upon a correct and emphatic declamation of the words is another important point in his dramatic reform. Readers interested in the matter will have noticed the striking parallelism between the views and aims advocated by Gluck in the 18th century and by Wagner in the 19th century—a parallelism which may be extended to the bitter animadversions evoked by these theories amongst contemporary critics. The means, however, by which the theories were to be realized are very different in the two cases. Gluck's reform is essentially directed against the encroachments of the singer; Wagner's against those of the composer as an independent artist. Gluck, it is true, felt the necessity of a perfect unity between music and poetry, but he never intended to bring about this desirable effect by surrendering any of the strict forms of his own art. The consequence was that the poet was more than ever bound to adapt his work to the demands of the composer, and that the latter remained practically the omnipotent ruler on the operatic stage. Wagner at last has made dramatic purpose the supreme consideration to which the forms of music, as a separate art, have to submit.

An altogether satisfactory biography of Gluck remains still to be written. With regard to the life, Anton Schmid's *Chr. W. Ritter von Gluck* may be consulted. Herr Marx, in his *Gluck und die Oper*, has attempted to define the composer's position in the history of dramatic music. M. Desnoiresterres's *Gluck et Piccini* refers to the most important portion of the composer's career. For it must always be remembered that Gluck, although a German by birth, belongs as an artist to France rather than to his native country. His works form as it were the musical complement to the tragedy of Corneille and Racine. In France he was first appreciated, and in France also his traditions were continued by a school of highly gifted composers. (F. H.)

GLÜCKSTADT, a town of Prussia, in the province of Schleswig-Holstein, is situated on the right bank of the Elbe, where it receives the small river Rhin, and on the railway from Itzehoe to Elmshorn, 28 miles N. W. of Altona. It has a Protestant and a Catholic church, a synagogue, a gymnasium, a provincial prison, and a provincial penitentiary. The inhabitants are chiefly engaged in commerce and fishing; but the frequent losses from inundations have greatly retarded the prosperity of the town. It suffers at the same time from a very deficient water supply for culinary purposes.

Glückstadt was founded by Christian IV. of Denmark in 1616, and fortified in 1620. It was formerly the seat of the royal dukes of Schleswig-Holstein, who assumed from it the name of Holstein-Glückstadt. In 1627–8 it was besieged for fifteen weeks by Tilly, without success. In 1814 it was blockaded by the allies and capitulated, whereupon its fortifications were demolished. In 1830 it was made a free port. It came into the possession of Prussia along with the rest of Schleswig-Holstein in 1866. The population in 1875 was 5031.

GLUCOSE, a species of sugar, on the chemical and other properties and the occurrence and manufacture of which see articles CHEMISTRY, vol. v. pp. 490, 497; DEXTRIN and DIABETES, vol. vii. pp. 126, 127; FERMENTATION, vol. ix. pp. 82, 84, 85; GALLIC ACID, vol. x. p. 37; and SUGAR.

GLUE. See GELATIN.

GLUKHOFF, or GLUCHOW, as the name is transliterated in German, a town of Russia, at the head of a district in the government of Tchernigoff, 132 miles E. of Tchernigoff in 51° 54′ N. lat. and 33° 35′ E. long., on the highway between Moscow and Kieff. It is situated on the sloping banks of the Yasmin, a sub-tributary of the Desna, which in its turn unites with the Dnieper. Among its buildings are eleven churches and two Jewish meeting-houses, a district school, an almshouse, and a hospital. In 1860 its population, mainly engaged in agricultural pursuits and petty commerce, amounted to 10,008, of whom 4998 were males; in 1873 it was 10,747; and according to the *St. Petersburg Calendar* for 1878, it has increased to 13,398. The Jews in 1860 numbered 2517. About 4 miles from the town, near the village of Poloshek, there exists an extensive deposit of white clay, which supplies nearly all the porcelain factories in Russia. Glukhoff is mentioned in the Laurentian Chronicle as early as 1152. For some time it was in the hands of a branch of the ducal family of Tchernigoff, which retired before the encroachments of the Tartars in the middle of the 13th century. Before its final incorporation with Russia, it passed under the sway first of the Lithuanians and then of the Poles. On the destruction of Baturin by Peter I. in 1708, it was made the residence of the hetmans.

GLUTEN, a tough, tenacious, ductile, somewhat elastic, nearly tasteless, and greyish-yellow albuminous substance, obtained from the flour of wheat by washing in water, in which it is insoluble. In Martin's apparatus for the preparation of gluten on a large scale, balls of dough are worked backwards and forwards in troughs by means of cylinders, whilst water plays upon them in fine jets delivered by copper pipes. A sack of flour may be thus made to yield about 110 lb of moist gluten, and twice that quantity of dry starch. Good samples of white English wheat contain some 10 or 11 per cent. of gluten; from hard Venezuela wheat as much as 22·75 per cent. has been procured. The outer and inner coats of wheat, separated from it as bran, contain respectively 4 or 5 and 14 to 20 per cent. of gluten. Gluten, when dried, loses about two-thirds of its weight, becoming brittle and semi-transparent; when strongly heated it crackles and swells, and burns like feather or horn. It is soluble in strong acetic acid, and in caustic alkalies, which latter may be used for the purification of starch in which it is present. When treated with ·1 to ·2 per cent. solution of hydrochloric acid it swells up, and at length forms a liquid resembling a solution of albumin, and lævorotatory as regards polarized light. Moistened with water and exposed to the air gluten putrefies, and evolves carbon dioxide, hydrogen, and sulphuretted hydrogen, and in the end is almost entirely resolved into a liquid, which contains leucin and ammonium phosphate and acetate. On analysis gluten shows a composition of about 53 per cent. of carbon, 7 per cent. of hydrogen, and nitrogen 15 to 18 per cent., besides oxygen, and about 1 per cent. of sulphur, and a small quantity of inorganic matter. It is not a simple substance, and according to Ritthausen consists of *glutencasein* (Liebig's vegetable fibrin), *glutenfibrin*, *gliadin* (Pflanzenleim), *glutin* or vegetable gelatin, and *mucedin*, which are all closely allied to one another in chemical composition. It is the gliadin which confers upon gluten its capacity of cohering to form elastic masses, and of separating readily from associated starch. In the so-called gluten of the flour of barley, rye, and maize, this body is absent (Kreusler and Ritthausen). The gluten yielded by wheat which has undergone fermentation or has begun to sprout is devoid of toughness and elasticity. These qualities can be restored to it by kneading with salt, lime-water, or alum. Koopmans found that a larger amount of raw gluten was digested in a relatively dilute than in a strong artificial gastric juice, the reverse holding good of albumin. From experiments on six pigs and three dogs, he came to the conclusion that the digestive fluid in the stomachs of living animals, even of the same species, dissolves unlike quantities of albumin and gluten, so that if much albumin be digested the loss of weight of gluten present with it is but small, and *vice versa* (see *Brit. and For. Med.-Chir. Rev.* 1857, ii pp. 318–25). Gluten is employed in the manufacture of gluten bread and biscuits for the diabetic (see DIABETES, vol. vii. p. 128), and of chocolate, and also in the adulteration of tea and coffee. For making bread it must be used fresh, as otherwise it decomposes, and does not knead well. Granulated gluten is a kind of vermicelli, made in some starch manufactories by mixing fresh gluten with twice its weight of flour, and granulating by means of a cylinder and contained stirrer, each armed with spikes, and revolving in opposite directions. The process is completed by the drying and sifting of the granules.

See H. Ritthausen, "Ueber die Bestandtheile des Weizenklebers," *Erdmann's Journ. f. praktische Chemie*, lxxxv., 1862, pp. 193–229; also *ib.*, lxxxvi., 1862, pp. 257–265; and lxxxviii., 1863, pp. 141–147; T. Langer, *Lehrbuch der Chemie*, pp. 361–371, Leipsic, 1878; and Payen, *Industrial Chemistry*, ed. B. H. Paul, 1878.

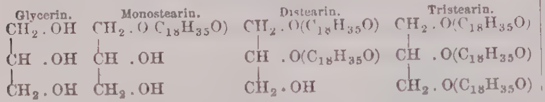
GLUTTON or WOLVERENE (*Gulo luscus*), a carnivorous mammal, belonging to the *Mustelidæ* or weasel family, but differing from the typical forms of the genus *Mustela* in the greater heaviness and clumsiness of its body, presenting in this respect a striking resemblance to the bear. Its legs are short and stout, with large feet, the toes of which terminate in strong, sharp claws, considerably curved. Its mode of progression is semi-plantigrade. In size and form it is not unlike the European badger, measuring from 2 to 3 feet in length, exclusive of the thick bushy tail, which is about 8 inches long. Its head is broad, its eyes small, with defective vision, and its back arched. Its fur consists of an undergrowth of short woolly hair mixed with long straight hairs, to the abundance and length of which on the sides and tail the creature owes its shaggy appearance. The color of its fur is blackish-brown, with a broad band of chestnut color stretching from the shoulders along each side of the body, the two meeting near the root of the tail; while, unlike the majority of arctic animals, the fur of the glutton in winter-time grows darker in color. Like other weasels it is provided with anal glands, which secrete a yellowish fluid possessing a highly fœtid odor. The glutton is a boreal animal, inhabiting the northern regions of both hemispheres, but most abundant in the circumpolar area of the New World, where it occurs throughout the British provinces and Alaska, being specially numerous in the neighborhood of the Mackenzie River, and extending southwards as far as New York and the Rocky Mountains. Many erroneous statements have been made regarding the glutton by early writers on natural history, from Olaus Magnus to Buffon, one of which has perpetuated itself in the animal's common name,—the fact being that the wolverene is not more gluttonous than are the majority of carnivorous animals. It feeds on grouse and the smaller rodents, and on foxes, which it digs from their burrows during the breeding season. Its want of activity, however, renders it dependent for most of its food on the dead carcases of animals. These it frequently obtains by methods which have made it peculiarly obnoxious to the hunter and trapper. Should the hunter, after succeeding in killing his game, leave the carcase insufficiently protected for more than a single night, the glutton, whose fear of snares is sufficient to prevent him from touching it during the first night, will, if possible, get at and devour what he can of it on the second, hiding the remainder beneath the snow. He annoys the trapper by following up his lines of marten traps which often extend to a length of 40 or 50 miles, each of which he enters from behind, extracting the bait, pulling up the traps, and devouring or concealing the entrapped martens. So persistent is the glutton in this practice, when once it discovers a line of traps, that its extermination along the trapper's route is a necessary preliminary to the successful prosecution of his business. This is, however, no easy task, as the glutton is too cunning to be caught by the methods successfully employed on the other members of the weasel family. The trap generally used for this purpose is one made to resemble a cache, or hidden store of food, such as the Indians and hunters are in the habit of forming, the discovery and rifling of which is one of the glutton's most congenial occupations,—the bait, instead of being paraded as in most traps, being in this case carefully concealed, to lull the knowing beast's suspicions. One of the most prominent characteristics of the wolverene is its propensity, akin to that of certain members of the crow family, to steal and hide things, not merely food which it might afterwards need, or traps which it regards as personal enemies, but articles which cannot possibly have any interest for it except that of curiosity. An amusing instance of this is quoted by Coues in his valuable work, recently published, on the *Fur-bearing Animals of North America,* in which he says—"A hunter and his family having left their lodge unguarded during their absence, on their return found it completely gutted—the walls were there, but nothing else. Blankets, guns, kettles, axes, cans, knives, and all the other paraphernalia of a trapper's tent had vanished, and the tracks left by the beast showed who had been the thief. The family set to work, and by carefully following up all his paths, recovered, with some trifling exceptions, the whole of the lost property." The cunning it displays in unravelling the oftentimes complicated snares set for it forms at once the admiration and the despair of every trapper, while its great strength and ferocity render it a dangerous antagonist to animals much larger than itself, and occasionally even to man. The rutting season occurs in March, and the female, secure in her burrow, produces her young—four or five at a birth—in June or July. In defence of these she is exceedingly bold, and the Indians, according to Coues, "have been heard to say that they would sooner encounter a she-bear with her cubs than a carcajou (the Indian name of the glutton) under the same circumstances." The wolverene has a curious habit which has not hitherto been observed in any other of the lower animals. On catching sight of its relentless human enemy, it may be observed, before finally determining on flight, sitting on its haunches, and, in order to get a clearer view of the danger, shading its eyes with one of its forepaws. When pressed for food it becomes fearless, and has then been known to come on board an ice-bound vessel, and in presence of the crew to seize on a canister of meat. The flesh of the glutton is uneatable; it is therefore only valuable for its fur, which, when several skins are sewn together, forms elegant hearth and carriage rugs.

Glutton, or Wolverene.

GLYCAS, Michael, a Byzantine historian, often called Siculus. The time when he flourished is very uncertain. He is justly reckoned among the better Byzantine historians on account of the terseness and perspicuity of his style. His MS. letters still extant are addressed to the last Constantine; their authenticity, however, has been questioned. His chief work is *Βίβλος χρονική*, divided into four parts, treating of history from the creation of the world to the death of Alexis I. Comnenus (1118). The best edition is that by J. Bekker, in the Bonn collection of the Byzantines (1836).

GLYCERIN, Glycerine, or Glycerol (in pharmacy Glycerinum), a sugar-like substance obtainable from most natural fatty bodies by the action of alkalies and similar reagents, whereby the fats are decomposed, water being taken up, and glycerin being formed together with the alkaline salt of some particular acid (varying with the nature of the fat). Owing to their possession of this common property, these natural fatty bodies and various artificial derivatives of glycerin, which behave in the same way when treated with alkalies, are known as *glycerides.* This decomposition into an organic acid and a substance of more or less neutral character is a typical kind of reaction with numerous classes of organic bodies, and is termed *saponification,* from the circumstance that the ordinary process of soap-making consists simply in the formation from natural fatty bodies and alkalies of the alkaline salts of the fatty acids thence derivable, soap being a mixture of these alkaline salts in various proportions, according to the particular purposes for which it is required, and its price. In the ordinary process of soap-making the complementary product, glycerin, remains dissolved in the aqueous liquors from which the soap is separated, and is usually thrown away; in many other instances, however, in which a substance capable of undergoing a reaction of saponification is thus treated, the product complementary to the alkaline salt is the more important of the two.

The fact that soap is obtainable by boiling together oily or fatty substances and alkalies (such as potashes and natron or mineral alkali) was known at an early period of history, being mentioned by Pliny, Galen, Aetius, and Paulus Ægineta. On the other hand, substances referred to in the Old Testament and translated "soap" (*e. g.,* Jeremiah ii. 22, "For though thou wash thee with nitre [properly, natron], and take thee much soap;" Malachi iii. 2, "For he is like a refiner's fire, and like fuller's soap") refer to the alkali itself (viz., *borith* = vegetable alkali, potash; or *neter* = mineral alkali, soda), and not to the substances prepared from oily bodies and these alkaline matters. Similarly Homer makes no mention of soap whilst describing the laundry operations of Nausicaa. The discovery of glycerin, however, is of modern origin, the body having been first described in 1776 by Scheele under the name of oelsüss (principe doux des huiles—sweet principle of oils), and more fully investigated subsequently by Chevreul, Berthelot, and many other chemists, from whose researches it results that glycerin is a trihydric alcohol indicated by the formula $C_3H_5(OH)_3$, the natural fats and oils, and the glycerides generally being substances of the nature of compound ethers formed from glycerin by the replacement of the hydrogen of the OH groups by the radicals of certain acids, called for that reason "fatty acids."[1] The relationship of these glycerides to glycerin will be more conveniently shown by an example, such as the series of bodies formed from glycerin by replacement of hydrogen by "stearyl" ($C_{18}H_{35}O$), the radical of stearic acid ($C_{18}H_{35}O.OH$):—



$$\begin{array}{llll}
\text{Glycerin.} & \text{Monostearin.} & \text{Distearin.} & \text{Tristearin.} \\
CH_2.OH & CH_2.O(C_{18}H_{35}O) & CH_2.O(C_{18}H_{35}O) & CH_2.O(C_{18}H_{35}O) \\
| & | & | & | \\
CH\ .OH & CH\ .OH & CH\ .O(C_{18}H_{35}O) & CH\ .O(C_{18}H_{35}O) \\
| & | & | & | \\
CH_2.OH & CH_2.OH & CH_2.OH & CH_2.O(C_{18}H_{35}O)
\end{array}$$

These four substances evidently form a progressive series, each number of which differs from the preceding one in the same way, viz., that one more stearyl group replaces hydrogen in the original OH groups.

The process of saponification may be viewed as the gradual progressive transformation of tristearin, or some analogously constituted substance, into distearin, monostearin, and glycerin, or as the similar transformation of a substance analogous to distearin or to monostearin into glycerin. If the reaction is brought about in presence of an alkali, the acid set free becomes transformed into the corresponding alkaline salt; but if the decomposition is effected without the presence of an alkali (*i. e.*, by means of water alone, or by an acid fluid), the acid set free and the glycerin are obtained together in a form which usually admits of their ready separation. It is noticeable that with few exceptions the fatty and oily matters occurring in nature are substances analogous to tristearin, *i. e.*, they are trebly replaced glycerins. Amongst these glycerides may be mentioned the following:

Tristearin—$C_3H_5(O.C_{18}H_{35}O)_3$. The chief constituent of hard animal fats, such as beef and mutton tallow, etc.; also contained in many vegetable fats in smaller quantity.

Triolein—$C_3H_5(O.C_{18}H_{33}O)_3$. Largely present in olive oil and other saponifiable vegetable oils and soft fats; also present in animal fats, especially hog's lard.

Tripalmitin—$C_3H_5(O.C_{16}H_{31}O)_3$. The chief constituent of palm oil; also contained in greater or less quantities in human fat, olive oil, and other animal and vegetable fats.

Triricinolein—$C_3H_5(O.C_{18}H_{33}O_2)_3$. The main constituent of castor oil.

Other analogous glycerides are apparently contained in greater or smaller quantity in certain other oils. Thus in cows' butter, *tributyrin*, $C_3H_5(O.C_4H_7O)_3$, and the analogous glycerides of other readily volatile acids closely resembling butyric acid, are present in small quantity; the production of these acids on saponification and distillation with dilute sulphuric acid is utilized as a test of a purity of butter as sold. *Triacetin*, $C_3H_5(O.C_2H_3O)_3$, is apparently contained in cod-liver oil. Some other glycerides isolated from natural sources are analogous in composition to tristearin, but with this difference, that the three radicals which replace hydrogen in glycerin are not all identical; thus kephalin, myelin, and lecithin are glycerides in which two hydrogens are replaced by fatty acid radicals, and the third by a complex phosphoric acid derivative. In no case, however, is the existence of a natural glyceride analogous to distearin or monostearin substantiated with certainty, bodies of these classes being either formed synthetically by reversing the reactions of saponification, or being produced by the partial saponification of substances analogous to tristearin.

Glycerin is also a product of certain kinds of fermentation, especially of the alcoholic fermentation of sugar; thus it is a constituent of many wines and other fermented liquors, being formed together with small quantities of various other substances by reactions sudsidiary only to the main change taking place, and hence varying in their nature and extent with circumstances. According to Pasteur, about $\frac{1}{30}$th of the sugar transformed under ordinary conditions in the fermentation of grape juice and similar saccharine liquids into alcohol and other products becomes converted into glycerin. In certain natural fatty substances, *e. g.*, palm oil, it exists in the free state, so that it can be separated by washing with boiling water, which dissolves the glycerin but not the fatty glycerides; but how far its occurrence in this form is due to the breaking up of the glyceride by a spontaneous saponification is open to some question.

Properties.—In a state of purity glycerin is a viscid, colorless liquid of sp. gr. 1·264, possessing a somewhat mawkish sweet taste; when exposed to a high degree of cold for a long time it sometimes solidifies to a crystalline mass, which then melts at about 7° C. The crystals when once melted often do not resolidify again readily, even when in contact with the solid substance, although sometimes contact with a crystal of the solid at a temperature of about 0° suffices to produce solidification of the whole. This solidification of glycerin is, however, a very exceptional phenomenon, only occurring with extremely pure substance under certain conditions not thoroughly understood, and then only after long continued exposure to a low temperature, as during a cold winter. When containing a minute quantity of water glycerin never solidifies, and to this circumstance several of its useful applications are due. A weak aqueous solution, when chilled sufficiently, allows crystals of ice to form, the glycerin accumulating in the unfrozen portion as alcohol does when a mixture of spirit and water is partially frozen. When heated alone it partially volatilizes, but the greater part decomposes; by reducing the pressure to about $\frac{1}{12}$th of an atmosphere, it can, however, be readily distilled unchanged, boiling under a pressure of 50 millimetres of mercury at about 20° C. In an atmosphere of steam, also, it distils without decomposition under ordinary barometric pressure. In water and alcohol it dissolves readily in all proportions; in ether it is insoluble. Under certain conditions, such as prolonged contact with poor cheese and chalk at about 35° to 40° C., it can be made to ferment partially, becoming changed into alcohol; but under any circumstances, only a small fraction, at most a tenth, becomes thus transformed, the rest remaining unaltered. It possesses remarkable solvent powers on many substances, whence it is employed for numerous purposes in pharmacy and the arts. Its viscid character, and its non-liability to dry and harden by exposure to air, also fit it for various other uses, such as lubrication, etc., whilst its peculiar physical characters, enabling it to blend with either aqueous or oily matters under certain circumstances, render it a useful ingredient in a large number of products of varied kinds. Applied to the living skin (and similarly to untanned leather) it produces a remarkable softening effect, whence it is largely employed as a cosmetic, either by itself or in admixture with other substances. Taken internally it is alleged to be valuable as a substitute for cod-liver oil for phthisical patients, not possessing the disagreeable fishy flavor of that valuable food, and having a fattening tendency. When it is given in moderately small repeated doses to the lower animals, it does not appear to possess any marked injurious action peculiar to itself; when, however, large doses of glycerin are subcutaneously injected into dogs, amounting to from 8 to 10 grammes per kilogramme of animal operated on (0·8 to 1·0 per cent. of the weight of the dog, corresponding to from 1 ℔ to $1\frac{1}{2}$ ℔ of glycerin for the weight of an average man), death ensues within twenty-four hours, accompanied by symptoms analogous to those of acute alcoholism (Dujardin, Beaumetz, and Audigé). Like sugar it possesses antiseptic qualities, so that meat, albumin, etc., immersed in it do not for long periods of time undergo putrefactive changes.

Manufacture.—The simplest modes of preparing glycerin in a state of purity are based on the saponification of fats, either by alkalies or analogous basic substances, or by superheated steam, and on the circumstance that, although glycerin cannot be distilled by itself under the ordinary pressure without decomposition, it can be readily volatilized in a current of superheated steam; in this way the glycerin formed is separated from the non-volatile substances present. It was by means of saponification of olive oil or lard with litharge (lead oxide), whereby a lead soap insoluble in water, or nearly so, is formed, together with glycerin, that the existence of glycerin was first demonstrated by Scheele, who obtained it as a bye-product in the formation of the "lead-plaster" of pharmacy made from lard and lead oxide. For a long time this was the only known method of preparing glycerin, the aqueous solution obtained being treated with sulphuretted hydrogen to remove any soluble lead compounds, filtered, and evaporated until almost all the water was driven off, leaving the glycerin behind as a syrupy fluid. By evaporating down the spent leys of the soapmaker (after the soap is separated therefrom by "salting out," and any excess of alkali neutralized with sulphuric acid), and treating the residue with alcohol, glycerin can also be obtained, the alcoholic solution of it thus formed being simply evaporated to drive off the alcohol; but this process is far too costly for ordinary purposes. An improvement on this method was patented in 1858 by H. Reynolds, the concentrated leys being passed into a vessel where they are met by a stream of superheated steam at about 200° C.; the glycerin then passes over with the aqueous vapor, whilst the inorganic salts present are left behind. In the manufacture of stearic acid for candle-making (see CANDLE) one of the older processes was the saponification of tallow with lime, forming an insoluble lime soap and an aqueous solution of impure glycerin, from which the pure substance can be readily obtained by distillation with superheated steam. Less pure products were formerly obtained by treating the crude solution with sulphuric acid to separate lime, boiling to remove small quantities of volatile acids, evaporation, and filtration through animal charcoal to decolorize; or by evaporating, dissolving out by alcohol, and purifying by treating with lead oxide, filtering to separate an insoluble lead compound formed, removing lead from this filtrate by sulphuretted hydrogen, filtering again, and evaporating to a syrup. In practice all these older methods have, however, been superseded by the process patented in 1854 by Wilson & Payne. This consists in heating the fatty matter to be saponified in an appropriate still to a temperature of 290° to 315° C. (550° to 600° Fahr.), and passing in heated steam in such a way that it rises up through the fatty matter in numerous streams; saponification is thus rapidly effected, and the liberated glycerin and fatty acids are volatilized and carried along with the steam to the condensing arrangement. If the temperature do not exceed 310° C. there is no fear of the glycerin being decomposed, whilst under suitable conditions even higher temperatures than this can be employed without causing its decomposition; but there is always a great liability to destruction of glycerin when the temperature of 310° is exceeded. This arises from the tendency of the glycerin to char on heating, and to split up into water and *acrolein* (acrylic aldehyde), thus:—

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[1] The name is often further extended so as to embrace other acids, analogous to the true acids of fats and oils in composition, properties, and chemical characters, but not yet found to exist in natural oils and fats.

$$C_3H_8O_3 = 2H_2O + C_3H_4O.$$

When a series of chambers is used as the refrigerator, the compartments nearest the still are found to condense little but fatty acids, the water and glycerin chiefly accumulating in the more distant chambers, the last of which is usually open to the air at the end; so that there is no excess of pressure in the still and condensers; the fatty acids readily separate from the aqueous solutions of glycerin, which only requires concentration by evaporation to be fit for the market. Since the date of Wilson's patent various special forms of apparatus for effecting the transformation have been patented by Wright & Fouché, Gilbee, and others.

This method of saponification is, strictly, only an improvement on former processes invented for the purpose of decomposing the glycerides and obtaining the fatty acids without the use of alkalies, lime, etc.; in these older methods the extraction of glycerin was not an important feature, and they were frequently worked in such a way as to decompose the whole or greater part of the glycerin *pari passu* with its liberation. Thus, as far back as 1825, Chevreul and Gay-Lussac sketched out the idea of the process of saponification by superheated steam, and the method was actually carried out with certain modifications by various chemists and manufacturers. For example, in 1842, E. Price & Co. patented, in the name of Jones & Wilson, a process of the kind, which was largely worked for some years; in this, the fatty matter freed from extraneous impurities is mixed with 6 to 8 per cent. of strong sulphuric acid, and then heated in copper boilers to about 180° C., by superheated steam blown through the mass for about two hours; after which hotter steam at about 300° to 350° is blown through, when fatty acids distil, but little or no glycerin passes over unaltered, almost the whole being charred or decomposed, forming acrolein, etc. Here the saponification and destruction of glycerin are largely effected by the sulphuric acid, as well as by the steam itself. Price's process was suggested to the inventors by Tilghman's method, brought out early in 1854, which consisted in making an emulsion of melted fatty matter and water (or solution of alkali) by agitation, and then pumping it through a long coil of iron tubing kept at a temperature near that of melted lead under a pressure of about 2000 ℔ to the square inch. In this way complete saponification is effected, fatty acids and an aqueous solution of glycerin being obtained when water is used, and soap with more or less water and glycerin when alkaline liquor is employed. It is noticeable that in this process it is not necessary that the alkali should be caustic, as it must be for the ordinary process of soap-boiling; sodium and potassium carbonates answer just as well as their respective hydrates (caustic soda, caustic potash).

Derivatives.—Among the numerous derivatives obtainable from glycerin by appropriate chemical reactions, may be more particularly mentioned *nitro-glycerin*, which is, strictly speaking, improperly named, inasmuch as it does not belong to the class of true nitro-substitution derivatives, but is simply constituted like tristearin, the radical of nitric acid displacing the hydrogen of the OH groups. By treating glycerin with nitric acid (preferably by dropping pure glycerin into a mixture of nitric and sulphuric acids) the following reaction ensues, the glycerin becoming what would be systematically termed *trinitrin* or *glycerotrinitrin*:—

$$\left\{\begin{array}{l} CH_2 \,.\, OH \\ CH \;\,.\, OH \\ CH_2 \,.\, OH \end{array}\right. + 3NO_2OH = 3H_2O + \left\{\begin{array}{l} CH_2.O.NO_2 \\ CH\;\,.O.NO_2 \\ CH_2.O.NO_2 \end{array}\right.$$

By treating the resulting "nitro-glycerin" with caustic potash, saponification ensues, potassium nitrate being formed and glycerin reproduced precisely as when tristearin is similarly saponified. Two other important products obtainable from glycerin are *isopropyl iodide* and *allyl iodide*, each of which serves as the starting-point of a large series of chemical products, many of them of utility in the arts. These substances are manufactured by heating glycerin with hydriodic acid, and are formed in virtue of the reactions:—

$$\overset{\text{Glycerin.}}{C_3H_5(OH)_3} + 5HI = 2I_2 + 3H_2O + \overset{\text{Isopropyl iodide.}}{C_3H_7I}$$

$$C_3H_5(OH)_3 + 3HI = I_2 + 3H_2O + \overset{\text{Allyl iodide.}}{C_3H_5I}$$

Again, glycerin is employed in the manufacture of *formic acid*, which is prepared most conveniently by heating together glycerin and oxalic acid. The splitting up of oxalic acid into carbon dioxide and formic acid, which takes place only to a minute extent when oxalic acid is heated alone (owing to the further decomposition of the formic acid), then ensues with but little formation of bye-products, and especially with but little loss of formic acid through further decomposition. This arises from the occurrence of a cycle of changes highly interesting from a chemical point of view, and consisting essentially in the continual formation of a body analogous to monostearin, and its continual breaking up into formic acid, which distils over, and glycerin, which acts over again on a fresh portion of oxalic acid.

Technical Uses.—Besides its use as a starting-point in the production of "nitro-glycerin" and other chemical products, glycerin is largely employed for a number of purposes in the arts, its application thereto being due to its peculiar physical properties. Thus its non-liability to freeze (when not absolutely anhydrous, which it practically never is when freely exposed to the air) and its non-volatility at ordinary temperatures, combined with its power of always keeping fluid and not drying up and hardening, render it valuable as a lubricating agent for clockwork, watches, etc., as a substitute for water in wet gas-meters, and as an ingredient in cataplasms, plasters, modelling clay, pasty coloring matters, dyeing materials, moist colors for artists, and numerous other analogous substances which are required to be kept in a permanently soft condition. From its softening property when applied to the skin, it constitutes a chief ingredient in many toilet preparations, creams, and the like. Many of these indeed, sold under fancy names, are nothing but glycerin diluted with water or weak alcohol, or mixed with some oleaginous emulsion or paste, and variously scented. Its solvent power for numerous substances renders it valuable in pharmacy as an ingredient in numerous preparations. In some of these the glycerin acts not merely as a solvent but also as a preservative against decomposition, owing to its antiseptic qualities, which also led to its being employed to preserve untanned leather (especially during transit when exported, the hides being, moreover, kept soft and supple); to make solutions of gelatin, albumen, gum, paste, cements, etc., which will keep without decomposition; to preserve meat and other edibles; to mount anatomical preparations; to preserve vaccine lymph unchanged; and for many similar purposes. Its solvent power is also utilized in the production of various coloring fluids, where the coloring matter would not dissolve in water alone; thus aniline violet, the tinctorial constituents of madder, and various allied coloring matters dissolve in glycerin, forming liquids which remain colored even when diluted with water, the coloring matters being either retained in suspension or dissolved by the glycerin present in the diluted fluid. It has been proposed to use glycerin as a medium for the extraction of the odoriferous principle of flowers, etc., and as a substitute for sugar in the manufacture of some sorts of tobacco, the aroma of which is liable to be deteriorated should fermentation of the saccharine matter set in. Certain kinds of copying inks are greatly improved by the substitution of glycerin, in part or entirely, for the sugar or honey usually added. In fine, the number of useful adaptations of glycerin as an ingredient in order to confer certain special properties is almost unlimited, and its use in these directions is increasing yearly.

Impurities.—For some of these purposes it is essential that the glycerin should be of considerable purity. The chief impurities liable to be present vary with the mode of preparation. Substances made by saponification of oils, etc., with oxide of lead or lime, are apt to retain more or less of the metallic compounds, whilst glycerin extracted from soap-leys may also contain mineral matters. Such impure substances are readily purified by distillation with steam or under greatly diminished pressure. Glycerin prepared by saponifying clarified tallow, etc., by superheated steam, rarely contains fatty acids; if not deprived of practically all the water with which it is mixed in the distillate first obtained, it is less viscid and has a lower density, so that the specific gravity forms a good test as to whether it contains much water or not. Occasionally glycerin is met with intentionally adulterated with sugar-syrup, gum, mineral matters, etc., but such falsifications are comparatively rare. They may be detected by the substance being not wholly soluble in alcohol, by its leaving a residue on ignition in air, by its precipitating a solution of basic lead acetate (after being dissolved in water), or by other special tests, according to the nature of the impurity sought for. Thus, whilst pure glycerin does not reduce alkaline copper solutions so as to precipitate cuprous oxide when boiled therewith, the precipitation is readily produced by certain kinds of sugar, either without any previous treatment (*e. g.*, glucose), or after boiling for a short time with water acidulated with a mineral acid such as sulphuric acid (*e. g.*, cane sugar). (C. R. A. W.)

GMELIN, Johann Georg (1709–1755), a distinguished naturalist, son of the chemist of the same name, was born at Tübingen, June 12, 1709. Having taken his degree in medicine, he in 1727 repaired to St. Petersburg, where in 1731 he was appointed professor of chemistry and natural history. In 1733, by order of the empress Anna, he joined Deslisle, G. F. Müller, and Behring in an expedition for the exploration of Siberia, which was penetrated as far as the Lena. He returned to St. Petersburg in 1743. In 1749 he was chosen professor of botany and chemistry at Tübingen, where he died, May 20, 1755. Linnæus named a genus of plants *Gmelina* in his honor.

His chief works are *Flora Sibirica* (4 vols., St. Petersburg, 1749–50), and *Reisen Durch Sibirien* (4 vols., St. Petersburg, 1752).

GMELIN, Leopold (1788–1853), a celebrated chemist, was born August 2, 1788, at Göttingen, in the university of which city his father, Johann Friedrich Gmelin, was professor of medicine. He studied medicine and chemistry at Göttingen, Tübingen, and Vienna, and in 1813 commenced lecturing on chemistry at Heidelberg, where in 1814 he was appointed extraordinary and in 1817 ordinary professor of medicine and chemistry; the latter office he held till 1850. He died at Heidelberg, April 13, 1853.

Gmelin's fame rests chiefly on his chemical dictionary, the *Handbuch der Chemie*, the first edition of which, in 2 vols., was published at Frankfort in 1817–19. The fourth edition (Heidelberg, 1843, etc.) was written by Gmelin himself as far as the end of vol. v., was continued by Drs. List and Kraut and others, and completed by an eighth volume on physiological chemistry, the work of Professors Lehmann and Rochleder. A revision of the *Handbuch* by Kraut, in two parts, has since appeared. Of the fourth edition an English translation by H. Watts was published by the Cavendish Society in 1848–59. Gmelin was the author also of *Versuch eines neuen chem. Mineralsystems* (Heidelberg, 1825), and of numerous scientific papers. With Tiedemann he wrote *Versuche über die Wege auf welchem Substanzen aus dem Magen und Darmkanale in das Blut gelangen* (Heidelberg, 1820), and *Die Verdauung* (2 vols., Heidelberg, 1826–27).

GMELIN, Samuel Gottlieb (1743–1774), an eminent naturalist, nephew of J. G. Gmelin (see above), was born at Tübingen, June 23, 1743. He graduated there as M. D. in 1763, went to St. Petersburg in 1767, and in 1768, with Pallas, Güldenstädt, and Lapuchin, commenced a journey for the scientific exploration of the south-east possessions of Russia. Having visited in succession the western districts of the Don, the Persian provinces to the south and southwest of the Caspian Sea, the regions of the Volga, and the eastern borders of the Caspian, he in 1774 was on his way back to St. Petersburg when he was seized as a hostage by Usmey Khan, of the Kaitak tribe, through whose illtreatment he died on July 27th of the same year.

His principal works are *Historia Fucorum iconibus illustrata* (St. Petersburg, 1768), and *Voyages dans differentes parties des l'Empire de Russie* (4 vols. 4to, St. Petersburg, 1770–84).

GMÜND, a town of Würtemberg, circle of Jaxt, formerly a free imperial town, is situated in a charming and fruitful valley on the Rems, here spanned by a beautiful bridge, 31 miles E. N. E. of Stuttgart. It is surrounded by old walls, flanked with towers, and has a considerable number of ancient buildings, among which are the church of the Holy Cross; St. John's church, which dates from the time of the Hohenstaufens; St. Leonard's church, situated on a height near the town, partly hewn out of the rock and much frequented by pilgrims; the chapels of St. Joseph and God's Rest; and the Dominican convent, founded in 1204, now a house of correction. Among the modern buildings are the gymnasium, the drawing and trade schools, the Roman Catholic seminary, the town hall, the royal deaf-mute and blind institute, the blind asylum, the lunatic asylum, and two hospitals. The industries include the manufacture of gold, silver, copper, bronze, and brass wares, silk and part-silk cloths, tobacco, wax, glue, leather, furniture, bone dust, and lucifer matches. There is also considerable trade in corn, hops, and fruit. Population in 1875, 12,838.

Gmünd was surrounded by walls in the beginning of the 12th century by Duke Frederick the elder of Swabia. It received town rights from Frederick Barbarossa, and after the dying out of the Hohenstaufens became a free imperial town. In 1546 it was besieged and taken by the Protestants, and in 1793 it was burned by the Swedes. It retained its independence till 1803, when it came into the possession of Würtemberg. Gmünd is the birth-place of the painter Hans Baldung and of the architect Heinrich Arler. In the Middle Ages the population was about 10,000.

GNAT, a name (Anglo-Saxon, *gnæt*) properly applied to the members of the *Culicidæ* (a family of the insect order *Diptera*, division *Orthorrhapha*, subdivision *Nematocera*, section *Eucephala*, but sometimes also used for the *Chironomidæ*. The *Culicidæ* consists of about 150 known species, of the genera *Culex*, *Anopheles*, *Aedes*, *Psorophora*, *Corethra*, etc.; they are distributed over the chief divisions of the world, and, in spite of their very feeble build, reach as far north as man has penetrated (having been found during Nares's recent Arctic expedition). As regards time, examples of a *Culex* and a *Corethra* have been discovered in the Tertiary beds of the Lower White River, Colorado. The *Culicidæ* are distinguished from their immediate allies, amongst other characters, by having the parts of the mouth produced into a slender porrected rostrum, nearly half the length of the insect, and composed of many distinct pieces (seven, according to Westwood, who remarks that the mouth in these delicate creatures is formed of the same number of pieces, and on the same plan, as that of the robust *Tabani*), and many-jointed palpi, very long and pilose in the male, in which sex the antennæ are plumose and 14-jointed. The fibrils of the antennæ are considered by Mayer as auditory organs. The usual special representative of the family is *Culex pipiens*, the common gnat, whose blood-sucking propensities have rendered it too well known. It pierces the skin with the needle-like lances of its rostrum, which are barbed at the tips, and gradually inserts the whole of those organs, at the same time liquefying the blood by some fluid secretion, which apparently adds to the subsequent irritation. The female, recognizable by her more simple antennæ and palpi, alone attacks man, and, in default of her favorite food, will feed on the honey of flowers. This blood-sucking taste is shared by the allied *Simuliidæ*. The dreaded mosquito is nothing but a species of *Culex*, so closely allied to *C. pipiens* that it is difficult to say where "gnat" ends and "mosquito" begins, though the original mosquito is a native of Cuba. The curious humming noise (from which the name *pipiens* is fancifully derived) accompanying the flight of the gnat is caused by the extremely rapid motion of its wings, which have been calculated to vibrate 3000 times in a minute—the great relative bulk of the thoracic muscles accounting materially for this. In connection with the gnat's wing it may be observed that, though apparently clear, "battledore scales" have been discovered upon it by microscopists. The habit of gnats to associate in clouds has been frequently noticed, from the poet Spenser downwards; and instances are even on record of their gatherings round church-spires having caused alarms of fire, from being mistaken for smoke. This apparently arises from the extreme spontaneity and ease of the individuals in their evolutions, which are so rapidly conducted as to enable them to fly unwet in a shower of rain. It has been observed that many of these large gatherings are exclusively composed of females. The transformations of the gnat have often been chronicled, and by none in a more interesting way than Réaumur. The female deposits her eggs in a little raft or boat-like mass, upon the surface of water, using her hind-legs while packing them together; the larvæ hatched from them are very active, diving in a jerky manner quickly, and often coming to the surface to breathe, suspending themselves head downwards, and taking in atmospheric air through a spiracle in one of the large tubes into which the end of the body subdivides. The pupæ are also capable of active motion by means of paddles at the tail, and also suspend themselves under the surface for respiratory purposes, though not breathing as in the larva, but through two little tubes on the back of the thorax. When the perfect insect makes it appearance, the pupa-skin is used by it as a floating foothold until it is ready to take to flight. So short a time is occupied by the entire series of metamorphosis that many generations are perfected in one summer.

GNESEN (Polish, *Gniezno*), the chief town of a circle in the Prussian province of Posen, government of Bromberg, is situated on the Wrzesnia, 30 miles E. N. E. of Posen. Besides the cathedral, which contains the remains of St. Adalbert, there are nine Roman Catholic churches, and there is also a Protestant church, a synagogue, a clerical seminary, and a convent of the Franciscan nuns. The industries are cloth and linen weaving and brandy making. A great horse and cattle market is held annually. The population in 1875 was 11,203, of whom about half are Poles.

Gnesen is said to be the oldest town in Poland, and was the capital of the kingdom till 1320. It was made the seat of an archbishop early in the 11th century. It is still the seat of the cathedral chapter, but the archbishop now resides at Posen.

GNOSTICISM, a general name applied to various forms of speculation in the early history of the church. The term γνῶσις is found in the Septuagint translation of the Old Testament, and in the Apocryphal Book of Wisdom, denoting the knowledge of the true God, or knowledge communicated by Him. In the New Testament the word is frequently used by St. Paul (1 Cor. i. 5, xii. 8; 2 Cor. iv. 6, x. 5), and in the second epistle of St. Peter (i. 5, 6; iii. 18), to express the saving knowledge of God in Christ; and in the first epistle to Timothy occurs the significant phrase, "Oppositions of Science (γνώσεως) falsely so called." It may be inferred, therefore, that the use of the simple term, in a bad as well as a good sense, was not unknown to the apostolic age, although the expression γνωστικός (Gnostic) is said not to be found till the beginning of the 2d century, when it was first employed by the sect of the Ophites, or, according to some, by Carpocrates. Both expressions were used by the early Christian fathers with the double meaning already indicated. Clement of Alexandria, in his *Stromata* or *Miscellanies*, entitles the enlightened or perfect Christian a Gnostic (*Strom.* i. 20, ii. 6). He points out at length the distinction between the true Gnostic and the disciples of false systems who laid claim to the name of Gnostics. It is only to systems of the latter kind that the name of Gnosticism is now applied.

The sources of Gnosticism are to be found in diverse forms of religious and speculative culture antecedent to Christianity, especially in the theology of the Alexandrian Jews, as represented in the writings of Philo, and again in the influences flowing from the old Persian or Zarathustrian religion and the Buddhistic faiths of the East. To the theosophic system of Philo, with its mixture of Platonic and Old Testament ideas, some of the most characteristic conceptions of Gnosticism are certainly to be traced, such as the infinite separation between God and the world, and the necessity of a mediating power or powers in the creation of the world. This class of ideas prevailed largely at the time of the introduction of Christianity, especially in Alexandria, which was the great meeting-point of Jewish and Hellenic culture. The more the state of the pre-Christian Jewish mind and Jewish literature is investigated, the more do we recognize everywhere a strange commingling of old with new thoughts, of tradition with philosophy, of religion with speculation. The age was in all its aspects eclectic, and the Jewish no less than the Gentile schools of the time were centres for the fusion of old streams of culture from many quarters, and the rise of broader intellectual tendencies. Ever since the captivity, Judaism had borne more or less the impress of the old state religion which it encountered in its exile. How far post-Exilian Judaism was moulded by Zarathustrian conceptions is a very difficult question; but no historical student can doubt that its cosmogony, its angelology, and even its anthropology, were largely modified by contact with Persia. But not only was Zarathustrianism active in and through Judaism. In itself, it spread westward, and became directly and indirectly both a precursor and a parent of Gnostic speculation. Certain forms of Gnosticism seem little else than adaptations of the Persian dualism to the solution of the great problem of good and evil. In other forms of it, again, the Pantheism of India seems to have been a pervading influence. This, too, has its representative in the Jewish schools of the time, in the secret doctrines of the Kabbala, which many carry considerably beyond the time of Christ, although the two books through which we alone know these doctrines—the *Book of Creation* and the book called *Zohar* or *Light*—are plainly of much later production. These doctrines sprang up in Palestine, and not among the Hellenistic Jews. The philosophy on which they rest is plainly pantheistic. Whereas the principle lying at the foundation of the theosophy of Philo makes almost an absolute distinction between the Supreme indefinable Source of all things and the world, the philosophic postulate of the Kabbala is the identity of God and the world—the one being the Eternal Substance of which the other is the manifestation and form. "In place of the personal God, distinct from the world, acknowledged in the Old Testament, the Kabbala substitutes the idea of an universal and infinite substance, always active, always thinking, and in the process of thought, developing the universe. In place of a material world distinct from God and created from nothing, the Kabbalist substitutes the idea of two worlds—the one intelligible, the other sensible,—both being, not substances distinct from God, but forms under which the Divine Substance manifests itself" (Mansel's *Gnostic Heresies*, p. 35).

Gnosticism is found reproducing one and all of these conceptions, with the additional idea of *redemption* directly borrowed from Christianity. In all its forms, it may be said to represent the efforts made by the speculative spirit of the time to appropriate Christianity, and to make use of some of its most fertile principles for the solution of the mysteries lying at the root of human speculation. The more advanced writers of the present day refuse to recognize Gnosticism as a *heresy*, or to speak of the Gnostics as deserters from the Christian Church. And they are right so far. The Gnostic schools were always so far outside the church. They were not *heretical*, therefore, in the ordinary sense. But it is no less true that Gnosticism, in all its developments, is only intelligible in connection with Christianity. It was the impulse of Christian ideas which alone originated it, which constituted the vital force of thought that made it one of the most significant phenomena of early Christian history; and it is only its connection with Christianity which can be said to make it any longer interesting.

The question as to the date of its origin has been much investigated of late by such writers as the late Dean Mansel among ourselves, and Lipsius, Harnack, and Hilgenfeld in Germany. Do we find traces of it in the New Testament writings? or are the supposed allusions to it there to be otherwise explained? It is well known that this question has an important bearing upon other questions as to the origin of some of the New Testament writings, and the special object for which these writings were composed. Without entering into details, or attempting to examine the several passages which may be supposed to contain allusions to Gnosticism in the New Testament, it may be said that such allusions, more or less definite, seem to occur in the later epistles of St. Paul, especially the epistles to the Ephesians and Colossians, and in the Pastoral epistles. A supposed allusion has also been traced in the first epistle to the Corinthians, where the word γνῶσις, for the first time in the New Testament writings, is found in a depreciatory sense, in the phrase ἡ γνῶσις φυσιοῖ, ἡ δὲ ἀγάπη οἰκοδομεῖ (1 Cor. viii. 1). In so very general a use of the expression, however, even in its connection with the question of eating meats which had been offered to idols, it must be held very doubtful whether anything more than a general meaning is intended. And the same remark applies to many even of the more defined modes of expression, such as *Pleroma* and *Æon*, which occur in the later epistles. The true explanation of all these phrases, as well as much else in St. Paul's writings, is probably the fact that the spirit of Gnosticism, and the language which it afterwards developed and applied, were "in the air" of the apostolic age. Its modes of thought, as already seen, were prevalent in Philo and in other quarters, and the tendencies which were afterwards worked up into systems were no doubt in existence in the time of St. Paul, and still more in the later apostolic time. It seems plainly against such tendencies, rather than against any special sects or schools, that the cautions of St. Paul are directed. In the Apocalypse, and in the epistles and gospel attributed to St. John, these tendencies are seen in a more developed although hardly in a more distinct state. The second chapter (vv. 6–15) of the Apocalypse has been held to mention a sect of the Gnostics by name—the Nicolaitans—a sect supposed to derive its name from Nicolas, one of the seven deacons, who had departed from the faith and fallen into licentious doctrines and practices. Even in such a sect as this, however, we recognize rather the expression of those lax and restless tendencies which sought everywhere to corrupt the doctrines of the gospel, than any clear philosophical bias. Upon the whole, it may be concluded that what we see in the writings of the New Testament is exactly what we might expect. The Gnostical spirit is present, but Gnosticism is as yet undeveloped. The apostolic age is an age of transition, in which the speculative and ethical spirit of the time is everywhere seen encountering the new life of Christianity, and new seeds of creative thought are everywhere springing from the encounter. There are teachers of all kinds, especially Jewish teachers, busy throughout the Roman world. But Gnosticism properly so-called, as a series of speculative systems, is not yet born. Its approach is heralded by many tendencies forecasting it; but it is only in the Syrian and Alexandrian schools of the beginning of the 2d century that we see it coming forth into distinct shape. Men like Simon Magus and his pupil Menander, the former the opponent of St. Peter, and again men like Cerinthus, the opponent of St. John, may be called Gnostics. In such traditions of their teaching as survive, we see the workings of the Gnostical spirit—the spirit which sought to transmute the facts of Christianity into some ideological theory. But none of these leaders elaborated systems, or at least we are no longer able to trace with precision of outline the doctrines which they taught. Properly speaking, therefore, they are the precursors of Gnosticism, rather than the founders of Gnostic schools. It is implied by Irenæus (i. 25) that the followers of Carpocrates first called themselves Gnostics; and again by Hippolytus that this designation was first assumed by the Ophites (l. v.). But little can be gathered from writers like Irenæus, or even Hippolytus, as to the true order of development of the Gnostic systems. With the former, for example, Saturninus and Basilides stand not only before Carpocrates, but before Cerinthus, the Ebionites, and the Nicolaitans (i. 24, 26). The last thing to seek in the early fathers is either accuracy of chronology, or a clear sequence of thought. They handle topics, for the most part, quite irrespective of either; and the student is forced back mainly, if not exclusively, on internal evidence as his only trustworthy guide in analyzing and classifying the systems of thought which prevailed in the first two centuries.

According to such evidence, and the bias of individual writers, the Gnostic systems have been very differently classified. Mosheim has divided them with reference to their greater or less recognition of the Dualistic principle; Neander with reference to their relation to Judaism; F. Baur with reference to their relation both to Judaism and heathenism. Lipsius, one of the most recent and careful writers on the subject, arranges the Gnostical systems in a threefold order—1st, in so far as they arise within the Jewish schools, and aim to distinguish between Christianity and Judaism; 2d, in so far as they appear within the broader sphere of Hellenism; and 3d, in so far as they approach the circle of Christian faith, and become more or less united with the doctrines of the church.

The most intelligible principle of classification seems to be that already indicated, which recognizes first an inchoate period corresponding to the New Testament age, and represented by many diverse teachers, chiefly of Jewish origin, and then fixes attention upon the great schools of Syria and of Egypt, with the addition of that of Asia Minor, represented by Marcion. These schools are distinguished by their internal features, and their respective relations to Judaism on the one hand and dualism on the other; but they stand out more clearly from their geographical centres, perhaps, than from any other distinguishing features.

I. The inchoate phase of Gnosticism is represented by men like Simon and Cerinthus, both prominently associated with apostles and sects, such as the Ophites or Naasseni (from נָחָשׁ, serpent), the Peratæ or Peratics, the Sethiani, and the followers of one Justinus, author of a book called the *Book of Baruch*, which was written probably not earlier than the beginning of the 2d century. All these sects are elaborately described by Hippolytus in the fifth book of his *Refutation of Heresies*. Simon Magus follows them in his order of treatment (l. v.). There can be little doubt, however, that Simon must be placed in the very front of the history of Gnosticism, in so far as he belongs to this history at all. This is the position that he occupies in the treatise of Irenæus (*Adv. Hæreses*, l. i. c. 23); and his association with St. Peter, as well as the account of him in the apostolic history in which he appears (Acts viii. 5, 9, 10) within seven years of the ascension of our Lord, plainly indicates that this is his true position. The character of his teaching, moreover, points to the same conclusion. It is a form of anti-Christianism, rather than any mere depravation of the Christian system. It is true that he is represented in the passage of the Acts of the Apostles already referred to (viii. 13) as having professed himself a believer, and having been baptized; but his whole career afterwards, and the doctrines attributed to him, prove that, whatever may have been his feelings for the moment, he neither understood Christianity nor came under its practical influence in any degree. Probably he regarded the apostles as only magicians of remarkable skill, and enrolled himself for a time in their company in order that he might learn their secrets and be able to exercise their powers. He was plainly an impostor of the first magnitude, who must be credited with a marvellous and unblushing audacity rather than with any clear philosophic or spiritual aims. He gave himself out as "the great power of God" (Acts viii. 10). "Ego sum sermo Dei," he said of himself, according to St. Jerome (on Matt. xxiv. 5), with much blasphemous nonsense besides. He carried about with him a "certain woman named Helena," a prostitute whom he had purchased in the city of Tyre, and who he said "was the first conception (Ἔννοια) of his mind, the mother of all things, by whom in the beginning he conceived the thought of making the angels and archangels" (Iren., *Adv. Hær.*, i. 23). He recognized Christ as Redeemer, but only as occupying an inferior position to himself. He was the true Logos or Power of God, which had previously in an imperfect degree appeared in Jesus. He himself is "the God who is over all things, and the world was made by his angels" (*Ibid.*, i. 23). It is clear that a teacher of this kind had little relation to Christianity, except in so far as it came across his own designing and ambitious path. He had knowledge and intellectual address to avail himself of the prevailing conceptions of the Alexandrian philosophy, so as to impart some coherency to his own insane dreams; but he was characteristically a magician (as his character has survived in history) rather than a philosopher or spiritual thinker. He claims the position assigned to him in the history of Gnosticism mainly in virtue of his pupil and successor Menander who laid the foundation at Antioch of the Syrian Gnostic school more conspicuously represented by Saturninus and others.

For an account of Cerinthus and his system we refer our readers to the article CERINTHUS. The account of his relations with St. John, as given by later Christian tradition, may be a mythical expression of the popular Christian feeling about an obnoxious teacher rather than a statement of actual facts; but there seems no doubt that Cerinthus represented, in the close of the 1st century, a type of doctrine especially opposed to that of the fourth gospel. He is supposed to have been of Jewish descent, to have been educated in Alexandria, and to have diffused his doctrine in Asia Minor. Opposed as he was to the Christianity of the church in attributing the creation of the world, not to the Supreme God, but to "a power separate and distinct from" Him, and in conceiving Jesus as a mere man to whom the Christ was united at baptism, and from whom the Christ departed before his death (Iren., i. 2; Hippolytus, vii. 33), he was yet far from being the mere anti-Christian impostor that Simon was. He makes no claim to miraculous or divine powers in himself, but holds a distinct, however erroneous, Christology. The idea of redemption is not only recognized by him, but recognized as verified in Christ and in Him alone. His chief conception of the Creator of the world being other than the Supreme God was probably borrowed by him from the Egyptian schools in which he seems to have taught.

The sects of the Naasseni, the Peratæ, the Sethiani, and the followers of Justin, placed, as we have said, by Hippolytus before Simon, may probably all be ranked along with him and Cerinthus in the early and still undeveloped stage of Gnosticism. It is very difficult to attain to any certainty as to their chronological position. Bunsen traces the origin of the Ophites as far back as the Pauline age; but on very definite grounds it may be concluded that the sect, if existent then, could hardly have acquired any prominence or intellectual interest,—not even in the time of St. John; and certain details of their teaching cannot well be earlier than the beginning of the 2d century. Hippolytus gives a distinct and lengthened account of these several sects. The Naasseni, he says, borrowed their opinions from the Greek philosophers and the teachers of the mysteries; the Peratæ took them "not from the Scriptures, but from the Astrologers;" the Sethiani "patched up their system out of shreds of opinion taken from Musæus, and Linus, and Orpheus;" and Justin was indebted for his to the "marvels of Herodotus!" He says, moreover, of the Naasseni that they "call themselves Gnostics." We must leave here, as elsewhere, the more particular description of these sects to special articles. All of them, however, may, with Mansel (*Gnostic Heresies*, p. 96), be regarded as branches of a common sect to which the title of Ophites particularly answers. The serpent was more or less a common symbol with them all; and the idea of the serpent as in some manner a redeeming power for mankind—"a symbol of intellect by whose means our first parents were raised to the knowledge of the existence of higher beings than their creator"—seems to have run through them all. The serpent no doubt tempted man, but he fell from allegiance to the Demiurge, or Creator of the present world, only to rise to the knowledge of a higher world. Thus to identify the serpent with the Redeeming Word or Divine Son came very near to converting the power of Evil into the ideal of Good. This was the logical conclusion which probably lay more or less in all their systems; but it only showed itself fully in a cognate sect called the Cainites, the description of which follows that of the Ophites and the Sethians in the first book of the treatise of Irenæus (c. xxxi.). This sect carried to its extreme form the inversion of Biblical story, and raised the serpent into a creative and redeeming power. All the evil characters in the Old Testament, with Cain at their head, are set forth as the true spiritual heroes; and, in consistency with the same view, Judas Iscariot, in the New Testament, is represented as alone "knowing the truth," and so accomplishing the betrayal of the Saviour, as some later theorists have also supposed, in order that His good work might be completed. They had a gospel of their own in the interest of such views, which they styled "the gospel of Judas."

Another name in the history of Gnosticism, that of Carpocrates, may be classed in this earlier period, although he is said to have been still active as a teacher in the time of Hadrian (117–138). The followers of Carpocrates, as already mentioned, are represented by Irenæus (i. 25) as first styling themselves Gnostics. His opinions had a certain affinity both with those of Cerinthus and the Ophites. They are described at length by Irenæus (i. 25) and Hippolytus (vii. 20). Both writers also ascribe to this teacher and his disciples a great devotion to magical arts, and accuse them of voluptuousness and even licentiousness of life. They seem to have cherished an esoteric doctrine which inculcated the indifference of all actions, and that nothing was really evil by nature. Some of the teachers of the sect marked their pupils by branding them on the inside of the lobe of the right ear. Epiphanes, a son of Carpocrates, is associated with his father in the reign of Hadrian as actively promoting the spread of their heresy, and, dying young, he is said to have been worshipped as a god by the inhabitants of a town in Cephalonia, of which his mother was a native. He must have been a remarkable youth, credited as he is with a work on *Justice*, fragments of which have been preserved by Clement of Alexandria, advocating a very outrageous form of communism. Women of note allied themselves to this free confederacy, one of whom, Marcellina, came to Rome in the time of Anicetus (d. 168), and "led multitudes astray" (Iren. i. 25; see also CARPOCRATES).

II. But, as already indicated, it is not till the first quarter of the 2d century that we see Gnosticism in full and systematic development; and then it ranges from two main centres—Antioch in Syria, and Alexandria.

(1.) Menander, the pupil of Simon, settled at Antioch, and there laid the foundation of the Syrian Gnostic school, whose chief representatives in the 2d century are Saturninus, Tatian, and Bardesanes, the last two of whom were more or less connected with the church—Tatian, as a pupil of Justin Martyr, and the writer of a harmony of the four gospels under the name of *Diatessaron*, and Bardesanes as one of the first of the interesting series of hymn-writers for which we are indebted to the Syrian church. The Syrian Gnosis is distinguished by its admixture of Zarathustrian elements, and the consequent sharpness and precision with which it seizes the idea of conflict between the powers of Good and Evil—the Supreme God, on the one hand, and the Demiurge and his angels or æons, on the other hand. For a more particular account of the characteristics of the system, see articles on the names above mentioned.

(2.) Along with the Syrian school, and occupying a more prominent place in the development of the religious thought of the 2d century, stands the great school of Alexandrian Gnosticism, represented especially by Basilides and Valentinus and their followers. Basilides appears to have been a native of Syria, and to have taught in Alexandria about the year 125. "He is the first Gnostic teacher," says Bunsen (*Hippolytus and his Age*, p. 107), who has left an individual personal stamp upon his age. . . . His erudition is unquestionable. He had studied Plato deeply. . . . All that was great in the Basilidean system was the originality of thought and moral earnestness of its founder." Bunsen also maintains that "Basilides was a pious Christian, and worshipped with his congregation," while admitting that his sect fell away from the church and from Christianity by refusing to recognize the authority of Scripture and the necessity of practical Christian communion.

Valentinus was probably educated in the school of Alexandrian Gnosticism, as he developed Gnostic ideas in their connection with Hellenic, rather than Persian, modes of thought into the most elaborate and carefully reasoned system which they reached. He came to Rome about the year 140, and there formed a sect which exercised considerable influence over the commingling speculations of the time which met in that great centre. Bunsen vindicates his Christian character, and says that St. Jerome speaks of him with great respect. If at any time he really belonged to the church, it seems to be admitted (Epiph., *Hær.*, xxxi. 7) that in Cyprus, whither he returned and where he died, he ultimately proclaimed himself outside its pale. The most illustrious disciples of the Valentinian Gnosticism, which prevailed on till the 6th century, were Ptolemæus, Heracleon, and Marcus. It is the tenets of these teachers, especially of the first, that are chiefly discussed in the opening chapter of the well-known treatise of Irenæus.

(3.) In addition to these two great schools of Gnosticism there is still a third, especially represented by the famous Marcion of Pontus, whose centre may be regarded as Asia Minor. Marcion was the son of a Christian bishop, by whom he is said to have been excommunicated. Following one Cerdon, a Gnostic of Antioch, Marcion distinguished himself by his extreme opposition to Judaism, and generally by a Gnostic attitude at variance with the Old Testament, the God of which is to him the Demiurge in conflict with the Supreme Being and the Christ whom He sent to redeem the world from the power of this Demiurge. His Christology was of course docetic,—the divine power being only united to the man Jesus for a time. He accepted only ten of St. Paul's epistles, and a mutilated copy of the gospel of St. Luke. The teaching of the Clementine fictions and a Jewish sect known by the name of Elkesaites, whose tenets seem to have resembled this teaching, is considered by Mansel and others to constitute a Judaizing reaction from the Pauline Gnosticism of Marcion.

Our readers are referred to special articles for a detailed exposition of these several Gnostic systems. It remains for us here to give a general sketch of the questions which Gnosticism discussed, and the broader features which characterized its main developments.

III. The fundamental questions with which Gnosticism concerned itself are the same which in all ages have agitated inquiry and baffled speculation, viz., the origin of life and the origin of evil,—how life sprung from the Infinite Source,—how a world so imperfect as this could proceed from a supremely perfect God. The Oriental notion of matter as utterly corrupt is found to pervade all Gnostical systems, and to give so far a common character to their speculations. It may be said to be the ground-principle of Gnosticism.

Setting out from this principle, all the Gnostics agree in regarding this world as not proceeding immediately from the Supreme Being. A vast gulf, on the contrary, is supposed to separate them. In the general mode in which they conceive this gulf to be occupied they also agree, although with considerable varieties of detail.

The Supreme Being is regarded as wholly inconceivable and indescribable—as the unfathomable Abyss (Valentinus)—the Unnamable (Basilides). From this transcendent source existence springs by emanation in a series of spiritual powers (*δυνάμεις*). It is only through these several powers or energies that the infinite passes into life and activity, and becomes capable of representation. To this higher spiritual world is given the name of *πλήρωμα*, and the divine powers composing it, in their ever-expanding procession from the Highest, are called Æons.

So far a common mode of representation characterizes all the Gnostical systems. All unite in this doctrine of a higher emanation-world. It is in the passage from this higher spiritual world to the lower material one that a speculative distinction of an important character begins to characterize them. On the one hand, this passage is apprehended as a mere continued degeneracy from the Source of Life, at length terminating in the kingdom of darkness and death—the bordering chaos surrounding the kingdom of light. On the other hand, this passage is apprehended in a more precisely dualistic form, as a positive invasion of the kingdom of light by a self-existent kingdom of darkness. According as Gnosticism adopted one or other of these modes of explaining the existence of the present world, it fell into the two great divisions which, from their places of origin, have received the respective names of the Alexandrian and Syrian Gnosis. The one, as we have seen, presents more a Western, the other more an Eastern type of speculation. The dualistic element in the one case scarcely appears beneath the Pantheistic, and bears resemblance to the Platonic notion of the *ὕλη*—a mere blank necessity, a limiting void. In the other case, the dualistic element is clear and prominent, corresponding to the Zarathustrian doctrine of an active principle of evil as well as of good—of a kingdom of Ahriman (Anro-Mainyus) as well as a kingdom of Ormuzd (Ahura-Mazdâo).

In the Alexandrian Gnosis a link of subordination is preserved between the two kingdoms, separated as they are. For the *ὕλη* only becomes a living and active power of evil through the quickening impartation of some element from the higher kingdom in its progressive descent from the Supreme Source. The stream of being in its ever-outward flow at length comes in contact with dead matter, which thus receives animation, and becomes a living source of evil. Its life and power, however, are withal only derived from the higher kingdom. But in the Syrian Gnosis the kingdom of darkness has no such dependence upon the kingdom of light. There appears from the first a hostile principle of evil in collision with the good.

Out of this main distinction other more special distinctions arise, still more clearly defining the one form of *γνῶσις* from the other. According as the two kingdoms are recognized as subordinate the one to the other, or as opposed to each other, it is obvious that different views will prevail as to the character of the *Δημιουργός*, or maker of this world, whose name and functions are so prominent in all systems of Gnosticism. In the one case, his relation to the Supreme Source of life will be apprehended as more dependent—in the other, as more hostile. In the former view, the *γνῶσις*, while rising in its pride of speculation far above all mere earthly relations and historical religions, could yet find in these a point of contact, whereby the higher spiritual truth, penetrating this lower world, would gradually raise it to its own elevation. In the latter, no such point of contact is left between nature, or history, and the *γνῶσις*. Accordingly, while the Alexandrian form of Gnosticism was found to embrace Judaism, as a divine institution, although very inferior and defective in its manifestation of the Divine character, the Syrian rejected it as being wholly the work of the spirit of the lower world—the *Δημιουργός* warring with the supreme God. This anti-Judaical spirit is found developed to its extreme in Marcion.

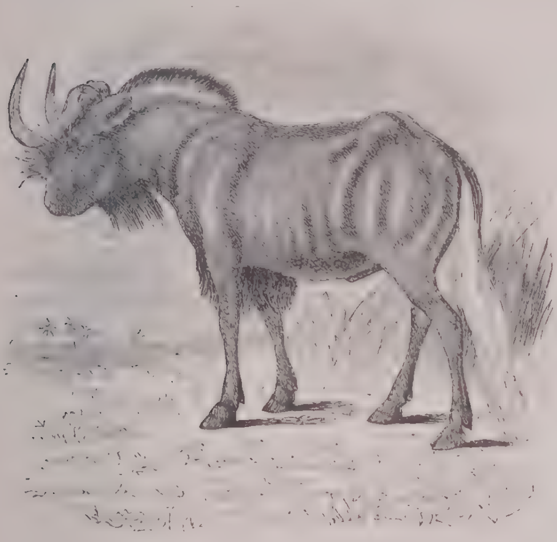
The Gnostic conception of Christ, in so far uniform, is also of course greatly modified by the different relations which the systems thus bore to Judaism. In all he is recognized as a higher Æon proceeding from the kingdom of light for the redemption of this lower kingdom of darkness. But, in the one case, however superior, he is yet allied to the lower region and the Δημιουργός, producing this lower world. His appearance, accordingly, admits of being historically connected with the previous manifestations of the Divine presence upon earth. But, in the other case, he is apprehended as a being wholly distinct from the *Δημιουργός*, and his appearance takes place in this lower world without any previous preparation, in order that he may draw to himself all kindred spiritual natures held in bondage by the power of this lower world. If any point of connection is admitted in this latter case betwixt Christianity and the lower world, it is certainly not found in Judaism or any historical religion, but in the theosophic schools, where an esoteric knowledge of the Supreme was cultivated.

IV. Vague, confused, and irrational as Gnosticism in most of its systems is, its influence upon the development of Christian thought was by no means detrimental. It compelled Christian teachers to face the great problems of which it attempted the solution in so many fantastic forms. It expanded the horizon of controversy within as without the church, and made men like Irenæus, and Clement, and Origen, and even Tertullian, feel that it was by the weapons of reason and not of authority that they must win the triumph of Catholic Christianity. Gnosticism, therefore, may be said to have laid the foundation of Christian science, and it is certainly interesting and deserving of notice that it is in the two great cities of Antioch and Alexandria,—where Gnosticism had chiefly planted itself,—that we see the rise of the first two schools of Christian thought. These centres of half-Pagan and half-Christian speculation became the first centres of rational Christian theology.

The several schools of Gnosticism seem to have gradually lost importance after the middle of the 3d century, although some of them continued to linger till the 6th century. Manichæism was little else than a revival of it in a Syrian form, and this system in the 4th and 5th centuries became so powerful as almost to be a rival to Christianity. The great Christian father St. Augustine, as is well known, was long fascinated by its influence. Again, strangely, in the 12th century the same spirit burst forth afresh, and in special connection with the name of the great apostle of the Gentiles. The sect of Paulicians, originating in the old Syrian haunt of heresy, Samosata, spread through Asia Minor, and then through Bulgaria and the borders of the Greek empire into Italy, Germany, and France. Gibbon, in the 54th chapter of his famous *Decline and Fall of the Roman Empire*, has given a vivid and powerful description of the fortunes and persecutions of the sect, and the readiness with which its doctrines seized upon whole populations. In southern France especially it spread like wildfire, and for a time almost entirely displaced Catholic Christianity. This Western development of the old Oriental dualism was characterized by many of the features of the earlier Gnosticism, such as the doctrine of the radical evil of matter, aversion to the Old Testament as the work of an evil Demiurge, and a docetic Christology. Extinguished in the horrors of the Albigensian war, it can hardly be said to have reappeared in the history of Christendom.

Literature.—Only one original Gnostic work has survived to modern times, the *πίστις σοφία* of Valentinus (edited by Petermann, Berlin, 1851); for all further knowledge of the system we are entirely dependent on the treatises of its avowed opponents, especially on that of Irenæus (*ἔλεγχος τῆς ψευδωνύμου γνώσεως*) and on that of Hippolytus (*ἔλεγχος κατὰ πασῶν αἱρέσεων*), although reference may also be made to passages bearing on the subject in the writings of Justin Martyr, Tertullian, Clemens Alexandrinus, Origen, Eusebius, Philastrius, Epiphanius, Theodoret, Augustine, and Porphyry. The subject is taken up with more or less fulness in all the church histories, and histories of philosophy. Among the more important recent works bearing upon the elucidation of Gnosticism may be mentioned those of Neander (*Genetische Entwickelung der vornehmsten Gnostischen Systeme*, 1818), Matter (*Histoire critique du Gnosticisme*, 1828, 2d. ed. 1843), Baur (*De Gnosticorum Christianismo Ideali*, 1827; *Die Christliche Gnosis*, 1835; *Die drei ersten Jahrhunderte*, 3d. ed., 1863), Bunsen (*Hippolytus u. seine Zeit*, 1852–53), Lipsius (art. "Gnosticismus" in Ersch and Gruber's *Encyclopädie*, republished in a revised form with the title *Der Gnosticismus; sein Wesen, Ursprung, und Entwickelung*, 1860), Harnack (*Zur Quellenkritik der Geschichte des Gnosticismus*, 1873), Mansel (*Gnostic Heresies*, 1875), and Lipsius (*Die Quellen der ältesten Ketzergeschichte neu untersucht*, 1875). References to the monographs by Ritschl, Volkmar, Heinrici, Hilgenfeld, and others on special branches of the subject will be found under the several headings BARDESANES, BASILIDES, MARCION, VALENTINUS, etc. (J. T.)

GNU (*Catoblepas*), a genus of ruminant mammals constituting the equine group of the antelope family, and containing two species—the gnu or kokoon (*Catoblepas gnu*) and the brindled gnu (*Catoblepas gorgon*). Owing to their singular appearance, which has been aptly compared to that of a creature compounded of a bison's head, a horse's body, and an antelope's legs, their proper zoological position has been a matter of dispute—some placing them among the oxen, while others regard them as a connecting link between bovine animals and the true antelopes. The gnu measures about 4½ feet in height at the shoulders, and 9 feet in extreme length. Its nose is broad and flattened, and bears on its upper surface a crest of reversed hair, while there is an abundant growth of bushy black hair beneath the chin and between the forelegs. The horns, which are present in both sexes, are very broad at their base, forming a solid helmet on the forehead, from which they bend downwards and outwards, thereafter curving rapidly upwards to the tip. A mane of light-colored hair, tipped with brown, and presenting a neatly clipped appearance, extends along the neck, while the horse-like tail, which is more or less of a creamy color, reaches to the ground. The nostrils are large, and are furnished with a muscular valve by which they can be closed. The gnu is a native of the arid plains of South Africa, where it congregates in considerable herds, its restlessness of disposition leading it to migrate frequently from place to place. The fantastic appearance of these creatures is fully equalled by the grotesqueness of their actions. Advancing, as they generally do, in single file, they may be seen wheeling and prancing in all directions, tossing their heads, switching their long tails, and then starting off, especially if alarmed by the appearance of a lion, at tremendous speed, raising columns of dust along their track, and leaving their pursuers hopelessly in the rear. Should they be surprised in their gambols by the sight of a caravan, their exceeding inquisitiveness impels them to approach the intruding object, which they do in a compact square, looking all the while the very picture of defiance. "During bright moonlight," says Captain Harris, "curiosity often prompted a *clump* of gnus to approach within a few yards of our bivouac, where they would stand for hours in the same position, staring wildly, lashing their dark flanks, and uttering a subdued note resembling the harsh croaking of a frog." The noise made by the old bulls, as they roam singly during the rutting season, is much more formidable, being usually compared to the roar of the lion; and many sportsmen who have hunted the gnu bear testimony to the remarkable likeness between the solitary males with their long manes, when seen at a considerable distance, and the "king of beasts." They are by no means the formidable creatures their ferocious aspect might lead one to suppose. However defiant the herd appears as it approaches a caravan, the report of a gun puts the whole troop of gnus to flight, and they are never known to attack man unless driven thereto in self-defence. The female has seldom more than a single young one at a birth, the calf at first being of a whitish color. When captured young, the gnu may, according to Captain Harris, be reared by the hand on cows' milk; and although of uncertain temper, it can be got to herd with the cattle on the farm. The flesh of the calf is considered a delicacy, but that of the adult is insipid, being almost destitute of fat. Its long silky tail is in great request for chowries, and its hide is cut into strips and used for ropes and twine.



Gnu.

The brindled gnu is a more northerly form, never being found south of the Orange river. It is readily distinguished from the other species by the black color of its tail and mane, the obscure vertical streaks on its body, is more elevated withers, and its extremely long aquiline nose. While equally grotesque in appearance and manner, it is much less spirited and active than the gnu. Its flesh is highly prized by the native, who also convert its hide into mantles, rendered attractive to South-African taste by being dressed without removing the long hair of the mane and beard.

GOA, a Portuguese settlement on the Malabar or western coast of India, lying between 15° 44′ 30′′ and 14° 53′ 30′′ N. lat., and between 73° 45′ and 74° 26′ E. long. It is bounded on the N. by the river Tirakul or Auraundem separating it from Śáwant Wári State, on the E. by the Western Gháts, on the S. by Kanara district, and on the W. by the Arabian Sea. Total area, 1062 square miles; population, 392,234.

This settlement forms a patch of foreign territory on the east of the Bombay coast, and is surrounded on all sides, except to the seaward, by British districts. Goa is a hilly country, especially the recently acquired portion known as the Novas Conquistas. Its distinguishing feature is the Sahyadri Mountains, which after skirting a considerable portion of the north-eastern and south-eastern boundary, branch off westwards across the territory with numerous spurs and ridges. The plains are well watered by large navigable rivers. The most important is the Mandavi river, on whose banks both the ancient and modern cities of Goa stand, with a fine harbor formed by the promontories of Bardez and Salsette. The port of New Goa or Panjim is divided into two anchorages by the projection of the *cabo* (cape) from the island of Goa, both capable of safely accommodating the largest shipping.

Goa ranks high as regards its early importance among the cities of western India. It emerges very distinctly in the 14th century, and was visited by the famous traveller Ibn Batuta. In the 15th century it formed the chief emporium of trade on the western side of India. Caravans of merchants brought down its products to the coast, and it was the only city in western India which enjoyed at this period a revenue of £10,000. Its wealth and advantageous situation attracted the Mahometan princes of the Deccan, and in 1469 it was taken by the Báhmani king. A fleet of 120 ships operated from the sea; the Báhmani troops forced their way down the passes of the Gháts; and Goa capitulated. It next passed under the Bijápur dynasty, and on the arrival of Albuquerque, at the beginning of the 16th century, its military and commercial capabilities at once struck his mind. In 1510 the fleet of Albuquerque, consisting of 20 sail of the line, with a few small vessels and 1200 fighting men, hove in sight off the harbor. A holy mendicant or *jogi* had lately foretold its conquest by a foreign people from a distant land, and the disheartened citizens rendered up the town to the strangers. Eight leading men presented the keys of the gates to Albuquerque on their knees, together with a large banner which was usually unfurled on state occasions. Mounted on a richly caparisoned steed, Albuquerque entered the city in a triumphal procession, with the Portuguese banners carried by the flower of the Lisbon nobility and clergy amidst the acclamations of an immense multitude, who showered upon the conqueror filigree flowers of silver and gold. Albuquerque behaved well to the inhabitants, but was shortly afterwards expelled by the Bijápur king. However, he returned a few months later with a fleet of 28 ships carrying 1700 men, and after a bloody attack, in which 2000 Mussulmans fell, forced his way into the town. For three days the miserable citizens were subjected to every atrocity. The fifth part of the plunder, reserved for the Portuguese crown, amounted to £20,000.

The conquest of Goa illustrates the essentially military basis on which the Portuguese power in India rested. The subsequent history of the town has been one of luxury, ostentation, and decay. After bearing a siege by the king of Bijápur, and suffering from a terrible epidemic, Goa reached the summit of its prosperity at the end of the 16th century, during the very years when the English Company was struggling into existence under Elizabeth. "Goa Dourada," or Golden Goa, seemed a place of fabulous wealth to the plain merchants who were destined to be the founders of British India. "Whoever has seen Goa need not see Lisbon," said a proverb of that day. Indeed, if the accounts of travellers are to be trusted, Goa presented a scene of military, ecclesiastical, and commercial magnificence, such as has had no parallel in the European capitals of India. The brilliant pomp and picturesque display of Goa were due to the fact that it was not only a flourishing harbor, but the centre of a great military and ecclesiastical power. The Portuguese based their dominion in India on conquest by the sword. They labored to consolidate it by a proselytizing organization which throws all other missionary efforts in India into the shade.

Goa reached its climax of pomp and power about the year 1600. Immediately afterwards commenced the long struggle with the Dutch, which before the end of the century had stripped Portugal of its fairest possessions in the East. In 1603 the Dutch blockaded Goa, but had to raise the siege. In 1635 the old epidemic fever which had afflicted Goa in the preceding century again broke out, and raged for five years. In 1639 the Dutch once more blockaded Goa, but found their meagre force of twelve ships insufficient for its capture. In 1666 luxury and the plague and the Dutch privateers had effectually crippled the commerce of Goa. Thevenot in that year drew a powerful picture of the decayed city. In 1675 Dr. John Fryer described the city as in a ruinous state, whilst the inhabitants still made pitiful attempts at display in spite of their increasing misery. In 1683 Goa narrowly escaped falling into the hands of the Marhattá hordes under Sambáji. Before 1687 the abandonment of Old Goa had taken place. "Many streets," says an official document of that year, "have now become lonely and uninhabited." The river had silted opposite its quays, ships could no longer approach the city, the fever had again broken out, and the population had moved out to suburbs nearer the mouth of the river. In 1695 only 20,000 inhabitants remained. In 1739 the whole territory was attacked by the Marhattás, and only saved by the unexpected appearance of a new viceroy with a fleet. Various attempts were made in vain to rebuild Old Goa, and by the middle of the 18th century "this fairest but poorest settlement had become a burden to the Portuguese Home Government, costing no less than 300,000 piastres a year."

In 1759 further attempts to rebuild Old Goa were given up, and the governor changed his residence to Panjim or New Goa, the present city, at the mouth of the river. In 1775 the population was reduced to about 1600 souls, of whom 1198 were Christians, almost entirely half-castes and native converts. In 1759 also the Jesuits were expelled. They had got into their hands what little commerce remained, and the last touch was put to the ruin of Old Goa. "The river washes the remains of a great city,—an arsenal in ruins, palaces in ruins, quay walls in ruins, churches in ruins,—all in ruins. We looked and saw the site of the Inquisition, the bishop's prison, a grand cathedral, great churches, chapels, convents, religious houses, on knolls surrounded by jungle and trees scattered all over the country. We saw the crumbling masonry which once marked the lines of streets and enclosures of palaces, dockyards filled with weeds and obsolete cranes."

Panjim or New Goa lies in lat. 15° 30′ N., long. 75° 53′ E., at the mouth of the river Mandavi, and is a modern town with few pretensions to architectural beauty. Ships of the largest tonnage can lie out in the harbor, but only vessels of moderate size can be brought alongside of the city. The population is estimated at 15,000. Panjim was the residence of the viceroy from 1759, and in 1843 was ranked the capital of the Portuguese possessions in India.

The territory of Goa, including the two cities of Old Goa and Panjim with the adjoining country under Portuguese rule, amounts, as already stated, to 1062 square miles. Of the total population, namely, 392,234, nearly two-thirds or 232,089 are Roman Catholics, 128,824 are Hindus, and 2775 Mahometans. The Roman Catholics are subject in spiritual matters to an archbishop, who has the title of primate of the East. The Hindus and Mahometans enjoy perfect liberty in their religious affairs, and have their own places of worship. Agriculture forms the chief industry of the country. The total area under cultivation is 234,754 acres. Rice is the staple produce; next is the cocoa-nut, which is deemed important from the variety of uses to which the products are applied. The chief exports are cocoa-nuts, betel-nuts, mangoes, water-melons, cinnamon, pepper, salt fish, gum, firewood, and salt; and the chief imports rice, cloth, sugar, wines, tobacco, glassware, and hardware. The district seldom suffers from great floods. Some parts are subjected to inundations during heavy rains, but little damage is done to the crops. The high-lying town of Panjim takes its name from the native word *Ponji*, meaning "arable land that cannot be inundated." The total revenue in 1873–74 was £108,148; the expenditure, £107,145. The police force numbers 919 men. In 1869–70 there were 137 lower schools, and 25 higher schools, including a National Lyceum with 2433 pupils. There are also medical and chemistry schools, and since 1870 a college for the study of practical sciences has been established. The prevailing endemic diseases are intermittent and remittent fevers, diarrhœa, and dysentery. The average annual rainfall for the three years ending 1875 was 100·22 inches.

See "Livro dos privilegios da Cidada de Goa," in *Archivio Portuguez Oriental*, 1857; *Archivo da Relaças de Goa contendo varios documentos dos Seculos, 17, 18, e 19*, by J. I. de Avranches Garcia, 1872, etc.; *Feições meterologicas de Goa*, 1867; *Boletim de Governo dos Estados da India*, Goa and New Goa, 1838–70, etc.; *O Gabinete litterario das Fontainhas* (monthly, 1846, etc.); Tolbort, "The Authorities for the History of the Portuguese in India," in *Journ. of Asiatic Soc. of Bengal*, 1873; R. F. Burton, *Goa and the Blue Mountains*, 1851; Mrs. Burton, *A.E.I., Arabia, Egypt, India*, 1879.

GOA POWDER, a drug occurring in the form of a yellowish-brown powder, varying considerably in tint, which has recently been brought into notice by Dr. Fayrer of Calcutta as a remedy for ringworm. It derives its name from the Portuguese colony of Goa, where it appears to have been introduced about the year 1852. In 1875 it was shown by Dr. Lima that the substance had been exported from Bahia to Portugal, whence it found its way to the Portuguese colonies in Africa and Asia. The tree which yields it belongs to the genus *Andria* of the natural order *Leguminosæ*, and has been named *A. Araroba*. It is met with in great abundance in certain forests in the province of Bahia, preferring as a rule low and humid spots. The tree is from 80 to 100 feet high, and is furnished with imparipinnate leaves, the leaflets of which are oblong, about 1½ inch long and ¾ inch broad, and somewhat truncate at the apex. The flowers are papilionaceous, of a purple color, and arranged in panicles. The Goa powder or araroba is contained in the trunk, filling crevices in the heartwood. To obtain it, the oldest trees are selected as containing the larger quantity, and after being cut down are sawn transversely into logs, which are then split longitudinally, and the araroba chipped or scraped off with the axe. During this process the workmen feel a bitter taste in the mouth; and great care has to be taken to prevent injury from the irritating action of the powder on the eyes. In this state, *i. e.*, mixed with fragments of wood, the Goa powder is exported in casks.

In India Goa powder has been used in the form of a paste, made by mixing the powder with vinegar or lime juice, as a local application for the cure of Indian ringworm. It appears to be one of the best remedies for that obstinate disease; and so highly is it valued that its price in Bombay averages £3 12s. per ℔. Its use in chloasma, intertrigo, and psoriasis, as well as in various other skin diseases, has also been attended with considerable success. The only disadvantages attending its use are—that it leaves a stain which is difficult to remove, and that the powder is apt to set up severe irritation of the eyes, if it come in contact with the conjunctiva. On this account Mr. Balmanno Squire prefers to use it in the form of ointment. When given internally it has been found to act as an emetic and purgative. In England it is now regarded as one of the most efficacious remedies in intractable cases of ringworm.

GOÁLPÁRA, the most westerly district of Assam, between 25° 21′ and 26° 54′ N. lat., and between 89° 44′ and 91° 0′ E. long., bounded on the N. by Bhután, E. by Kámrúp, S. by the Gáro Hills, and W. by Kuch Behar and Rangpur. The district is situated on the Brahmaputra, at the corner where the river takes its southerly course into Bengal. The scenery is striking. Along the banks of the river grow clumps of cane and reed; farther back stretch fields of rice cultivation, broken only by the fruit trees surrounding the villages, and in the background rise the forest-clad hills overtopped by the white peaks of the Himálayas. The soil of the hills is of a red ochreous earth, with blocks of granite and sandstone interspersed; that of the plains is of alluvial formation. Earthquakes are common, and occasionally severe shocks have been experienced. The Brahmaputra annually inundates vast tracts of country. Numerous extensive forests yield valuable timber. Wild animals of all kinds are found.

Goálpára has always formed the frontier between Bengal and Assam; originally it must have constituted part of the legendary Hindu kingdom of Kámrúp; from that it must have fallen into the hands of the early rájás of Kuch Behar, who, however, were unable long to retain their kingdom. From the east the wild Ahams came down the valley of the Brahmaputra, while from the west the Mughuls extended the limits of the Delhi empire. In 1603 the Mughuls came into collision with the Ahams, but were forced to retreat with a decisive defeat. The district came into British possession with the rest of Bengal in 1765. It has undergone several changes in administration, and in 1872, when Assam was constituted a separate administration, Goálpára was included within it.

In 1872 the population was 407,714,—311,419 being Hindus, and 89,916 Mahometans. Goálpára town, with between 3000 and 4000 inhabitants, is the most populous place, as well as the chief centre of trade. Dhubri is the point where the traffic of northern Bengal is shipped on board the Assam steamers. Gauripur and Lakhshmipur carry on a thriving trade in timber.

Rice forms the staple crop of the district. Mustard and jute are also largely grown. The area under cultivation is estimated at 600,000 acres, or about one-third of the total area. The district is not liable to any form of natural calamity; occasionally blights have been caused by worms and insects, but the harvests have never been affected. The manufactures consist of the making of brass and iron utensils and of gold and silver ornaments, weaving of silk cloth, basket-work, and pottery. The cultivation of tea has recently been introduced, and is advancing considerably. The chief centres of traffic are Goálpára town, Dhubri, Jogigopha, Bijni, Gauripur, and Singiwári. Local trade is in the hands of Márwári merchants, and is carried on at the *bázárs*, weekly *háts* or markets, and periodical fairs. The chief exports are mustard-seed, jute, cotton, timber, lac, silk cloth, india-rubber, and tea; the imports, Bengal rice, European piece goods, salt, hardware, oil, and tobacco. The Brahmaputra and its tributaries are the chief means of communication, and are navigated by river steamers and the largest native boats. Goálpára is considered an unhealthy district both for Europeans and for natives. The principal diseases are intermittent and remittent fevers, diarrhœa, dysentery, rheumatism, and chest complaints. Cholera frequently occurs in an epidemic form, and small-pox is more or less prevalent every year. The mean annual temperature is 75° Fahr.; and the average annual rainfall is 98·75 inches.

Goálpára, the chief town of above district, situated on the left bank of the Brahmaputra, in 26° 11′ 0″ N. lat., 90° 41′ 0″ E. long. It was the frontier outpost of the Mahometan power in the direction of Assam, and has long been a flourishing seat of river trade. The civil station is built on the summit of a small hill commanding a magnificent view of the valley of the Brahmaputra, bounded on the north by the snowy ranges of the Himálayas and on the south by the Gáro hills. The native town is built on the western slope of the hill, and the lower portion is subject to inundation from the marshy land which extends in every direction. Population (1872) 4678.

GOAT. All the species of the genus *Capra* may be divided into two classes, the one being represented by the ibex (see Ibex) and the other the goat. The latter class is subdivided into the ægagrus or wild goat (*Capra ægagrus*) and the domestic goat (*Capra hircus*), of which there are many varieties.

The Wild Goat, or Paseng of the Persians (*Capra ægagrus*, Pall.), is an inhabitant of the mountainous regions of Central Asia from the Caucasus to the Himalayas, and is occasionally met with in troops at great elevations. It stands somewhat higher than any of the domesticated varieties of the goat, from which it further differs in its stouter limbs and more slender body. Its neck is short, and is thus fitted to bear the enormous horns, which in the male are larger proportionally than in any other ruminant animal. These measure nearly three feet in length, are obscurely triangular in form, transversely ridged, and are bent backward as in the domestic varieties. The wild goat of the Himalayas, according to Darwin, when it happens to fall accidentally from a height, makes use of its massive horns by bending forward its head and alighting on them, thus breaking the shock. In the female the horns are exceedingly diminutive, or are altogether awanting. The fur, which over the greater part of the body is short, is of a greyish-brown color, with a black line running along the entire length of the back; the short tail and the muzzle are also black, while the under surface of the neck, and the beard, which is present in both sexes, are of a brown color. The paseng is exceedingly wary of the approach of man, and as its agility is no less remarkable there has been little opportunity of studying it closely. The concretions known as *bezoar-stones*, which were formerly much used in medicine and as antidotes of poison, are believed to have been originally obtained from the intestines of this species.

Considerable diversity of opinion has been expressed by naturalists as to the original stock of the domestic goat, which is met with in nearly every quarter of the globe,—the now prevalent and the most probable opinion being that the various domestic breeds are severally descended from wild stock now extinct. Both the ibex and the ægagrus interbreed freely with the common goat, though the produce is not always fertile. Instances of this are not unusual in the Alps and Pyrenees, where goats abound in a semi-domesticated state. Hybrids between the goat and the sheep are also known to have occurred, but are rare.

The following are the chief domestic breeds, possessing distinct characteristics:—the Common Goat, the Maltese, the Syrian, the Angora, the Cashmere, the Nubian or Egyptian, and the Dwarf Goat of Guinea.

The Common Goat.—This has many varieties which differ from each other in length of hair, in color, and slightly in the configuration of the horns. The ears are more or less upright, sometimes horizontal, but never actually pendent, as in some Asiatic breeds. The horns are rather flat at the base and not unfrequently corrugated; they rise vertically from the head, curving to the rear, and are more or less laterally inclined. The color varies from a dirty white to a dark-brown, but never black, which indicates Eastern blood. Most of the European countries possess more than one description of the common goat. In the British Isles there are two distinct types, one short and the other long haired. In the former case the hair is thick and close, with frequently an undercoat resembling wool. The horns are large in the male, and of moderate size in the female, flat at the base and inclining outwards. The head is short and tapering, the forehead flat and wide, and the nose small; the legs strong, thick, and well covered with hair. The color varies from white or grey to black, but is frequently fawn, with a dark line down the spine and across the shoulders. The other variety owns a shaggy coat, generally of a reddish-black hue, though sometimes grey or pied and occasionally white. The head is long, heavy, and ugly, the nose coarse and prominent, the horns are situated close together, and often continue parallel almost to the extremities, being also large, corrugated, and pointed. The legs are long, and the sides flat, the animal itself being generally gaunt and thin. This breed is peculiar to Ireland, the Welsh being of a similar description, but more often white. The short-haired goat is the English goat proper. From the constant crossing, however, that takes place between these native breeds and imported foreign specimens, one meets in England with animals possessing very great diversity of form. Both the British breeds and those from abroad are frequently ornamented with two peculiar tassel-like appendages, which hang near together under the throat. It is supposed by many that these ornaments are traceable to some foreign origin; but although there are foreign breeds that possess them, they appear to pertain quite as much to the English native breeds as to those of distant countries, and indeed the peculiarity referred to is mentioned in very old works that describe the goats of the British Islands. The milk produce in the common goat as well as other kinds varies very greatly with individuals. Irish goats often yield a quantity of milk, but the quality is comparatively poor. The goats of France are very similar to those of Britain, varying in length of hair, color, and character of horns. A French writer describes them as possessing "a particularly neat and compact head, small mouth, horns corrugated, and inclining upwards and outwards, a thin neck, narrow chest, and long body, long but muscular legs, and in color white, black, fawn, or pied." The Norway breed is frequently pure white with long hair; it is rather small in size, with small bones, a short rounded body, head small with a prominent forehead, and short, straight, corrugated horns. The facial line is concave. The horns of the male are very large, and curl round after the manner of the wild goat, with a tuft of hair between and in front.

The *Maltese Goat* has its ears long and wide and perfectly pendulous, hanging down below the jaw. The hair is long and cream-colored. Specimens of this kind are usually hornless, which is perhaps the cause of it having been called the "Hornless Variety." It would appear, however, that the absence of these appendages is simply a freak of nature, and not the peculiar characteristic of a particular species.

The Syrian Goat.—This breed is met with in various parts of the East, in Lower Egypt, on the shores of the Indian Ocean, and in the island of Madagascar. Both its hair and ears are excessively long, the latter so much so that they are sometimes clipt to prevent their being torn by stones or thorny shrubs. Its horns are somewhat erect and spiral, with an outward bend.

The *Angora Goat* is often confounded with the Cashmere, but is in reality quite distinct from it. The principal feature of this breed, of which there are two or three varieties, is the length and quantity of its hair, which has a particularly soft and silky texture, covering the whole body and a great part of the legs with close matted ringlets. The horns of the male differ from those of the female, being directed vertically, and in shape spiral, whilst in the female they have a horizontal tendency, somewhat like those of a ram. The face has a sheepish expression. The coat is composed of two kinds of hair, the one short and coarse and of the character of hair, which lies close to the skin, the other long and curly and of the nature of wool, forming the outer covering. Both are used by the manufacturer, but the exterior portion, which makes up by far the greater bulk, is much the more valuable. The process of shearing takes place in early spring, and is conducted with the utmost care; the average amount of wool yielded by each animal is about 2½ ℔. The best quality comes from castrated males, the females producing the next best. The annual export of wool from Angora is estimated at about 2,000,000 ℔, and its value at £200,000. Large herds are shipped at Constantinople and sent to Cape Colony, where this breed thrives well and is largely propagated, the climate being specially suitable to the perfect development of the wool. A very valuable consignment of these animals arrived in London in May, 1879, for transshipment to the Cape, having been procured from different parts of Asia Minor, by means of great personal exertion, by Mr. J. B. Evans, a South-African goat farmer. The wool or mohair, as it is technically termed, of these goats was remarkably long, fine, and heavy, the average weight of the produce of the herd being reckoned at 6 ℔ per head. So highly is this breed esteemed by the Turkish farmers that it was with the greatest reluctance they were induced to sell them, and then only at exorbitant prices, some of the males costing £250 and females £150. £50 and £60 are common prices for these goats at Angora. Fig. 1 is from a photograph of the finest male of the flock, the fleece of which was estimated to weigh when shorn full 15 ℔. The breed was introduced at the Cape about 1864. In 1878, according to the customs returns, 1,300,585 ℔ weight of mohair was exported, of the value of £105,313. The Angora is a bad milker and an indifferent mother, but its flesh is better eating than that of any other breed, and in its native country is preferred to mutton. The kids are born very small, but grow fast, and arrive early at maturity. This variety of the goat approaches nearest in its nature, form, and habits to the sheep, even the voice having a strong resemblance.

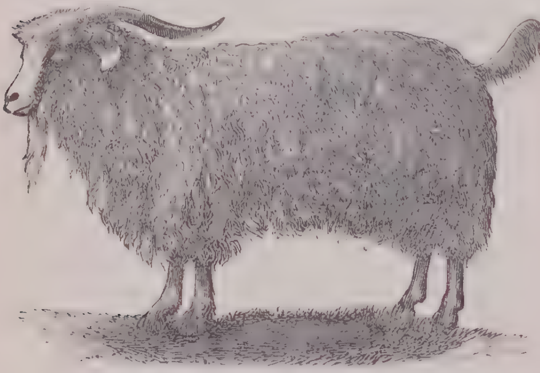


Fig. 1.—Angora Male Goat.

The Cashmere Goat.—This animal has a delicate head, with semi-pendulous ears, which are both long and wide. The hair varies in length, and is coarse and of different colors, according to the individual. The horns are very erect, and sometimes slightly spiral, inclining inwards and to such an extent in some cases as to cross. The coat is composed, as in the Angora, of two materials; but in this breed it is the under coat that partakes of the nature of wool and is valued as an article of commerce. This undergrowth, which is of a uniform greyish-white tint, whatever the color of the hair may be, is beautifully soft and silky, and of a fluffy description resembling down. It makes its appearance in the autumn, and continues to grow until the following spring, when if not removed, it falls off naturally; its collection then commences, occupying from eight to ten days. The animal undergoes during that time a process of combing by which all the wool and a portion of the hair, which of necessity comes with it, is removed. The latter is afterwards carefully separated, when the fleece in a good specimen weighs about half a pound, being worth between half to three quarters of a rupee. It is sold by the "turruk" of 12 ℔. This is the material of which the far-famed and costly shawls are made, which at one time had such a demand that, it is stated, "16,000 looms were kept in constant work at Cashmere in their manufacture." Those goats having a short, neat head, very long, thin ears, a delicate skin, small bones, and a long heavy coat, are for this purpose deemed the best. There are several varieties possessing this valuable quality, but those of Cashmere, Thibet, and Mongolia are the most esteemed. About the year 1816 a small herd of Cashmeres was introduced into France with a view to acclimatize and breed them for the sake of their wool, but the enterprise failed. A few were purchased and brought over to England by Mr. C. T. Tower, who, by careful treatment, so far succeeded with them that, in course of time, he had a shawl made from their fleece, which turned out to be of good quality. At the death of the owner some years later, the herd, which had then deteriorated through in-breeding, was presented to the Queen and placed in Windsor Park.

The *Nubian Goat*, which is met with in Nubia, Upper Egypt, and Abyssinia, differs greatly in appearance from all those previously described. The coat is in the female extremely short, almost like that of a race-horse, and the legs are very long. This breed therefore stands considerably higher than the common goat. One of its peculiarities is the strongly convex shape of the face, the forehead being very prominent and the nostrils sunk in, the nose itself extremely small, and the lower lip projecting from the upper. The ears are long, broad, and thin, and hang down by the side of the head like a "double lop" rabbit. The horns are quite black, slightly twisted, and very short, flat at the base, pointed at the tips, and recumbent on the head. But little was known of this breed in Europe—in the West at least—until some ten or twelve years ago, when some were imported into France by the Société d'Acclimatation of Paris, who found its milking qualities to surpass those of all other breeds. Among the goats that are met with in England a good many show unmistakable signs of a more or less remote cross with this breed derived probably from specimens brought from the East on board ships for supply-

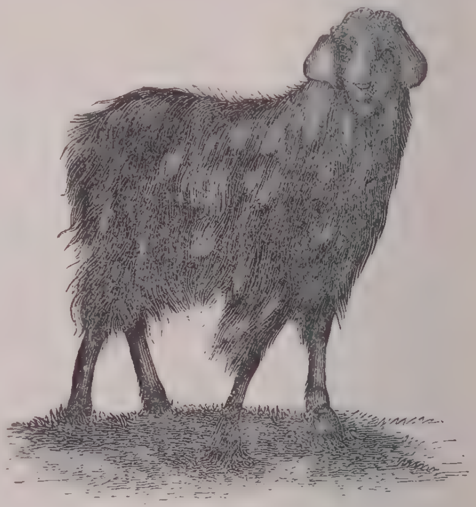


Fig. 2.—Nubian Goat.

ing milk during the voyage. It is no doubt on this account that they often go by the name of "Indian" goats.

The *Nepaul Goat* appears to be a variety of the last breed, it having the same arched facial line, pendulous ears, and long legs. The horns, however, are more spiral. The color of the hair, which is longer than in the Nubian, is black, grey, or white, with black blotches.

The *Guinea Goat* is a dwarf species originally from the coast whence its name is derived. There are three varieties Besides the commonest (*Capra recurva*, Linn.), there is a rarer breed (*Capra depressa*, Linn.), inhabiting the Mauritius and the islands of Bourbon and Madagascar. The other variety is met with along the White Nile, in Lower Egypt and at various points on the African coast of the Mediterranean. Some of these dwarf goats may be seen at the Jardin d'Acclimatation in Paris.

Habits and Management.—The milch goat has been aptly described as the "poor man's cow"—a designation it well merits, for with a couple of these animals the cottager may at an almost nominal expense enjoy the same advantages in a domestic point of view as the rich man with his "Alderney." Comparatively few are kept in England, because the advantages of goat-keeping are but very imperfectly known, and also on account of the large proportion of land under cultivation. The goat in a state of nature frequents hills and mountainous places, and in a domesticated condition it generally gives preference to elevated situations; but it is a mistake to suppose that it will not thrive on low ground. Being naturally adapted to rocks and dry soils, however, it should not be exposed in marshy places, as this brings on disease of the feet and general ill health; otherwise there is no animal more uniformly hardy. The common varieties will stand heat and cold equally well, but have a decided objection to storms of wind and rain; when they are left to roam loose, therefore, a rough shed should be erected to shelter them from the weather. Under this arrangement a goat may be left out day and night the whole year round; but, if it is kept for the sake of its milk, the yield is greater and it thrives better if housed during winter. Owing to the troublesome propensity of these animals to bark trees and destroy shrubs by nipping off all young and tender shoots, they should not be allowed to roam loose—except on a common—unless proper protection is afforded by wire netting or some such arrangement.

The goat breeds, generally speaking, but once a year. If well housed and under liberal treatment, it will bring forth young twice in twelve months; but this is not advisable. As a rule, at the first birth one kid only is produced, but afterwards two and sometimes three. One has been known for three consecutive years to drop four at a birth; but this is rare and by no means desirable, as the progeny are sure to be small and thrive badly,—the dam in most cases having insufficient milk for so large a family.

The goat propagates at a very early period of its life. The male is generally capable of engendering at seven months; and, in the case just referred to of four at a birth, the father on one occasion was barely six months old. One is sufficient for a hundred females. The latter bring forth at twelve months, and sometimes earlier. For the sake of the future growth and productiveness of the animal, however, it is unwise to permit intercourse between the sexes earlier than at eighteen or at least sixteen months. It is owing to the baneful practice of letting them breed as soon as they will, under the mistaken idea that a more rapid return is obtained, that so many diminutive specimens are met with, both dam and progeny being spoiled in consequence.

The best kind for milch purposes are those with long and deep bodies, not necessarily so broad at the chest as about the haunches, the belly ample and the legs tolerably short; head fine and tapering, with prominent eyes, ears long, thin, wide, and inclining horizontally, horns short and not corrugated, neck thick, and coat close and short. The udder above all must be not only large but soft and elastic, with nice pointed teats. Hornless specimens are often the best milkers.

The goat has 32 teeth, and by these the age up to five years may be pretty accurately ascertained. The lower jaw possesses 12 molars and 8 incisors, and the upper 12 molars alone. The kid at its birth has 6 molars but no incisors; the latter, however, are generally all cut in about three weeks, the first cut molar being visible at three months. At a year or fifteen months old the two front "milk teeth," as the first set of incisors are called, fall, and are replaced by permanent ones; the next two at from two years to thirty months, the third pair from two and a half to three and a half years, and the fourth and last at from three and a half to four and a half years. When all are changed the mouth is said to be "full."

Between two and five years old the she-goat gives the best return in milk, continuing productive often for eight or nine years; its length of life is on an average from ten to fifteen. These animals vary very greatly in the quantity of milk they yield. An ordinary specimen gives from 2 to 3 pints, a superior one 2 quarts, and occasionally first-rate individuals are found supplying 3 quarts a day. The Nubian breed surpasses the common goat in this respect, as the following table from the French work of M. du Plessis will show, in which the yield of a Nubian is compared with that of a half-bred, itself a superior milker.

Half-bred Nubian and Native.			*Pure Nubian Breed.*		
	Milk.	Cream.		Milk.	Cream.
1st day	3·57 litres.	·22 litres.	1st day	4·39 litres.	·3800 litres.
2d "	3·42 "	·21 "	2d "	4·41 "	·3848 "
3d "	3·35 "	·20 "	3d "	4·53 "	·3850 "
4th "	3·62 "	·23 "	4th "	4·67 "	·3969 "
5th "	3·69 "	·24 "	5th "	4·94 "	·4030 "
	17·65 "	1·10 "		22·94 "	1·9497 "

The litre being as near as possible 1¾ pints, the return in English measure is accordingly—from the half-bred 31 pints, or an average per day of 3 quarts, and from the pure Nubian 40 pints, or nearly 4 quarts daily, the richness of the quality being proportionately greater.

Milking should be performed at regular hours, morning and night; but with heavy milkers three times daily is better for the first two or three months, as the oftener the udder is emptied when once full the quicker it is replenished, a sufficient supply of food being of course provided. It is a good plan to accustom the animal to jump on a platform whilst being milked: the teats are thus more easily manipulated, and more command is obtained over the goat and the pail. Feeding and milking should always be carried on at the same time.

Many persons are under the wrong impression that the milk of the she-goat,—which by the way has no strong *hircine* scent attaching to her like the male, another common error,—possesses a flavor peculiar to itself; but this is quite a mistake. Out of dozens kept by the present writer, only one has been found to yield milk differing from that of the cow in taste. The peculiarity in this case seemed natural to the animal, and the milk was decidedly unpalatable.

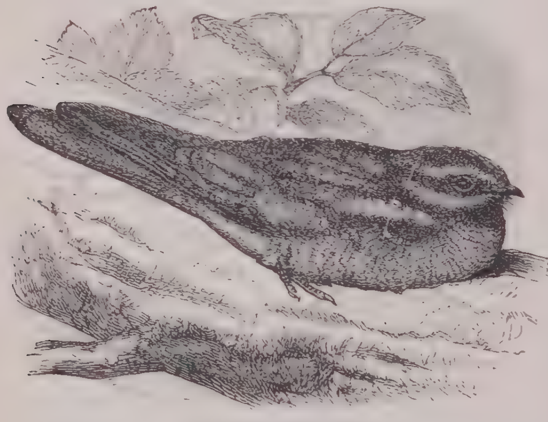
The flesh of the common goat, although quite eatable, is not to be recommended in comparison with mutton, being rather hard and indigestible. Kid, however, is a great delicacy, and tastes like lamb or veal, according to the manner of dressing. It is preferable cooked like veal, with layers of bacon tied round and stuffed, for with the exception of the suet there is very little fat. A good rich gravy should accompany the joint when served, and there should be no lack of cooking. Hot or cold it is then equally acceptable. Suckling kids are the best eating, as they have then their milk flesh, and are nice and plump. The skins dressed and sewed together make handsome rugs. For food and other remarks on goat-keeping see AGRICULTURE, vol. i. p. 354.

(S. H. P.)

GOATSUCKER, a bird from very ancient times absurdly believed to have the habit implied by the common name it bears in many European tongues besides our own —as testified by the Greek Αἰγοθήλας, the Latin *Caprimulgus*, Italian *Succiacapre*, Spanish *Chotacabras*, French *Tettechèvre*, and German *Ziegenmelker*. The common Goatsucker (*Caprimulgus europæus*, Linn.) is admittedly the type of a very peculiar and distinct Family, *Caprimulgidæ*, a group remarkable for the flat head, enormously wide mouth, large eyes, and soft pencilled plumage of its members, which vary in size from a Lark to a Crow. Its position has been variously assigned by systematists. Though of late years judiciously removed from the *Passeres*, in which Linnæus placed all the species known to him, Professor Huxley considers it to form, with two other Families —the Swifts (*Cypselidæ*) and Humming-birds (*Trochilidæ*), the division *Cypselomorphæ* of his larger group *Ægithognathæ*, which is equivalent in the main to the Linnæan *Passeres*. There are two ways of regarding the *Caprimulgidæ* —one including the genus *Podargus* and its allies, the other recognizing them as a distinct Family, *Podargidæ*. As a matter of convenience we shall here comprehend these last in the *Caprimulgidæ*, which will then contain two subfamilies, *Caprimulginæ* and *Podarginæ:* for what, according to older authors, constitutes a third, though represented only by *Steatornis*, the singular Oil-bird, or Guacharo, certainly seems to require separation as an independent Family (see GUACHARO).

Some of the differences between the *Caprimulginæ* and *Podarginæ* have been pointed out by Mr. Sclater (*Proc. Zool. Soc.*, 1866, p. 123), and are very obvious. In the former the outer toes have *four* phalanges only, thus presenting a very uncommon character among birds, and the middle claws are pectinated; while in the latter the normal number of five phalanges is found and the claws are smooth, and other distinctions more recondite have also been indicated by him (*tom. cit.*, p. 582). The *Caprimulginæ* may be further divided into those having the gape thickly beset by strong bristles, and those in which there are few such bristles or none—the former containing the genera *Caprimulgus, Antrostomus, Nyctidromus*, and others, and the latter *Podager, Chordiles, Lyncornis*, and a few more.

The common Goatsucker of Europe (*C. europæus*) arrives late in spring from its winter retreat in Africa, and its presence is soon made known to us by its habit of chasing its prey, consisting chiefly of moths and cockchafers, in the evening-twilight. As the season advances the song of the cock, from its singularity, attracts attention amid all rural sounds. This song seems to be always uttered when the bird is at rest, though the contrary has been asserted, and is the continuous repetition of a single burring note, as of a thin lath fixed at one end and in a state of vibration at the other, and loud enough to reach in still weather a distance of half-a-mile or more. On the wing, while toying with its mate, or performing its rapid evolutions round the trees where it finds its food, it has the habit of occasionally producing another and equally extraordinary sound, sudden and short, but somewhat resembling that made by swinging a thong in the air, though whether this noise proceeds from its mouth is not ascertained. In general its flight is silent, but at times when disturbed from its repose, its wings may be heard to smite together. The Goatsucker, or, to use perhaps its commoner English name, Nightjar,[1] passes the day in slumber, crouching on the ground or perching on a tree—in the latter case sitting not across the branch but lengthways, with its head lower than its body. In hot weather, however, its song may sometimes be heard by day and even at noontide, but it is then uttered, as it were, drowsily, and without the vigor that characterizes its crepuscular or nocturnal performance. Towards evening the bird becomes active, and it seems to pursue its prey throughout the night uninterruptedly, or only occasionally pausing for a few seconds to alight on a bare spot—a pathway or road—and then resuming its career. It is one of the few birds that absolutely make no nest, but lays its pair of beautifully-marbled eggs on the ground, generally where the herbage is short, and often actually on the soil. So light is it that the act of brooding, even where there is some vegetable growth, produces no visible depression of the grass, moss, or lichens on which the eggs rest, and the finest sand equally fails to exhibit a trace of the parental act. Yet scarcely any bird shows greater local attachment, and the precise site chosen one year is almost certain to be occupied the next. The young, covered when hatched with dark-spotted down, are not easily found, nor are they more easily discovered on becoming fledged, for their plumage almost entirely resembles that of the adults, being a mixture of reddish-brown, grey, and black, blended and mottled in a manner that passes description. They soon attain their full size and power of flight, and then take to the same manner of life as their parents. In autumn all leave their summer haunts for the south, but the exact time of their departure has hardly been ascertained. The habits of the Nightjar, as thus described, seem to be more or less essentially those of the whole Subfamily—the differences observable being apparently less than are found in other groups of birds of similar extent.



Common Goatsucker.

A second species of Goatsucker (*C. ruficollis*), which is somewhat larger, and has the neck distinctly marked with rufous, is a summer visitant to the south-western parts of Europe, and especially to Spain and Portugal. The occurrence of a single example of this bird at Killingworth, near Newcastle-on-Tyne, in October, 1856, has been recorded by Mr. Hancock (*Ibis*, 1862, p. 39); but the season of its appearance argues the probability of its being but a casual straggler from its proper home. Many other species of *Caprimulgus* inhabit Africa, Asia, and their islands, while one (*C. macrurus*) is found in Australia. Very nearly allied to this genus is *Antrostmous*, an American group containing many species, of which the Chuck-will's widow (*A. carolinensis*) and the Whip-poor-will (*A. vociferus*) of the eastern United States (the latter also reaching Canada) are familiar examples. Both these birds take their common name from the cry they utter, and their habits seem to be almost identical with those of the Old-World Goatsuckers. Passing over some other forms which need not here be mentioned, the genus *Nyctidromus*, though consisting of only one species (*E. albicollis*) which inhabits Central and part of South America, requires remark, since it has tarsi of sufficient length to enable it to run swiftly on the ground, while the legs of most birds of the Family are so short that they can make but a shuffling progress. *Heleothreptes*, with the unique form of wing possessed by the male, needs mention. Notice must also be taken of two African species, referred by some ornithologists to as many genera (*Macrodipteryx* and *Cosmetornis*), though probably one genus would suffice for both. The males of each of them are characterized by the wonderful development of the ninth primary in either wing, which reaches in fully adult specimens the extraordinary length of 17 inches or more. The former of these birds, the *C. macrodipterus* of Afzelius, is considered to belong to the west coast of Africa, and the shaft of the elongated remiges is bare for the greater part of its length, retaining the web, in a spatulate form, only near the tip. The latter, to which the specific name of *vexillarius* was given by Mr. Gould, has been found on the east coast of that continent, and is reported to have occurred in Madagascar and Socotra. In this the remigial streamers do not lose their barbs, and as a few of the next quills are also to some extent elongated, the bird, when flying, is said to look as though it had four wings. Specimens of both are rare in collections, and no traveller seems to have had the opportunity of studying the habits of either so as to suggest a reason for this marvellous sexual development.

The second group of *Caprimulginæ*, those which are but poorly or not at all furnished with rictal bristles, contains about five genera, of which there is here only room to particularize *Lyncornis* of the Old World and *Chordiles* of the New. The species of the former are remarkable for the tuft of feathers which springs from each side of the head, above and behind the ears, so as to give the bird an appearance like some of the "Horned" Owls—those of the genus *Scops*, for example; and remarkable as it is to find certain forms of two Families, so distinct as are the *Strigidæ* and the *Caprimulgidæ*, resembling each other in this singular external feature, it is yet more remarkable to note that in some groups of the latter, as in some of the former, a very curious kind of dimorphism takes place. In either case this has been frequently asserted to be sexual, but on that point doubt may fairly be entertained. Certain it is that in some groups of Goatsuckers, as in some groups of Owls, individuals of the same species are found in plumage of two entirely different hues—rufous and grey. The only explanation as yet offered of this fact is that the difference is sexual, but, as just hinted, evidence to that effect is conflicting. It must not, however, be supposed that this common feature, any more than that of the existence of tufted forms in each group, indicates any close relationship between them. The resemblances may be due to the same causes, concerning which future observers may possibly enlighten us, but at present we must regard them as analogies not homologies. The species of *Lyncornis* inhabit the Malay Archipelago, one, however, occurring also in China. Of *Chordiles* the best known species is the Night-hawk of North America (*C. virginianus* or *C. popetue*), which has a wide range from Canada to Brazil. Others are found in the Antilles and in South America. The general habits of all these birds agree with those of the typical Goatsuckers.

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[1] Other English names of the bird are Evejar, Fern-Owl, Churn-Owl, and Wheel-bird—the last from the bird's song resembling the noise made by a spinning-wheel in motion.

We have next to consider the birds forming the genus *Podargus* and those allied to it, whether they be regarded as a distinct Family, or as a Subfamily of *Caprimulgidæ*. As above stated, they have feet constructed as those of birds normally are, and their sternum seems to present the constant though comparatively trivial difference of having its posterior margin elongated into two pairs of processes, while only one pair is found in the true Goatsuckers. *Podargus* includes the bird (*P. cuvieri*) known from its cry as More-pork to Tasmanian colonists,[1] and several other species, the number of which is doubtful, from Australia and New Guinea. They have comparatively powerful bills, and it would seem feed to some extent on fruits and berries, though they mainly subsist on insects, chiefly *Cicadæ* and *Phasmidæ*. They also differ from the true Goatsuckers in having the outer toes partially reversible, and they are said to build a flat nest on the horizontal branch of a tree for the reception of their eggs, which are of a spotless white. Apparently allied to *Podargus*, but differing among other respects in its mode of nidification, is *Ægotheles*, which belongs also to the Australian Subregion; and further to the northward, extending throughout the Malay Archipelago and into India, comes *Batrachostomus*, wherein we again meet with species having aural tufts somewhat like *Lyncornis*. The *Podarginæ* are thought by some to be represented in the New World by the genus *Nyctibius*, of which several species occur from the Antilles and Central America to Brazil. Finally, it may be stated that none of the *Caprimulgidæ* seem to occur in Polynesia or in New Zealand, though there is scarcely any other part of the world suited to their habits in which members of the Family are not found. (A. N.)

GOBELIN, the name of a family of dyers, who in all probability came originally from Rheims, and who in the 15th century established themselves in the Faubourg Saint Marcel, Paris, on the banks of the Bièvre. The first head of the firm was named Jehan, and died in 1476. He discovered a peculiar kind of scarlet dye, and he expended so much money on his establishment that it was named by the common people *la folie Gobelin*. To the dye works there was added in the 16th century a manufactory of tapestry. So rapidly did the wealth of the family increase, that in the third or fourth generation some of them forsook their trade and purchased titles of nobility. More than one of their number held offices of state, among others Balthasar, who became successively treasurer general of artillery, treasurer extraordinary of war, councillor secretary of the king, chancellor of the exchequer, councillor of state, and president of the chamber of accounts, and who in 1601 received from Henry II. the lands and lordship of Briecomte-Robert. He died in 1603. The name of the Gobelins as dyers cannot be found later than the end of the 17th century. In 1662 the works in the Faubourg Saint Marcel, with the adjoining grounds, were purchased by Colbert on behalf of Louis XIV., and transformed into a general upholstery manufactory, in which designs both in tapestry and in all kinds of furniture were executed under the superintendence of the royal painter Lebrun. On account of the pecuniary embarrassments of Louis XIV., the establishment was closed in 1694, but it was reopened in 1697 for the manufacture of tapestry, chiefly for royal use and for presentation. During the Revolution and the reign of Napoleon the manufacture was suspended, but it was revived by the Bourbons, and in 1826 the manufacture of carpets was added to that of tapestry. In 1871 the building was partly burned by the Communists.

See Lacordaire, *Notice historique sur les manufactures impériales de tapisserie des Gobelin et de tapis de la Savonnerie, précédée du catalogue des tapisseries qui y sont exposées*, Paris, 1853; and also the article TAPESTRY.

GOBI is the name usually applied by European geographers to a vast stretch of desert in Central Asia, which has its western limits in the neighborhood of 75° E. long., and its eastern somewhere between 114° and 115°. Like many other geographical designations, the word is not only of doubtful origin, but in conventional usage has modified its meaning. According to Sir T. Douglas Forsyth, it is originally the Turki for "great;" and Richthofen informs us that by the Chinese it is employed, not as a proper name, but, like Shamo, as a general term for any sandy and desert piece of country. This being the case, the great German geographer proposes to displace the word Gobi in European usage by the Chinese Han-hai or Dry Sea, suggestive as he says not only of the present appearance but also of the former history of the region; but it is to be feared that the older designation has become too familiar, and the disadvantages arising from its use are of too recondite a character, to render it likely that his proposal will be generally accepted.

As a sea the Gobi or Han-hai must have been comparable in extent to the Mediterranean, and the ancient coast-line can be pretty clearly recognized. In its present state it may be divided into two distinct basins, the western taking its name from the river Tarim or Tarym, and the eastern from the Chinese Shamo or "Sand Desert." The Dzungarian valley stretches westwards like a gulf. The Tarim basin is bounded on the S. by the range of mountains which, under various names applicable to different portions, such as the Kwen-lun and the Altyntag, forms the northward rim of the great plateau of Thibet; on the west it comes up to the spurs of the Pamir plateau, and on the north it lies along the foot of the Thian Shan. If we measure from the source of any of its principal tributaries, the Tarim must have a course of more than 1000 miles. The head-waters rise in the mountains just named, and the more important of them in the south and west. The Khotan river and its confluent the Kara-Kash both descend from the Karakorum mountains, and flow in a generally northward direction; the Zarafshan or Yarkand River, rising in the same range, winds about in the first part of its course so as to enter the Gobi almost from the west; and the Kizil Su or Kashgar River has its numerous head streams in the Kizil Yart mountains belonging to the Pamir plateau. The Aksai River and the Shah Yar are the most important contributions from the Thian Shan. The course of all of these rivers after they enter the Gobi is largely matter of conjecture, and all that can be asserted with confidence is that they unite to form the Tarim, and find their final goal in an inland lake. They have probably all reached a common channel about 82° E. long.; but as the stream presses eastward it again breaks up into numerous branches, the arrangement of which, except along the route followed by Przhevalski, is still unknown. As it passes east the stream gradually loses in volume by absorption, evaporation, and the demands of riparian populations. In the neighborhood of the Ugendarya, the breadth is about 300 or 360 feet, and the depth about 20. The course of the Tarim lies much nearer the northern side of the Gobi than the southern, but it gradually trends south-east, and at length passing through Lake Karaburan, loses itself in Lake Chon-Kul (*i. e.*, great lake) or Kara-Kurchin. This last lake is identified with the famous Lob-nor, the position of which has been one of the outstanding problems of comparative geography. Against the identification a number of objections have been urged by Richthofen (*cf.* "Bemerkungen zu den Ergebnissen von Ober-lieut. Prejewalski's Reise" in *Zeitsch. für Erdk.*, Berlin, 1878), the most important of which are the prevailing tradition that the Lob-nor was a salt lake while the Chon-Kul is fresh, and the fact that the Chinese maps place the Lob-nor to the north of the position assigned to the Chon-Kul, which according to Przhevalski lies about 39° 30′ N. lat., immediately to the N. of the Altyntag range (13,000 to 14,000 feet high). The country through which the Lower Tarim flows is dreary and monotonous. "In general," reports the traveller, "the Lob-nor desert is the wildest and most unfertile of all that I have yet seen in Asia; it is sadder than the desert of Ala-Shan."

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[1] In New Zealand, however, this name is given to an Owl (*Sceloglaux novæ-zelandiæ*).

A meagre vegetation of tamarisks and reeds lines the course of the river. Away towards the south-west there stretch, if we may trust to native reports, those vast fields of drifting and treacherous sands which have given so much of its terror to the legendary account of the desert of Gobi. That the reports are in the main true, and that the legends are founded on fact, appears to be rendered probable by the statements of Sir T. Douglas Forsyth, who has contributed an interesting paper on the subject to the *Proceedings of the Royal Geographical Society* (1876). The population of the Tarim basin is scanty and poverty-stricken. On the Lower Tarim there are nine villages with a total of 1200 souls. Cattle rearing is more general than agriculture, which indeed is of the most recent introduction, and confines itself to barley and wheat. Mahometanism is the universal religion, and the language appears to be identical with the Taranchi and the Sart.

The Shamo or eastern basin is quite different in its character. Here we have no large river like the Tarim, and, instead of its boundaries being marked by lofty ranges of mountains from 13,000 to 20,000 feet high, the ground gradually rises in a series of scarcely marked terraces. The central point, at Ozon Khoshu, is the lowest discovered in Central Asia, being only 607 metres (1948 feet) above the level of the sea. "The aspect of the country," says Ney Elias, "who crossed in a north-westerly direction from China, is that of low hills or downs, with valleys and plains intervening, the whole of a rocky or stony nature rather than sandy, though patches of sand do occur every here and there. What little vegetation exists is chiefly composed of weeds, 'scrub,' and heath, there being scarcely any grass, and only a dwarfed and stunted tree here and there, in the gorges or passes of those low rocky ranges that at uncertain intervals cross the desert in almost parallel lines from east to west." Of the western portion of the basin we have no modern account.

Marco Polo was the first European who gave a distinct description of the desert of Gobi. He tells us how on quitting Charchan (the modern Chachan, according to Yule) "you ride some five days through the sands finding none but bad and bitter water; and then you come to a city called Lop at the edge of the desert. . . . The length of the desert is so great that it would take a year and more to ride from one end of it to the other. It is all composed of hills and valleys of sand." And then he goes on to speak of spirits that haunt the waste, and syllable men's names, and of strange noises like the tramp and hum of a great cavalcade, of the sound of drums, and a variety of musical instruments. Polo appears to have proceeded east from Khotan to Lob, and then further east to Etsina on the southern edge of the desert, and afterwards to have spent forty days in crossing the desert northwards to Karakorum.[1]

Later notices of the Gobi, especially of its eastern portions, are given by Gerbillon, 1688–98 (in Duhalde's appendix), by the Dutchman Evert Ysbrand Ides (1692–94), and by Lorenz Lange, who was sent in 1727–28 and in 1736 by Peter the Great to Peking.[2] But it was not till the present century that accurate information began to accumulate about the eastern portions, and the traveller who has lifted the veil from the western portions is still engaged in his explorations. In 1830–31 Fuss and Bunge crossed the eastern Gobi from Urga to Kalgan; and Dr. Fritsche executed a series of journeys in the same district between 1869 and 1873.[3] The missions of the Russian officials Andre Gustavitch Prinz (1863) and Shishmaroff (1868) added little to the knowledge of the region; but in 1870 Pavlinoff, consul at Chuguchak, being accompanied by a Government topographer Matusovski, made valuable observations on the route from Suok to Kobdo, and from Kobdo to Uliassutai.[4] Of still greater moment were the travels of Ney Elias in 1872–73, and of Przhevalski between 1870 and 1877. In his earlier journey (1870–72) Przhevalski travelled across the Gobi in a line almost due south from Urga, and in 1877 he struck south-east from the Yulduz range, one of the outrunners of the Thian Shan.

Besides the works referred to in the text see especially Richthofen's masterly account of the Gobi in his *China*, vol. i., Berlin, 1877, and Prejevalsky, *Mongolia, the Tangut Country*, etc., London, 1876, and *From Kulja across the Tian-Shan to Lob Nor*, London, 1879. An account of Elias's journey will be found in *Journal of the Royal Geographical Society*, 1873, and in Guido Cora's *Cosmos*, 1874.

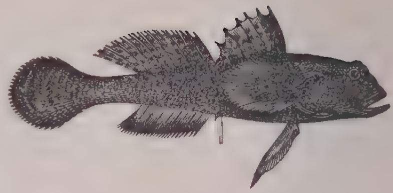

Fig. 1.—*Gobius lentiginosus*.

GOBY. The Gobies (*Gobius*) are small fishes readily recognized by their ventrals (the fins on the lower surface of the chest) being united into one fin, forming a suctorial disk, by which these fishes are enabled to attach themselves in every possible position to a rock or other firm substances. They are essentially coast-fishes, inhabiting nearly all seas, but disappearing towards the Arctic and Antarctic Oceans. Many enter, or live exclusively in, such fresh waters as are at no great distance from the sea. Between 200 and 300 different kinds are known.

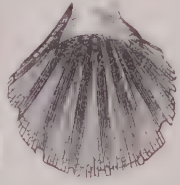

Fig. 2.—United ventrals of Goby.

GOD. See Theism.

GODALMING, a municipal borough and market-town of England, county of Surrey, is situated 32 miles S. W. of London, in a valley on the right bank of the Wey, which is navigable thence to the Thames. It consists principally of one street nearly a mile in length, on the high road between London and Portsmouth. The chief public buildings are the town-hall and market-house, Wyat's almshouses for poor men, the public hall, and the parish church, an old cruciform building, of mixed architecture, but principally Early English and Perpendicular. The church was repaired in 1840, and also in 1867. It contains a large number of old memorials. Godalming has manufactures of paper, leather, parchment, and hosiery, and some trade in corn, malt, bark, hoops, and timber. The town obtained a market from Edward I. in 1300, and was incorporated in 1575. The population in 1871 was 2444.

GODÁVARI, a river of Central India, which flows across the Deccan from the western to the Eastern Gháts, for sanctity, picturesque scenery, and utility, surpassed only by the Ganges and the Indus. The total length is 898 miles; the estimated area of drainage basin, 112,200 square miles. Its traditional source is on the side of a hill behind the village of Trimback in Nasik district, Bombay, but according to popular legend it proceeds from the same ultimate source as the Ganges, though underground. Its course is generally south-easterly. After passing through Nasik district, it crosses into the dominions of the nizám of Hyderabad. When it again strikes British territory it is joined by the Pranhita, with its tributaries the Waraha, the Penganga, and Wainganga. For some distance it flows between the Nizám's dominions and the upper Godávari district, and receives the Indravati, the Sal, and the Sabári. The stream is now very imposing, with a channel varying from 1 to 2 miles in breadth, occasionally broken by alluvial islands. Parallel to the river stretch long ranges of hills; on the opposite side the country is more open and cultivated. Below the junction of the Sabári the scenery is such that the Godávari has got the name of the Indian Rhine. The channel here begins to contract. The flanking hills gradually close in on both sides, and the result is a magnificent gorge only 200 yards wide through which the water flows into the plain of the delta, about 60 miles from the sea. The head of the delta is at the village of Dhaulaishvaram, where the main stream is crossed by the irrigation anicut. The river has seven mouths, the largest being the Gautami Godávari. The Godávari is regarded as peculiarly sacred, and once every twelve years the great bathing festival called *Pushkaram* is held on its banks.

The upper waters of the Godávari are scarcely utilized for irrigation, but the entire delta has been turned into a garden of perennial crops by means of the anicut at Dhaulaishvaram, from which three main canals are drawn off. The river channel here is 3½ miles wide. The anicut is a substantial mass of stone, bedded in lime, cement, about 2½ miles long, 130 feet broad at the base, and 12 feet high

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[1] See Yule's *Marco Polo*, vol. i. p. 178–200.

[2] Lange's narrative has often been printed. See especially *Tagebuch Zweer Reisen von L. Lange: aus ungedruckten Quellen mitgetheilt vom Herrn Prof. Pallas*, Leipsic, 1781.

[3] See *Verhandlungen der Gesellschaft für Erdkunde*, 1874, and for map *Zeitsch. der Ges. für Erdk.*, Berlin, 1874.

[4] See results of journey in Petermann's *Mittheil.*, Jan., 1873.

The stream is thus pent back so as to supply a volume of 3000 cubic feet of water per second during its low season, and 12,000 cubic feet at time of flood. The canals have a total length of 528 miles, capable of irrigating 780,000 acres, while 463 miles are also used for navigation. In 1864 water-communication was opened between the river systems of the Godávari and Kistna. Rocky barriers and rapids obstruct navigation in the upper portion of the Godávari. Attempts have been made to construct canals round these barriers but with little success, and lately the undertaking has been entirely abandoned.

GODÁVARI, a district of Madras presidency, British India, lying between 16° 15′ and 17° 35′ N. lat., and between 80° 55′ and 82° 38′ E. long.; and bounded N. by the Central Provinces and Vizagapatam district, E. by Vizagapatam and the Bay of Bengal, S. by the Bay of Bengal and Kistna district, and W. by the Nizám's dominions. The district is divided by the Godávari river into two nearly equal parts. The scenery along the course of the river is varied and striking. The only lake of importance is the Koléru, which is studded with islands and fishing villages. Building stone and limestone are abundant in the uplands. Iron is also found. The jungle products are myrobalans, soap-nuts, tamarinds, bamboo-rice, honey, and beeswax. Wild animals and game birds are numerous.

The population in 1871 numbered 1,592,939 (803,603 males, 789,336 females), showing a considerable increase on former years. The Hindus numbered 1,555,981, the Mahometans 35,173, the Christian. '483 (Protestants and Roman Catholics in nearly equal numbers), 39 were Buddhists, and 263 not separately classified. Nineteen towns each contain upwards of 5000 inhabitants,—the aggregate population of the three chief towns, Ellor, Rájahmandri, and Cocanada, being 63,064.

The total area of the district is 7345 square miles, of which 2713 square miles belong to Government. Of Government land, 386,400 acres are under cultivation; the rest either belongs to the *zamindári* estates, or is waste and uncultivable. The chief products are rice, gram, jute, hemp, gingelly, tobacco, sugar-cane, and indigo; rice and food grains have improved in quality owing to the extension of irrigation by canals. Government tenants have permanent right of occupancy so long as they pay the Government demand, while on the *zamindári* estates cultivators are merely yearly tenants. The district is well supplied with means of communication by 491 miles of good road and 431 miles of canals. The principal manufactures are cotton and woollen carpets, sheep wool blankets, uppada cloths, sugar, and indigo. The chief articles of trade are grain, cotton, jaggery, turmeric, cocoa-nut, flax-cloth, onions, garlic, lace cloths, tobacco, gingelly seed, lamp oil, salt, tamarinds, cattle, teak-wood, skins, opium, and indigo. Cocanada, Ellor, Rájahmandri, Mandapetta, Jaggampetta, Husanbada, Nasapur, Palakollu, Dowlaishvaram, Ambajipetta, and Jagannathpur are the most important seats of commerce. The estimated value of imports in 1874–75 was £204,238, and of exports, £903,253. The total revenue in 1875–76 was £558,812; the expenditure, £28,604; the total municipal income, £5152. There are 28 magisterial and 15 revenue and civil courts. There are 387 schools, attended by 7759 pupils. The administrative headquarters is at Cocanada. The prevailing epidemic diseases are *beri-beri* and fevers; cholera and small-pox occur during the hot season, but only the poorer classes are attacked. Cattle diseases also prevail. The average annual rainfall from 1871 to 1875 was 43·35 inches; the average mean temperature at Rájahmandri in 1876 was 82·7° Fahr. Two severe storms, which caused great destruction to property, occurred in 1832 and 1839.

The Godávari district formed part of the Andhra division of Dravida, the north-west portion being subject to the Orissa kings, and the south-western belonging to the Vengi kingdom. For centuries it was the battlefield on which various chiefs fought for independence with varying success till the beginning of the 16th century, when the whole country may be said to have passed under Mahometan power. At the conclusion of the struggle with the French in the Carnatic, Godávari with the Circars was ceded to the English by the nawáb, and finally confirmed by the imperial *sanad* in 1765. The present district was constituted in 1859, by the redistribution of the territory comprising the former districts of Guntoor, Rájahmandri, and Masulipatam, into what are now the Kistna and Godávari districts.

GODEFROI. See GOTHOFRED.

GODFREY OF BOUILLON. See BOUILLON.

GODOLPHIN, SIDNEY GODOLPHIN, EARL OF (*c.* 1635–1712), was a cadet of an ancient family of Cornwall, and was born most probably in 1635. At the Restoration he was introduced into the royal household by Charles II., with whom he had previously become a favorite, and he also at the same period entered the House of Commons as member for Helstone. Although he very seldom addressed the House, and when he did so, only in the briefest manner, he gradually acquired a reputation as its chief if not its only financial authority. In March, 1679, he was appointed a member of the privy council, and in the September following he was promoted, along with Viscount Hyde (afterwards earl of Rochester) and the earl of Sunderland, to the chief management of affairs. Though he voted for the Exclusion Bill in 1680, he was continued in office after the dismissal of Sunderland, and in September, 1684, he was created Baron Godolphin of Rialton, and succeeded Rochester as first lord of the treasury. After the accession of James II. he was made chamberlain to the queen, and, along with Rochester and Sunderland, enjoyed the king's special confidence. In 1687 he was named commissioner of the treasury. He was one of the council of five appointed by King James to represent him in London, when he went to join the army after the landing of William prince of Orange in England, and, along with Halifax and Nottingham, he was afterwards appointed a commissioner to treat with the prince. On the accession of William, though he only obtained the third seat at the treasury board, he had virtually the chief control of affairs. He retired in March, 1690, but was recalled on the November following, and appointed first lord. While holding this office he for several years continued, in conjunction with Marlborough, a treacherous intercourse with James II., and is said even to have anticipated Marlborough in disclosing to James intelligence regarding the intended expedition against Brest. After Fenwick's confession in 1696 regarding the Assassination Plot, Godolphin, who was compromised, was induced to tender his resignation; but when the Tories came into power in 1700, he was again appointed lord treasurer, and retained office for about a year. Though not a favorite with Queen Anne, he was, after her accession, appointed to his old office, on the strong recommendation of Marlborough. He also in 1704 received the honor of knighthood, and in December, 1706, he was created Viscount Rialton and Earl of Godolphin. The influence of the Marlboroughs with the queen was, however, gradually supplanted by that of Mrs. Masham and Harley earl of Oxford, and with the fortunes of the Marlboroughs those of Godolphin were indissolubly united. The services of both were so appreciated by the nation that they were able for a time to regard the loss of the queen's favor with indifference, and even in 1708 to procure the expulsion of Harley from office; but after the Tory reaction which followed the impeachment of Dr. Sacheverel, the queen made use of the opportunity to take the initiatory step towards delivering herself from the irksome thralldom of Marlborough by abruptly dismissing Godolphin from office, 7th August, 1710. He died 15th September, 1712.

Godolphin owed his rise to power and his continuance in it under four sovereigns chiefly to his exceptional mastery of financial matters; for if latterly he was in some degree indebted for his promotion to the support of Marlborough, he received that support mainly because Marlborough recognized that for the prosecution of England's foreign war his financial abilities were an indispensable necessity. He was cool, reserved, and cautious, but his prudence was less associated with high sagacity than traceable to the weakness of his personal antipathies and prejudices, and his freedom from political predilections. Perhaps it was his unlikeness to Marlborough in that moral characteristic which so tainted Marlborough's greatness that rendered possible between them a friendship so intimate and undisturbed: he was, it would appear, exceptionally devoid of the passion of avarice; and so little advantage did he take of his opportunities of aggrandizement that, though his style of living was unostentatious,—and in connection with his favorite pastimes of horse-racing, card-playing, and cockfighting he gained perhaps more than he lost,—all that he left behind him did not, according to the duchess of Marlborough, amount to more than £12,000. His treacherous intercourse with James II. was doubtless largely due to the spell of Marlborough's influence; but in any case it indicates that, if in other respects his political conduct was upright and trustworthy, this is to be accounted for by his prudence and certain other mental peculiarities, rather than by the strength of his moral principle or his keen sense of honor. His son and successor Francis, who had married Henrietta, eldest daughter of the duke of Marlborough, in 1698, died in 1766, leaving no male issue.

GODOY. See Alcudia.

GODWIN, Francis (1561–1633), son of Dr. Godwin, bishop of Bath and Wells, was born at Havington in Northamptonshire in 1561. He was elected student of Christ Church, Oxford, in 1578, took his bachelor's degree in 1580, and that of master in 1583. Entering holy orders, he became successively rector of Sampford-Orcais in Somersetshire, and vicar of Weston-in-Zoyland in the same county. In 1587 he was appointed subdean of Exeter. Having turned his attention to the subject of British antiquities, he became acquainted with Camden, whom in 1590 he accompanied in a journey through Wales. He was created bachelor of divinity in 1593, and doctor in 1595. In 1601 he published his *Catalogue of the Bishops of England since the first planting of the Christian Religion in this Island*, a work which procured him in the same year the bishopric of Llandaff from Elizabeth. A second edition appeared in 1615, and in 1616 he published an edition in Latin with a dedication to King James, who in the following year conferred upon him the bishopric of Hereford. The work was republished, with a continuation by Dr. Richardson in 1743. In 1616 Godwin published *Rerum Anglicarum, Henrico VIII., Edwardo VI., et Maria regnantibus, Annales*, which was afterwards translated and published by his son under the title *Annales of England*, 1630. The last of his works published before his death, which took place in 1633, was *Computation of the value of the Roman Sesterce and Attic Talent*, which appeared in 1630. He is also the author of a somewhat remarkable story, published posthumously in 1638, and entitled *The Man in the Moon, or a Discourse of a Voyage thither, by Domingo Gonsales*, written apparently some time between the years 1599 and 1603. In this production Godwin not only declares himself a believer in the Copernican system, but adopts so far the principles of the law of gravitation by supposing that the earth's attraction diminishes with the distance. The work, which displays considerable fancy and wit, was translated into French, and was imitated in several important particulars by Cyrano de Bergerac, from whom Swift obtained valuable hints in writing his voyage to Laputa. Another work of Godwin's, *Nuncius Inanimatus in Utopia*, originally published in 1629, but subsequently suppressed, seems to have been the prototype of Wilkins's *Mercury, or Secret and Swift Messenger*, which appeared in 1641. Godwin's pamphlet was again published in 1657.

GODWIN, Mary Wollstonecraft (1759–1797), an English authoress of the last century, was born at Hoxton, on April 27, 1759. Her family was of Irish extraction, and Mary's grandfather, who was a respectable manufacturer in Spitalfields, realized the property which his son squandered. Her mother, whose maiden name was Dixon, was Irish, and of good family. Mr. Wollstonecraft, after dissipating the greater part of his patrimony, tried to earn a living by farming, which only plunged him into deeper difficulties, and he led a wandering, shifty life. The family roamed from Hoxton to Edmonton, to Essex, to Beverley in Yorkshire, to Laugharne, Pembrokeshire, and back to London again.

After Mrs. Wollstonecraft's death in 1780, soon followed by her husband's second marriage, the three daughters, Mary, Everina, and Eliza, sought to earn their own livelihood. The sisters were all clever women,—Mary and Eliza far above the average,—but their opportunities of culture had been few. They turned their thoughts towards the profession of teaching, and Mary, the eldest, was to make the first venture. She went in the first instance to live with her friend Fanny Blood, a girl of her own age, whose father, like Wollstonecraft, was addicted to drink and dissipation. As long as she lived with the Bloods, Mary helped Mrs. Blood to earn money by taking in needle-work, while Fanny painted in water-colors. Everina went to live with her brother Edward, and Eliza made a hasty and, as it proved, unhappy marriage with a Mr. Bishop. All the Wollstonecraft sisters were enthusiastic, excitable, apt to exaggerate trifles, and to magnify inattentions into slights; and Eliza had the family temperament in excess. Bishop was a man of violent temper, and when his wife's reason had almost given way under the miseries of her married life, Mary resolved to find some means of supporting her, and arranged her secret and sudden flight. A legal separation was afterwards obtained, and the sisters, together with Fanny Blood, took a house, first at Islington, afterwards at Newington Green, and opened a school, which was carried on with indifferent success for nearly two years. During their residence at Newington Green, Mary was introduced to Dr. Johnson, who, as Godwin tells us, "treated her with particular kindness and attention."

In 1785 Fanny Blood married Hugh Skeys, a merchant, and went with him to Lisbon, where she died in childbed after sending for Mary to nurse her. "The loss of Fanny," as she said in a letter to Mrs. Skeys's brother, George Blood, "was sufficient of itself to have cast a cloud over my brightest days. . . . I have lost all relish for pleasure, and life seems a burden almost too heavy to be endured." Her first novel, *Mary, a Fiction*, written in 1787, was intended to commemorate her friendship with Fanny. After closing the school at Newington Green, Mary obtained a situation as governess in the family of Lord Kingsborough, in Ireland, which she held for nearly a year. Her pupils were much attached to her, especially Margaret King, afterwards Lady Mountcashel; and indeed Lady Kingsborough gave the reason for dismissing her that the children loved their governess better than their mother. Mary now resolved to devote herself to literary work, and she was encouraged in this purpose by Johnson, the publisher in St. Paul's Churchyard, in whose house she resided for a few weeks, before she obtained lodgings in George Street, Blackfriars. She acted as Johnson's literary adviser, and undertook translations, chiefly from the French. *Mary, a Fiction*, the story already mentioned, was not published till 1796. *The Elements of Morality*, an old-fashioned book for children, and Lavater's *Physiognomy*, were among her translations. Her *Original Stories from Real Life* were published, with illustrations by Blake, and in 1792 appeared *A Vindication of the Rights of Woman*, the work with which her name is always associated.

It is not among the least oddities of this book that it is dedicated to M. Talleyrand Périgord, late bishop of Autun. Mary Wollstonecraft still believed him to be sincere, and working in the same direction as herself. In the dedication she states the "main argument" of the work, "built on this simple principle that, if woman be not prepared by education to become the companion of man, she will stop the progress of knowledge, for truth must be common to all, or it will be inefficacious with respect to its influence or general practice." In carrying out this argument she used extraordinary plainness of speech, and it was this that caused all, or nearly all, the outcry. For she did not attack the institution of marriage, nor assail orthodox religion; her book was really a plea for equality of education, passing into one for state education and for the joint education of the sexes. It was a protest against the assumption that woman was only the plaything of man, and she asserted that intellectual companionship was the chief, as it is the lasting, happiness of marriage. It may, however, be admitted that she discussed some subjects, not usually mentioned in print, with a certain want of reticence and delicacy. She dealt directly with dangerous and explosive questions, incidentally upheld greater freedom of divorce, and denied the eternity of the torments of hell.

Mrs. Wollstonecraft, as she now styled herself, desired to watch the progress of the Revolution in France, and went to Paris in 1792. Godwin, in his memoir of his wife, considers that the change of residence may have been prompted by the discovery that she was becoming attached to Fuseli, but there is nothing to confirm this surmise; indeed, it was first proposed that she should go to Paris in company with him and his wife, nor was there any subsequent breach in their friendship. She remained in Paris during the Reign of Terror, when communication with England was difficult or almost impossible. Some time in the spring or summer of 1793, Captain Gilbert Imlay, an American, became acquainted with Mary—an acquaintance which ended in a more intimate connection. There was no legal ceremony of marriage, and it is doubtful whether such a marriage would have been valid at the time; but she passed as Imlay's wife, and her brother, Charles Wollstonecraft, wrote from Philadelphia that he had seen a gentleman who informed him "that Mary was married to Captain Imlay of this country." Imlay himself terms her in a legal document, "Mary Imlay, my best friend and wife," and she believed that his love, which was to her sacred, would endure. In August, 1793, Imlay was called to Havre on business, and was absent for some months, during which time most of the letters published after her death by Godwin were written. Towards the end of the year she joined Imlay at

Havre, and there in the spring of 1794 she gave birth to a girl, who received the name of Fanny, in memory of the dear friend of her youth. Imlay became involved in a multitude of speculations, which rendered him restless and dissatisfied, and his affection for Mary and their child was already waning. He left her for some months at Havre, and when he allowed her to join him in England, it appears from her letters that she went with a heavy heart and forebodings of sorrow. In June, 1795, in less than two months after their reunion, Mary again left England for Norway, empowered by the document in which Imlay calls her his wife, to act for him in his business relations with Norwegian timber merchants. Her *Letters from Norway*, divested of all personal details, were afterwards published. She returned to England late in 1795, and found letters awaiting her from Imlay, intimating his intention to separate from her, and offering to settle an annuity on her and her child. For herself she rejected this offer with scorn. "From you," she wrote, "I will not receive anything more. I am not sufficiently humbled to depend on your beneficence." They met again, and for a short time lived together, until the discovery that he was carrying on an intrigue under her own roof drove her to despair, and she attempted to drown herself by leaping from Putney bridge, but she was rescued by watermen. Imlay now completely deserted her, although she continued to bear his name.

In 1796, when Mary Wollstonecraft was living in London, supporting herself and her child by working, as before, for Mr. Johnson, she met William Godwin. A friendship sprang up between them—a friendship, as he himself says, which "melted into love." Godwin states that "ideas which he is now willing to denominate prejudices, made him by no means willing to conform to the ceremony of marriage;" but these prejudices were overcome, and they were married at St. Pancras Church on March 29, 1797. And now Mary had a season of real calm in her stormy existence. Godwin, for once only in his life, was stirred by passion, and his admiration for his wife equalled his affection. But their happiness was of short duration. A daughter, Mary, afterwards the wife of Percy Bysshe Shelley, was born August 30, 1797. At first all seemed to go well, but unfavorable symptoms set in, and on September 10th the mother, after enduring all her sufferings with unvarying gentleness and sweetness of temper, passed away. She was buried in the churchyard of Old St. Pancras, but her remains were afterwards removed by Sir Percy Shelley to the churchyard of St. Peter's, Bournemouth.

Her principal published works are as follows :— *Thoughts on the Education of Daughters*, 1787 ; *The Female Readers* (selections), 1789 ; *Original Stories from Real Life*, 1791 ; *An Historical and Moral View of the Origin and Progress of the French Revolution, and the Effects it has produced in Europe*, vol. i. (no more published), 1790 ; *Vindication of the Rights of Woman*, 1792 ; *Vindication of the Rights of Man*, 1793 ; *Mary, a Fiction*, 1796 ; *Letters written during a Short Residence in Sweden, Norway, and Denmark*, 1796 ; *Posthumous Works*, 4 vols., 1798. It is impossible to trace the many articles contributed by her to periodical literature, or to identify the translations executed for Mr. Johnson. A memoir of her life was published by Godwin soon after her decease. A large portion of the work, *William Godwin, his Friends and Contemporaries*, was devoted to her, and a new edition of the *Letters to Imlay*, London, 1879, of which the first edition was published by Godwin, is prefaced by a somewhat fuller memoir. (C. K. P.)

GODWIN, William (1756–1836), an English political writer, historian, novelist, and dramatist, was born March 3, 1756, at Wisbeach in Cambridgeshire, at which place his father was a Nonconformist minister. His family came, on both sides, of worthy middle-class people, able to trace their descent in the same level of society for about 150 years; and it was probably only as a joke that Godwin, a stern political reformer and philosophical radical, attempted to trace his pedigree to a time before the Norman conquest and the great Earl Godwine. His father was a cold and dull man, his mother uneducated, but clever, shrewd, and full of sound common sense. Both parents were Calvinists: the father strict in observances beyond what was even then ordinary; the mother regretting in Godwin's maturer years, and when some of her sons had turned out ill, that she had given birth to so many children, who, as she thought, were heirs of damnation. Mr. Godwin, senior, died young, and never inspired love or much regret in his son; but in spite of wide differences of opinion, the most tender affection always subsisted between William Godwin and his mother, until her death at an advanced age.

William Godwin was educated for his father's profession, and was at first more Calvinistic than his teachers, becoming a Sandemanian, of which sect he says, that they were the followers of "a celebrated north-country apostle [Glas], who after Calvin had damned ninety-nine in a hundred of mankind, has contrived a scheme for damning ninety-nine in a hundred of the followers of Calvin."

He officiated as a minister at Ware, Stowmarket, and Beaconsfield. At the second of these places the teachings of French Reformers were brought before him by a friend, and these, while they intensified his political, undermined his religious opinions. He came to London, still nominally a clergyman, to set about the work of the regeneration of society with his pen—a real enthusiast, who, theoretically, shrank from no conclusions from the premises which he laid down. These were the principles of the Encyclopedists, and his own aim was the complete overthrow of all existing institutions, political, social, and religious. He believed, however, that calm discussion was the only thing needful to carry every change, and from the beginning to the end of his career he deprecated every approach to violence. He was, like Bentham—whom, however, he does not seem to have influenced or been influenced by—a philosophic radical in the strictest sense of the term.

His first published work was an anonymous *Life of Lord Chatham;* the first to which he gave his name was still nominally clerical. Under the inappropriate title *Sketches of History*, he published six sermons on the characters of Aaron, Hazael, and Jesus, in which, though writing in the character of an orthodox Calvinist, he enunciates the pregnant proposition, "God himself has no right to be a tyrant." This was published in 1782, and for the next nine years he wrote largely in the *Annual Register* and other periodicals, producing also three novels, which have more completely vanished from the world than even the contributions to reviews. They were probably not worth preserving, but the "Sketches of English History" written for the *Annual Register* from 1785 onward still deserve study. He joined a club called the Revolutionists, and associated much with Lord Stanhope, Horne Tooke, Holcroft, and others, who, from their political principles and activity, were obnoxious to men in power. It is perhaps needless to say that the title of "reverend" dropped off from him without difficulty, and with no sense of discordance between the old and the new. Doubt and change never seem to have brought with them any keen sense of pain or outrooting. The equable calm of a cold temperament preserved him from much which affects warmer natures; but he also knew that he was at all times seeking after truth, and striving for what seemed right; and while such an one can scarcely be called modest, he is preserved for many qualms which affect more nervous and more self-distrustful persons.

In 1793 Godwin published his great work on political science, *The Inquiry concerning Political Justice, and its Influence on General Virtue and Happiness.* Although this work is little known and less read now, it was one of the epoch-making books of English thought. Godwin could never have been himself a worker on the active stage of life. But he was none the less a power behind the workers, and *Political Justice* takes its place with Milton's *Speech for Unlicensed Printing*, with Locke's *Essay on Education*, with Rousseau's *Émile*, among the unseen levers which have moved the changes of the times. It is therefore necessary to speak of this book more particularly. By the words "political justice" the author meant "the adoption of any principle of morality and truth into the practice of a community," and the work was therefore an inquiry into the principles of society, of government, and of morals. For many years Godwin had been "satisfied that monarchy was a species of government unavoidably corrupt," and from desiring a government of the simplest construction, he gradually came to consider that "government by its very nature counteracts the improvement of original mind." Believing in the perfectibility of the race, that there are no innate principles, and therefore no original propensity to evil, he considered that "our virtues and our vices may be traced to the incidents which make the history of our lives, and if these incidents could be divested of every improper tendency, vice would be extirpated from the world." All control of man by man was more or less intolerable, and the day would come when each man, doing what seems right in his own eyes, would also be doing what is in fact best for the community, because all will be guided by principles of pure reason. But all was to be done by discussion, and matured change resulting from discussion. Hence, while Godwin thoroughly approved of the philosophic schemes of the precursors of the Revolution, he was as far removed as Burke himself from agreeing with the way in which they were carried out. So logical and uncompromising a thinker as Godwin could not go far in the discussion of abstract questions without exciting the most lively opposition in matters of detailed opinion. An affectionate son, and ever ready to give of his hard-earned income to more than one ne'er-do-well brother, he maintained that natural relationship had no claim on man, nor was gratitude to parents or benefactors any part of justice or virtue. In a day when the penal code was still extremely severe, he argued gravely against all punishments, not only that of death. Property was to belong to him who most wants it; accumulated property was a monstrous injustice. Hence marriage, which is law, is the worst of all laws, and property the worst of all properties. A man so passionless as Godwin could venture thus to argue without suspicion that he did so only to gratify his wayward desires. Portions of this treatise, and only portions, found ready acceptance in those minds which were prepared to receive them. Perhaps no one received the whole teaching of the book. But it gave cohesion and voice to philosophic radicalism; it was the manifesto of a school without which the milder and more creedless liberalism of the present day had not been. Godwin himself in after days modified his communistic views, but his strong feeling for individualism, his hate of all restrictions on liberty, his trust in man, his faith in the power of reason remained; it was a manifesto which enunciated principles modifying action, even when not wholly ruling it.

In May, 1794, Godwin published the novel of *Caleb Williams, or Things as they are*, a book of which the political object is overloooked by many readers in the strong interest of the story. It is one of the few novels of that time which may be said still to live. A theorist who lived mainly in his study, Godwin yet came forward boldly to stand by prisoners arraigned of high treason in that same year—1794. The danger to persons so charged was then great, and he deliberately put himself into this same danger for his friends. But when his own trial was discussed in the Privy Council, Pitt sensibly held that *Political Justice*, the work on which the charge could best have been founded, was priced at three guineas, and could never do much harm among those who had not three shillings to spare.

From this time Godwin became a notable figure in London society, and there was scarcely an important person in politics, on the liberal side, in literature, art, or science, who does not appear familiarly in the pages of Godwin's singular diary. For forty-eight years, beginning in 1788, and continuing to the very end of his life, Godwin kept a record of every day, of the work he did, the books he read, the friends he saw. Condensed in the highest degree, the diary is yet easy to read when the style is once mastered, and it is a great help to the understanding of his cold, methodical, unimpassioned characters. He carried his method into every detail of life, and lived on his earnings with extreme frugality. Until he made a large sum by the publication of *Political Justice*, he lived on an average of £120 a year. In 1797, the intervening years having been spent in strenuous literary labor, Godwin married Mary Wollstonecraft (see last article). Since both held the same views regarding the slavery of marriage, and since they only married at all for the sake of possible offspring, the marriage was concealed for some time, and the happiness of the avowed married life was very brief. Mrs. Godwin died in giving birth to a daughter, afterwards the second wife of Percy Bysshe Shelley, on September 10, 1797, leaving Godwin, prostrated by affliction, and with a charge for which he was wholly unfit—his own little daughter Mary, and her step-sister, Fanny Imlay, who ever afterwards bore the name of Godwin. His unfitness for the cares of a family, far more than love, let him to contract a second marriage with Mrs. Clairmont, in 1800. She was a widow with two children, energetic and painstaking, but a harsh stepmother; and it may be doubted whether the children were not worse off under her care than they would have been under Godwin's neglect. The second fiction which proceeded from Godwin's pen was called *St. Leon*, and published in 1799. It is chiefly remarkable for the beautiful portrait of Marguerite, the heroine, which was drawn from the character of his own wife.

The events of Godwin's life were few. Under the advice of the second Mrs. Godwin, and with her active co-operation, he carried on business as a bookseller under the pseudonym of Edward Baldwin, under which name he published several useful school-books and books for children, some by Charles and Mary Lamb. But the speculation was unsuccessful, and for many years Godwin struggled with constant pecuniary difficulties, for which more than one subscription was raised by the leaders of the Liberal party, and by literary men. In his later years the Government of Earl Grey conferred upon him the office known as "Yeoman Usher of the Exchequer," to which were attached apartments in Palace Yard, where he died in the full possession of his faculties, April 7, 1836, having completed his eightieth year.

In his own time, by his writings and by his conversation, Godwin had a great power of influencing men, and especially young men. Though his character would seem, from much which is found in his writings, and from anecdotes told by those who still remember him, to have been unsympathetic, it was not so understood by enthusiastic young people, who hung on his words as those of a prophet. The most remarkable of these was Percy Bysshe Shelley, who in the glowing dawn of his genius turned to Godwin as his teacher and guide. The last of the long series of young men who sat at Godwin's feet was Edward Lytton Bulwer, afterwards Lord Lytton, whose early romances were formed after those of Godwin, and who, in *Eugene Aram*, succeeded to the story as arranged, and the plan to a considerable extent sketched out by Godwin, whose age and failing health prevented him from completing it.

Godwin's more important works are—*The Inquiry concerning Political Justice, and its Influence on General Virtue and Happiness*, 1793; *Things as they are, or the Adventures of Caleb Williams*, 1794; *The Inquirer, a series of Essays*, 1796; *Memoirs of the Author of the Rights of Woman*, 1798; *St. Leon, a Tale of the Sixteenth Century*, 1799; *Antonio, a Tragedy*, 1801; *The Life of Chaucer*, 1803; *Fleetwood, a Novel*, 1805; *Faulkner, a Tragedy*, 1807; *Essay on Sepulchres*, 1809; *Lives of Edward and John Philips, the Nephews of Milton*, 1815; *Mandeville, a Tale of the Times of Cromwell*, 1817; *History of the Commonwealth*, 1824–1828; *Cloudesley, a Novel*, 1830; *Thoughts on Man, a series of Essays*, 1831; *Lives of the Necromancers*, 1834. A volume of essays was also collected from his papers and published in 1873, as left for publication by his daughter Mrs. Shelley. Many other short and anonymous works proceded from his ever busy pen, but many are irrecoverable, and all are forgotten. Godwin's place in literature is permanent, in that he produced one work which proved effective in changing the course of thought in its time, but not permanent in the sense that his writings will continue to be widely read. His life was published in 1876 in two volumes, under the title *William Godwin, his Friends and Contemporaries*, by C. Kegan Paul. The best estimate of his literary position is that given by Mr. Leslie Stephen in his *English Thought in the 18th Century*.

(C. K. P.)

GODWINE, son of Wulfnoth, earl of the West-Saxons, is the leading Englishman in the first half of the 11th century, and he holds a special place in English history generally. He is the first Englishman who plays the part of a minister and a parliamentary leader, of one high in office under the crown who at the same time sways the assemblies of the nation by his power of speech. Such a position was perfectly possible before the Norman Conquest; it did not again become possible for some ages. Godwine appears as the chief champion of England against Norman influence, and as the father of the last English king of the native stock. In these two characters he drew on himself the fullest bitterness of Norman hatred; and to this hatred is doubtless largely, though not wholly, owing the extraordinary contradiction with which the chief events of his life are told, and the amazing slanders which have been heaped upon his memory.

His birth and origin are utterly uncertain. The highest authorities, the contemporary English Chronicles, are silent. There are two alternative statements, which are seemingly quite irreconcilable, but either of which alone would have much to be said for it. By putting together certain passages in the English Chronicles, in Domesday, and in the will of the Ætheling Æthelstan, son of King Æthelred, a strong presumption is raised that Godwine was the son of Wulfnoth the South-Saxon who was outlawed in 1009, and that his services in the war against Cnut were deemed to entitle him to a restitution of his father's forfeited lands. There is no direct statement to this effect, but a number of undesigned coincidences point towards such a belief. On the other hand, there is a story which appears in various quarters, and which seems to come from more than one independent source, which makes Godwine's father Wulfnoth a churl somewhere on the borders of Gloucestershire and Wiltshire, and which makes Godwine win the favor of the Danish earl Ulf by showing him his way after the battle of Sherstone in 1016. A third account connects Godwine with the family of Eadric the traitor of Æthelred's day; but this version seems at once to be impossible to reconcile with either of the other two stories, and to rest on less authority than either.

But, whatever was Godwine's origin, there is no doubt that, according to Cnut's rule of preferring Englishmen to high office, he rose to power very early in that king's reign. He was an earl in 1018. The next year he distinguished himself at the head of the English troops in Cnut's Northern wars, and received in marriage Gytha, the sister of the king's brother-in-law Earl Ulf. In 1020 he became earl of the West Saxons, that is, of all England south of the Thames, a new office, doubtless connected with Cnut's frequent absences from England. All this again is not in the Chronicles, though particular points are incidentally confirmed by them. Still this stage of his history seems to be fairly made out from other sources.

From Cnut's death in 1035 the events of Godwine's life are recorded in the Chronicles, often with great minuteness. Much is also learned from the contemporary biographer of Eadward. He asserted the claims of Harthacnut, the son of Cnut and Emma, to the crown of his father; but he had to consent to a division of the kingdom, and could only secure Wessex for Harthacnut, while Harold reigned in Northumberland and Mercia. He then acted as the chief minister of Emma, while she was regent on behalf of Harthacnut during his first reign. During this time the Ætheling Ælfred, son of Æthelred and Emma, landed in England in the hope of winning back his father's crown; but coming into the power of Harold, he was blinded by his order, and died of his wounds. Godwine was said to have betrayed Ælfred to Harold, and the charge was eagerly seized upon by the Norman writers. But it was not invented by them. At the beginning of Harthacnut's second reign in 1040, Godwine was formally accused of the death of Ælfred, and was regularly tried and acquitted. His guilt is asserted in a poem inserted in one of the Chronicles, but the words which tell against him are carefully altered in another version. The story is told with great confusion and contradiction, and the version unfavorable to Godwine seems to be inconsistent with his position at the time as minister, not of Harold, to whom he is said to have betrayed Ælfred, but of Harthacnut, whose kingship seems to be forgotten in the story. Godwine remained in power during the reigns of Harold and Harthacnut, and on the death of the last-named king in 1042, he was foremost in promoting the election of Eadward, the son of Æthelred and Emma, to the vacant throne. As earl of the West-Saxons he was the first man in the kingdom, but his power was still balanced by that of the other great earls, Leofric in Mercia and Siward in Northumberland. His sons Swegen and Harold, together with Beorn, the nephew of his wife Gytha, were promoted to earldoms (1043–1045), and his daughter Eadgyth was married to the king (1045). We hear much of his good and strict government of his earldom, and of his influence with the king and with the whole nation. He was not, however, all-powerful; in one very remarkable case, which is most instructive as a piece of constitutional history, he was out-voted in the witenagemót on a question of foreign policy. In 1047, when his wife's nephew Swegen Estrithson, now king of the Danes, was at war with Magnus of Norway, Godwine proposed to help Swegen with fifty ships; but the notion was opposed by Leofric, and "all folk" accepted the amendment of the Mercian earl. Godwine had also to strive against the king's fondness for Normans and other strangers, above all in the disposal of ecclesiastical offices. Godwine's policy, in this and in other matters, was opposed to all French connections of every kind. Next to Englishmen he favored natives of the kindred Continental lands, and he supported a policy of alliance with the empire and its princes. In all this, at home and abroad, he had specially to withstand the influence of the king's Norman favorite Robert of Jumiéges, appointed bishop of London in 1044 and archbishop of Canterbury in 1051. Godwine was supported by the English bishops Stigand of Winchester and Lyfing of Worcester. The appointment of Robert to the archbishopric marks the decline of Godwine's power, the foreign influence was now at its height, and the English earl was to feel the strength of it.

In the course of 1051 a series of outrages committed by the king's foreign favorites led to a breach between the king and the earl. The king's brother-in-law, Eustace count of Boulogne, returning with his followers from a visit to the king, tried to obtain quarters by force in the houses of the burgesses of Dover. An Englishman who withstood them was killed; a fight followed, in which the count and his company were driven out of the town. The king, hearing the tale from Eustace, bade Godwine inflict military chastisement on the townsmen; the earl refused, and demanded a fair trial of the charge before the witan. About the same time men's minds were stirred by the outrages of several Normans who had received estates in Herefordshire. The influence of the archbishop was used against Godwine, and he was summoned to appear before the witan at Gloucester as a criminal. He and his sons now gathered the whole force of their earldoms, and marched towards Gloucester in arms. They demanded the surrender of count Eustace and of the other strangers who had done outrages, whether at Dover or in Herefordshire. The king called the other earls to his help; war was hindered by the mediation of Leofric, and matters were adjourned to another meeting in London. There the king appeared with an army; Godwine and his sons were arraigned as criminals, and, on refusing to appear without a safe-conduct, were outlawed. Godwine and his whole family now left the kingdom, except his daughter, the Lady Eadgyth, who was banished from court to the monastery of Wherwell. The foreign favorites of the king were now supreme.

The next year the tide turned; the feeling of the nation showed itself in favor of Godwine. When his petition for a removal of his outlawry was refused, he came back from his shelter in Flanders at the head of a fleet. In most parts of England he was welcomed; he sailed up the Thames to London; the army gathered by the king refused to fight against him; and, in a great meeting outside the walls of London, he and his family were restored to all their offices and possessions, and the archbishop and many other Normans were banished. Godwine's friend Stigand succeeded to the archbishopric. The next year Godwine was smitten with a fit at the king's table, and died three days later, April 15, 1052. His death was worked up into a fabulous tale by his Norman enemies.

The patriotism and good government of Godwine are undoubted; but it is plain that he accumulated vast wealth for himself. Sometimes, it was said, he showed little regard to the rights of the church; but in the only case where we hear both sides, that of some lands in Kent disputed between him and the Norman archbishop, it appears that he had a legal claim. It is much more certain that he was unduly bent on the promotion of his own family. His eldest son Swegen gave great and deserved offence by the seduction of Eadgifu, abbess of Leominster, and still more by the treacherous murder of his cousin Beorn. He was outlawed, but was afterwards restored to his earldom. He accompanied his father to Flanders, but did not come back, having gone on a pilgrimage to Jerusalem, on his return from which he died. Of his other sons, the second, Harold, succeeded Godwine in his earldom and Eadward in his kingdom; Tostig, Gyrth, and Leofric, all earls, play a part in the later history; Wulfnoth, the youngest, was a captive of William. Of his daughters the Lady Eadgyth survived her father, husband, and brother, and lived in great honor under the Conqueror. The others were Gunhild and Ælfgifu, the latter of whom appears in the story of Harold's oath to William.

See the English Chronicles and Florence of Worcester, 1035–52; the Life of Eadward, published in the Chronicles and Memorials; the *Encomium Emmæ* or *Gesta Cnutonis*, published by Pertz, and elsewhere; various notices in Domesday, and in the writers of the time generally. All the passages, historical and legendary, bearing on Godwine's life are collected and examined in the appendices to Freeman's *History of the Norman Conquest*, vols. i. ii. (E. A. F.)

GODWIT, a word of unknown origin, the name commonly applied to a marsh-bird in great repute, when fattened, for the table, and formerly abundant in the fens of Norfolk, the Isle of Ely, and Lincolnshire. In Turner's days (1544) it was worth three times as much as a Snipe, and at the same period Belon said of it—"C'est vn Oyseau es delices des Françoys." Casaubon, who Latinized its name "*Dei ingenium*" (*Ephemerides*, 19th September, 1611), was told by the "*ornithotrophœus*" he visited at Wisbech that in London it fetched twenty pence. Its fame as a delicacy is perpetuated by many later writers, Ben Jonson among them, and Pennant says that in his time (1766) it sold for half-a-crown or five shillings. Under the name Godwit two perfectly distinct species of British birds were included, but that which seems to have been especially prized is known to modern ornithologists as the Black-tailed Godwit, *Limosa œgocephala*, formerly called, from its loud cry, a Yarwhelp,[1] Shrieker, or Barker, in the districts it inhabited. The practice of netting this bird in large numbers during the spring and summer, coupled with the gradual reclamation of the fens, to which it resorted, has now rendered it but a visitor; and it probably ceased from breeding regularly in England in 1824 or thereabouts, though under favorable conditions it may have occasionally laid its eggs for some thirty years later or more (Stevenson, *Birds of Norfolk*, ii. p. 250). This Godwit is a species of wide range, reaching Iceland, where it is called *Jardræka* (=earth-raker), in summer, and occurring numerously, it is said, in India in winter. Its chief breeding-quarters seem to extend from Holland eastwards to the south of Russia. The second British species is that which is known as the Bar-tailed Godwit, *L. lapponica*, and this seems to have never been more than a bird of double passage in the United Kingdom, arriving in large flocks on the south coast about the 12th of May, and, after staying a few days, proceeding to the north-eastward. It is known to breed in Lapland, but its eggs are of great rarity. Towards autumn the young visit our coasts, and a few of them remain, together with some of the other species, in favorable situations throughout the winter. One of the local names by which the Bar-tailed Godwit is known to the Norfolk gunners is Scamell, a word which, in the mouth of Caliban (*Tempest*, act ii. scene 2), has been the cause of much perplexity to Shakespearian critics.

The Godwits belong to the group *Limicolæ*, and are about as big as a tame pigeon, but possess long legs, and a long bill with a slight upward turn. It is believed that in the genus *Limosa* the female is larger than the male. While the winter plumage is of a sober greyish-brown, the breeding-dress is marked by a predominance of bright bay or chestnut, rendering the wearer a very beautiful object. The Black-tailed Godwit, though varying a good deal in size, is constantly larger than the Bar-tailed, and especially longer in the legs. The species may be further distinguished by the former having the proximal third of the tail-quills pure white, and the distal two-thirds black, with a narrow white margin, while the latter has the same feathers barred with black and white alternately for nearly their whole length.

America possesses two species of the genus, the very large Marbled Godwit or Marlin, *L. fedoa*, easily recognized by its size and the buff color of its axillaries, and the smaller Hudsonian Godwit, *L. hudsonica*, which has its axillaries of a deep black. This last, though less numerous than its congener, seems to range over the whole of the continent, breeding in the extreme north, while it has been obtained also in the Strait of Magellan and the Falkland Islands. The first seems not to go further southward than the Antilles and the Isthmus of Panama.

From Asia, or at least its eastern part, two species have been described. One of them, *L. melanuroides*, differs only from *L. œgocephala* in its smaller size, and is believed to breed in Amurland, wintering in the islands of the Pacific, New Zealand, and Australia. The other, *L. uropygialis*, is closely allied to and often mistaken for *L. lapponica*, from which it chiefly differs by having the rump barred like the tail. This was found breeding in the extreme north of Siberia by Dr. von Middendorff, and ranges to Australia, whence it was, like the last, first described by Mr. Gould. (A. N.)

GOES, or Ter Goes, a town of the Netherlands in the province of Zealand, on the island of South Beveland, with railway communication since 1868 with Bergen-op-Zoom, and since 1872 with Middelburg, its distances from these places being respectively 12 and 15 miles. The Reformed church, called in the olden times St. Mary Magdalen's, is considered the finest ecclesiastical building of Zealand, and dates from 1423. In the one half, known as the Preekkerk or preaching church, there is a splendid organ, and in the other half, known as the Wandelkerk or walking church, stands the tomb of Frans Naerebout the philanthropist. Goes further boasts of a fine old town-house, a high school, and the remains of the old castle of Ostende, which was the nucleus round which it began to form itself in the 14th century. The industries of the town are varied but not extensive, dealing with linen, dyes, chocolate, oil, flour, straw hats, wood, and cigars. Ship-building is also carried on, as well as a trade in wood and coals. The harbor, which is defended by a fort, is formed by a short canal communicating with the eastern Scheldt, extended and improved in 1818–19. The population of the town, which received its municipal rights in 1406, and was surrounded with a wall about 1420, numbered 4916 in 1860, 5205 in 1870, and 6063 in 1876.

GOES, Hugo van der (? –1482), a painter of considerable celebrity at Ghent, was known to Vasari, as he is known to us, by a single picture in a Florentine monastery. At a period when the family of the Medici had not yet risen from the rank of a great mercantile firm to that of a reigning dynasty, it employed as an agent at the port of Bruges Tommaso Portinari, a lineal descendant, it was said, of Folco, the father of Dante's Beatrix. Tommaso, at that time patron of a chapel in the hospital of Santa Maria Nuova at Florence, ordered an altar-piece of Hugo van der Goes, and commanded him to illustrate the sacred theme of "*Quem genuit adoravit.*" In the centre of a vast triptych, comprising numerous figures of life size, Hugo represented the Virgin kneeling in adoration before the new-born Christ attended by Shepherds and Angels. On the wings he portrayed Tommaso and his two sons in prayer under the protection of Saint Anthony and St. Matthew, and Tommaso's wife and two daughters supported by St. Margaret and St. Mary Magdalen. The triptych was sent to Florence, and placed on the altar upon which it still remains. Van der Goes, like Hubert Van Eyck and Jodocus of Ghent, has bequeathed but this one picture to posterity; but it is a picture which shows that he was an artist of whom Ghent might be proud, as Bruges was proud of John Van Ecyk and Brussels of Roger van der Weyden. Unhappily the triptych of Santa Maria Nuova suffered so much from decay and restoring that the defects peculiar to the Flemings became unduly prominent as time and neglect effaced the brilliancy and harmony of the principal colors. We can only discern at the present day that the art of Van der Goes is a variety of that which characterizes Van Eyck and Van der Weyden. Less finished and less colored than the work of the first, it is less subtle and expressive than that of the second. It lacks depth of religious feeling, and hardly rises above the common level of the school in respect of feeling or execution. It is a cold and stiff art, marked by hardness of surface, dryness of contour, angularity of drapery, overladen ornament, and ill-balanced light and shade. Imposing because composed of figures of unusual size, the altar-piece is more remarkable for portrait character than for charms of ideal beauty. There are small pieces in public galleries which claim to have been executed by Van der Goes, but none that are certified as the work of his hands. One of these pictures in the National Gallery in London is more nearly allied to the school of Memling than the triptych of Santa Maria Nuova; another, a small and very beautiful John the Baptist, at the Pinakothek of Munich, is really by Memling; whilst numerous fragments of an altar-piece in the Belvedere at Vienna, though assigned to Hugo, are by his more gifted countryman of Bruges. Any one who visits Continental collections will see that the name of Van der Goes was given to pictures of which he could not have been the author. None of the compositions mentioned by historians have survived except the altar-piece at Florence. But Van der Goes was not habitually a painter of easel pieces. He made his reputation at Bruges by producing colored hangings in distemper. After he settled at Ghent, and became a master of his guild in 1465, he designed cartoons for glass windows. He also made decorations for the wedding of Charles the Bold and Margaret of York in 1468, for the festivals of the Rhetoricians and papal jubilees on repeated occasions, for the solemn entry of Charles the Bold into Ghent in 1470–1, and for the funeral of Philip the Good in 1474. The labor which he expended on these occasions might well add to his fame without being the less ephemeral. About the year 1475 he retired to the monastery of Rouge Cloitre near Ghent, where he took the cowl. There, though he still clung to his profession, he seems to have taken to drinking, and at one time to have shown decided symptoms of insanity. But his superiors gradually cured him of his intemperance, and he died in the odor of sanctity in 1482.

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[1] This name seems to have survived in Whelp Moor, near Brandon, in Suffolk.

Birth and education.

GOETHE, JOHANN WOLFGANG VON (1749–1832), was born in Frankfort on August 28, 1749. His parents were citizens of that imperial town, and Wolfgang was their only son and their eldest child. His father was born on July 31, 1710, and in 1742 received the title of imperial councillor. He married on August 20, 1748, at the age of thirty-eight, Catherine Elizabeth Textor, a girl of seventeen. Her family was better than his own, and held a higher position in the town. Her father was imperial councillor, and had been schultheiss or chief magistrate. In December, 1750, was born a daughter, Cornelia, who remained until her death, at the age of twenty-seven, her brother's most intimate friend. She was married in 1773 to John George Schlosser. The house in which Goethe was born is still to be seen in the Hirschgraben. Goethe has described to us how it was rebuilt, and it has since been much altered. His education was irregular; he went to no school, and his father rather stimulated than instructed him. But the atmosphere by which he was surrounded gave him, perhaps, the best education he could have received. Frankfort, a free town of the empire, still preserved the appearance of the Middle Ages. It had lost the reality of power, but its citizens naturally grew up with a strong sense of independence, and a power of realizing the unity of Germany which was wanting in a small state. The boy from his earliest youth was accustomed to the companionship of his elders. His father was strict and formal, his mother quick and lively, inspired with no small share of the genius of her son. Goethe lived in the freest intercourse with every kind of society in the town, in which he might expect some day to be an important personage. There was no capital like London or Paris to call him away; Berlin was poor and distant, Vienna half Italian and half Spanish. Goethe must have been brought up with the ambition to take his degree at the university as doctor, to return home and become an advocate, to make a rich marriage, to go through the regular course of civil offices, to inherit his father's house, and perhaps one day to be burgomaster. His home was a cultivated one. The father was fond of art and of the German poetry then in fashion. The influence of Lessing had scarcely made itself felt; Herder was only five years older than Goethe himself. Gellert and Gottsched were the two oracles of poetry,—Gottsched a pedantic product of the earlier French culture, Gellert old and immovable, and unable to comprehend the new spirit. The chief debt that Goethe owed to him was the improvement in his handwriting, on which Gellert laid great stress, and which he coupled with moral excellence. Goethe's father had a great respect for these rhyming poets, and he so strongly objected to the new German hexameters that Wolfgang could only read Klopstock's *Messiah* with his sister in the greatest secrecy and in terror of discovery. He did, however, read it, and learned much of it by heart. French culture gave at this time the prevailing tone to Europe. Goethe could not have escaped its influence, and he was destined to fall under it in a special manner. In the Seven Years' War, which was now raging, France took the side of the empire against Frederick the Great. Frankfort was full of French soldiers, and a certain Comte Thorane, who was quartered in Goethe's house, had an important influence on the boy. Still more strongly was he affected by the French company of actors, whom he came to know both on and off the stage. He learned to declaim in this manner passages of Racine without understanding a word of them. At a later period he knew French thoroughly well, and composed both prose and poetry in that language. His first writings were imitations of the French manner; his earliest play was the imitation of a French after-piece. We can understand how these different forces were to work upon his future life. From his father he derived the steadfastness of character which enabled him to pursue an independent career of self-culture and devotion to art in the midst of every kind of distracting influence; from his mother he inherited the joyous nature and lively sympathy, the flow of language and love of narration, without which he could not have been a poet. Before the age of sixteen he had seen every kind of life in a city particularly favorable to a richness of individual character; he was entirely free from the prejudices of a small state; and as far as he cared for Germany he cared for it as a whole. He was tinged at an early age with the influence of the clearest and most finished language in Europe, and this influence, uniting with the natural clearness of Goethe's mind, made his prose a new phenomenon in the literature of his country, unlike anything which had been seen before. Lastly, with the most passionate aspirations for freedom and independence of life, he was born into the slavery of a mechanical career of prosaic prosperity, the pressure of which was not strong enough to confine him, but was strong enough to stimulate all his efforts to break the bonds.

First love.

Goethe, if we may believe his autobiography, experienced his first love about the age of fifteen in the person of Gretchen, whom some have supposed to be the daughter of an innkeeper at Offenbach. He worshipped her as Dante worshipped Beatrice. She treated him as a child, much as Miss Chaworth treated Byron. But there is no other evidence of this first love, and it would be quite in accordance with Goethe's manner to enlarge on a very small foundation, or to concentrate on one person the feelings which were devoted to several individuals. His letters speak of a boyish love for one Charitas Meixner, a friend of his sister, two years younger than himself, the daughter of a rich merchant at Worms. He expresses his affection for her with all the fervor of French phraseology, and the passion did not leave him when he had removed to Leipsic. But Charitas was able to console herself with another engagement. She married in February, 1773, a merchant of her native town, and died at the end of the following year.

Leipsic.

In the autumn of 1765 Goethe, who had just completed his sixteenth year, travelled to Leipsic in the company of a bookseller, Fleischer, and his wife, who were on their way to attend the fair. On the 19th of October he was admitted as a student of the Bavarian nation, one of the four into which the university was divided. For his lodging he had two neat little rooms in the Feuerkugel, the Fire Ball, looking into the long courtyard which leads from the old market to the new. When we remember that his three years at Leipsic, about which so much has been written, correspond with the last three years of an English boy at a public school, we can form some idea of the singular individuality of his character and the maturity and ripeness of his genius. He was sent to Leipsic to study law, in order that he might return to Frankfort fitted for the regular course of municipal distinction. For this purpose he carried with him a letter to Professor Böhme, who taught history and imperial law in the university, but had no other distinction to recommend him. He told Professor Böhme that he intended to devote himself not to law but to belles lettres, or, to use the word which F. A. Wolf had invented, philology. Böhme did his best to dissuade him, and in this was assisted by his wife. The effect of their advice was rather to disgust Goethe with modern German literature, to make him despise what he had already written, and to drive him into the distractions of society, which wasted both his time and his money. He did, however, attend some lectures. He heard Ernesti on Cicero's *Orator*, but he dealt rather with questions of grammer than of taste. He attended Gellert's lectures on literature, and even joined his private class. Gellert held a high position among German men of letters, which was due quite as much to his character as to his genius. He advised Goethe to desert poetry for prose, and to take to authorship only as an employment subordinate to the serious occupations of his life. Goethe tells us that in his lectures upon taste he never heard Gellert mention the names of Klopstock, Kleist, Wieland, Gessner, Gleim, or Lessing. He also attended the lectures of another literary professor, Clodius, a young man about ten years older than himself. Clodius corrected Goethe's writings with red ink, and pointed out the faults without showing the way to mend them. Goethe had written a poem of congratulation for the marriage of his uncle Textor (February 17, 1766), which, according to the fashion of the time, was full of gods and goddesses and other mythological apparatus. Clodius was unsparingly hard upon this production, and Goethe then perceived that his critic was just as faulty as himself in the use of abstractions and strange outlandish words to give weight and authority to his verse. He satirized Clodius in a poem in praise of the cakes of the confectioner Händel, and by a parody of his drama *Medon*. His position towards the professors of his university was not an enviable one. His real university education was derived from intercourse with his friends. First among these was J. G. Schlosser, who afterwards married his sister. Goethe used to dine with him at a table d'hôte kept by a wine-dealer, Schönkopf, in the Bruhl (No. 79), in a house which still exists. Schlosser, who was at this time private secretary to the duke of Würtemberg and tutor to his children, was ten years older than Goethe. He had a great influence upon him, chiefly in introducing him to a wider circle of German, French, English, and Italian poetry. At the table of Professor Ludwig, where Goethe had previously dined, the conversation had generally turned on medical and scientific subjects. Another friend of Goethe's was Behrisch, tutor to the young Count Lindenau. He was a man in middle life, and he combined originality of character and clearness of literary judgment with a dry and caustic wit, and an ever-abiding sense of humor, much in the same proportions as were found in Merck, who exercised at a later period an important influence over Goethe's career. His friendship with Goethe was not at first of advantage to him. He was deprived of his tutorship from a suspicion that he did not always keep the most select society, and his successor was forbidden to allow his charge to associate with the young poet. This is supposed to have been caused by Goethe's disrespectful behavior to Professor Clodius. Gellert obtained for Behrisch an educational post at the court of Dessau, and Goethe kept up a constant correspondence with him till his death in 1809. Behrisch would not allow Goethe to print his poems, but copied them out instead in a beautiful hand. He probably had a considerable effect in producing the simplicity and naturalness of Goethe's early style.

Oeser.

But the person who had the strongest effect on Goethe's mental development was Adam Frederick Oeser, at this time director of the academy of arts in Leipsic. Goethe took lessons from him in drawing, and, not content with this, tried his hand at etching. A little device of his for a book-plate or a bill-head is extant, in which a slab with the name C. G. Schönkopf is represented with three bottles above and a wreath of flowers below. Oeser had been a friend of Winckelmann's, and exercised great influence over his views of art. This was a source of considerable reputation to him, and Winckelmann's tragic death, the news of which reached Leipsic whilst Goethe was there, must have brought the relation between them into stronger relief. Goethe always spoke of Oeser's influence with the greatest affection and respect. He writes—"Oeser's discoveries have given me a fresh opportunity of blessing myself that I had him for my instructor. He entered into our very souls, and we must indeed have been without souls not to have derived benefit from him. His lessons will produce their effects through all the rest of my existence. He taught me that the ideal of beauty is simplicity and repose." We find Goethe at Weimar continually consulting Oeser for designs for furniture and for theatrical entertainments.

Käthchen Schönkopf.

Goethe from his earliest years was never without a passion, and at Leipsic his passion was Kitty Schönkopf, the Aennchen of the autobiography, the daughter of the host at whose house he dined. She often teased him with her inconstant ways, and to this experience is due his first drama *Die Laune des Verliebten*, "Lovers' Quarrels," as it may be styled. It is a mere trifle, a pastoral in one act, written in alexandrines in the French style. Two happy and two unhappy lovers are contrasted. The only interest of the piece is that it is a fragment from Goethe's own life. A deeper chord is struck in *Die Mitschuldigen* (The Fellow Sinners), which forms a dismal and forbidding picture both of the time and of the experiences of the youth who wrote it. The daughter of an innkeeper has made an unhappy marriage, and is visited by a former lover who is in good circumstances. An assignation is arranged, and the interview is witnessed by the husband, who has come to steal the stranger's purse. The father comes in to read one of the stranger's letters. He is surprised, and is with his daughter suspected of the theft. The real culprit is discovered, but defends himself by accusing the stranger of his conduct to his wife. So they are all guilty. This play was first written in one act. It was afterwards enlarged to three acts, and published in 1787. The manuscript, which still exists, was given to Frederike Brion of Sesenheim. Besides these plays Goethe wrote at Leipsic twenty little songs of an erôtic character, which were set to music by his young friend Breitkopf. He describes them as moral-sensuous, but they are more sensuous than moral. They have the merit of a musical easy flow of expression, various moods of passion, with a happy readiness and elegance. Only a few of them were included in his collected works, and those very much altered. They show the influence of Wieland, but by one side of Wieland Goethe was never affected. He was never led to mingle classical ideas and emblems with the unrestrained and sensual frivolity which was disseminated from France. He never imitated Agathon or Musarion. Whatever may have been the bitterness of his experience of life, or the waywardness of his excited fancy, he conceived a true idea of the real nature of classical art. In this Winckelmann and Lessing were his teachers, and he was never untrue to the lessons which they inculcated. This was the most valuable possession he brought back from Leipsic. He had an opportunity of establishing his principles of taste during a short visit to Dresden, in which he devoted himself to the pictures and the antiques. The end of Goethe's stay at Leipsic was saddened by illness. One morning at the beginning of the summer he was awakened by a violent hemorrhage. For several days he hung between life and death, and after that his recovery was slow, although he was tended with the greatest anxiety by his friends. He finally left Leipsic far from well on August 28, 1768, his nineteenth birthday.

Frankfort.

Goethe made an enforced stay of a year and a half in his native town. It was perhaps the least happy part of his life. He was in bad health. His cure proceeded slowly, and he had several relapses, and the weakness of the lungs, which was his first complaint, was succeeded by a weakness of the digestion, which was yet more troublesome and painful. The society of Frankfort seemed to him far less agreeable than that of Leipsic; he contrasted the cold, stiff, formal, old-fashioned life of the imperial city with the freshness, geniality, and intellectual activity of the Saxon university. His family relations were not pleasant. His grandfather Textor was struck with paralysis; his father showed but little sympathy with his aspirations for universal culture, and could imagine no career for him but that of a successful jurist. His sister had grown somewhat harsh and cold during his absence, and was possessed by a morbid self-consciousness, which she committed to the confidential pages of a secret diary. The tone of this diary, partly the result of family temperament, partly of the character of the age, throws an interesting light on the despair of Werther. Goethe's mother was always the same to him, a bright, genial, sympathetic friend. But her love could not ward off the pressure of circumstances, or supply a substitute for a wider and more unfettered life. Goethe, during his illness, received great attention from Fräulein von Klettenberg, a friend of his mother's, a pietist of the Moravian school. She initiated him into the mystical writings of those abstracted saints, and she engaged him in the study of alchemy, which served at once to prepare him for the conception of *Faust* and for the scientific researches of his later days. During his stay at Frankfort he wrote very little. It may be that the two Leipsic dramas received here their completed form. A farce in memory of his Leipsic life, a poetical letter to Frederike Oeser, the daughter of his teacher, a few songs, some of them religious, make up the tale of his productions, as far as we know them.

Strasburg.

He arrived at Strasburg April 2, 1770. It was intended that after a sojourn in the university of that place he should visit Paris, the centre of refinement. Goethe stayed in Strasburg till August 28, 1771, his twenty-second birthday, and these sixteen months are perhaps the most important of his life. During them he came into active contact with most of those impulses of which his after life was a development. If we would understand his mental growth, we must ask who were his friends. He took his meals at the house of the Fräulein

Lauth in the Krämergasse. The table was mainly filled with medical students. At the head of it sat Salzmann, a grave man of fifty years of age. His experience and his refined taste were very attractive to Goethe, who made him his intimate friend. Goethe was soon drawn by the studies of his companions to desert his own. A note-book of this date is preserved, which gives us a full account of his studies and employments. He attended lectures on anatomy, on midwifery, and on chemistry. His own studies were chiefly devoted to the last science; and he did not forget his favorite alchemy. He had brought with him to Strasburg introductions to pietistic circles, and this made him at first somewhat staid and retired in his pleasures, and disinclined for general society. This soon wore off, and the natural cheerfulness of his genial nature returned to him. Two songs, *Blinde Kuh* and *Stirbt der Fuchs so gilt der Balg*, refer to the social life of this period. He went on picnics, he wrote French poetry, he took dancing lessons, he learnt the violoncello. The table of the Fräulein Lauth received some new guests. Among these was Jung-Stilling, the self-educated charcoal-burner, who in his memoir has left a graphic account of Goethe's striking appearance, his broad brow, his flashing eye, his mastery of the company, and his generosity of character. Another was Lerse, a frank open character, who became Goethe's favorite, and whose name is immortalized in *Götz von Berlichingen*. Goethe did not desert his studies in art. He learnt from the constant study of the cathedral of Strasburg the effect of Gothic architecture, and he shuddered when he saw the reception-rooms of the youthful Marie Antoinette hung with tapestries which represented the marriage of Jason and Medea, and seemed to forebode the coming doom. His diary also shows that he spent much time in philosophical speculation. But the most important event of his Strasburg sojourn was his acquaintance with Herder. He was five years older than Goethe. Herder was then travelling as tutor to the young prince of Holstein-Eutin, but was obliged to spend the whole winter of 1770–71 in Strasburg on account of an affection of his eyes. Goethe was with him every day, often all day. Herder, who was a pupil of a more original genius, Hamann, taught him the true value of nature in art, and the principles of what we should now call the romantic school. He made *Ossian* known to him, and the wealth of popular poetry in all nations which the publication of *Ossian* revealed; he enchanted him with the idyllic simplicity of the *Vicar of Wakefield;* but, above all, he shook his sensibility to the roots by revealing to him the power of the mighty Shakespeare. He now saw how far superior Homer was to his Latin imitators, and how false were the canons of French art. Goethe's spirit was liberated from its trammels, and *Götz* and *Faust* and *Wilhelm Meister* became possible to his mind. At a later period he forged for himself fetters of a different kind.

Sesenheim.

Goethe's stay at Strasburg is generally connected still more closely with another circumstance,—his passion for Frederike Brion of Sesenheim. The village lies about twenty miles from Strasburg, and her father was pastor there. Goethe was introduced by his friend Weyland, an Alsatian, as a poor theological student. Fresh from his study of Goldsmith, he found the *Vicar of Wakefield* realized. The father was a simple worthy man, the eldest of the three daughters was married, the two younger remained,—Maria Salome, whom Goethe calls Olivia, and Frederike, to whom the poet principally devoted himself. She was tall and slight, with fair hair and blue eyes, and just sixteen years of age. Goethe gave himself up to the passion of the moment; what he felt and suffered is known to us by his songs. At least ten songs are addressed to her, and several others were written for her. During the winter of 1770, in the intervals of his conversations with Herder, Goethe often rode over to Sesenheim. Neither storm, nor cold, nor darkness kept him back. He should have been busy with his dissertation for the degree of doctor. The subject he had chosen was the duty of providing an established church. But the attractions of Frederike were a great interruption to his labors. In the spring Herder went away. The fine weather drew him still more strongly to Sesenheim. Picnics, water-parties, games, dances, illuminated by enthusiasm for literature, filled up the weeks. As his time for leaving Strasburg came nearer, he felt that his love was merely a dream, and could have no serious termination. Frederike felt the same on her side. A visit of the mother and daughters to Strasburg in July made this appear more clearly. On August 6th Goethe took his degree as doctor of law. Shortly afterwards he bade adieu to Sesenheim, and the tears stood in Frederike's eyes as he reached out his hand from horseback. From Frankfort he wrote his final farewell, and it was then, as he tells us, that he found from her answer for the first time how deeply she had loved him. The account of this love episode in the autobiography does Goethe injustice. There is nothing in the letters or the poems of the time to show that he had wantonly trifled with her affections. Eight years afterwards, on his way to Switzerland, he spent a night with the Brions at Sesenheim, and was received with the utmost kindness. He was shown the arbor where he had sat, the songs he had written, the carriage he had painted. He left them in the morning with content. Frederike lived till 1813, well known for her works of charity. She never married; the heart that Goethe had loved, she said, should never love another.

Return to Frankfort.

Goethe's return to Frankfort is marked by a number of songs, of which the "Wanderer's Sturmlied" is the most remarkable. He found his Frankfort existence more intolerable than before. He had outgrown many of the friends of his youth. Those with whom he felt most sympathy were the two Schlossers and his sister Cornelia. He found in her one who sympathized with all his aspirations. He cared nothing for his profession; he was more determined than ever to devote himself to letters, and not to law. He found in the neighboring town of Darmstadt a literary circle which Frankfort did not supply. The landgravine Caroline set a good example, and had collected round her a number of kindred spirits, men and women. Among them were Wenck, and Petersen, and Caroline Flachsland, who was afterwards to marry Herder. But the soul of the literary circle was Merck, now thirty years of age, attached to the war office. Goethe has represented him in the autobiography as a cold and unfeeling cynic, a spirit who always said no, a prototype of Mephistopheles. History represents him otherwise as a man of cultivated and chastened judgment, a represser of enthusiasm, a respecter of the rules of art, anxious to hold the balance between the old school and the new. Goethe had dominated over all his other friends; Merck dominated over him. He has left but little of his own writings. He was one of those who inspire genius in others, and whose truest picture lives in the recollections of their friends. These months were full of literary activity. To them belong an oration on Shakespeare, delivered at Frankfort, an essay on Erwin von Steinbach, the builder of the Strasburg cathedral, two theological treatises of a neologistic character on the commandments of Moses and the miraculous tongues of Pentecost, and a number of reviews written for the *Frankfurter Gelehrte Anzeiger*, which had been founded by Merck. But the work into which he threw all his genius was the dramatization of the history of the imperial knight of the Middle Ages, Gottfried or Götz von Berlichingen.

Götz von Berlichingen.

The immediate cause of this enterprise was his enthusiasm for Shakespeare. After reading him he felt, he said, like a blind man who suddenly receives his sight. The unities of time and place vanished into nothing. The true form of art was seen to be that which holds the wayward impulses together by an invisible bond, just as in the life of man necessity is wedded to free will. The study of a dry and dull biography of Götz, published in 1731, supplied the subject for his awakened powers. From this miserable sketch he conceived within his mind a complete picture of Germany in the 16th century. The chief characters of his play are creatures of his imagination representing the principal types which made up the history of the time. Every personage is made to live; they speak in short sharp sentences like the powerful lines of a great master's drawing. The first sketch of *Götz* was finished in six weeks, in the autumn of 1771. Cornelia was consulted at every stage in the work. Herder saw it, and gave his approval. On his return from Wetzlar in 1773 Goethe wrote the piece over again, and published it, with the help of Merck, in the form in which we now possess it. It ran like wild-fire through the whole of Germany. It was the progenitor, not only of the "Sturm und Drang" period to which it gave the tone, but of the romantic knightly literature which teemed from the German press. At a later period, in 1804, Goethe prepared another edition for the stage, which took five hours in acting. It has never been represented since.

Wetzlar.

With the manuscript of *Götz* in his pocket, Goethe left Frankfort in the spring of 1772 for Wetzlar, a quiet country town on the Lahn, one of the seats of government of the Holy Roman Empire. The emperors lived at Vienna; they were crowned at Frankfort; they held their parliaments at Ratisbon, and at Wetzlar their courts of justice. It was the custom for young lawyers to attend the sittings of these courts for a certain time before they could be admitted to practise on their own account. The company of these students, of the embassies from the component parts of the empire, and of various imperial officials, made the society a pleasant and lively one. Goethe soon found friends. The secretary of the Brunswick legation, Goué, formed a round table of knights,—a Ritter-tafel. The members adopted names from the age of chivalry, and apportioned among themselves the neighboring villages as commanderies and fiefs. Goethe took the name of Götz. Deeds of prowess were performed in friendly rivalry, chiefly of eating and drinking. This masquerade at least served to keep the idea of Götz constantly before his mind. But the place has sadder associations. It is impossible to dissociate the name of Wetzlar from that of Werther. The Deutsches Haus, then the property of the knights of the Teutonic order, exists still in the main street of Wetzlar. It was occupied by one of the officials of the order, by name Buff, an honest man with a large family of children.

Lotte Buff.

The second daughter, Lotte, blue-eyed, fair, and just twenty years of age, was first met by Goethe shortly after his arrival at a ball at Wolpertshausen. She strongly attracted him; he became a constant visitor at the house. He found that Lotte was a second mother to her brothers and sisters, and he delighted to play games with them and tell them stories. Lotte was really though not formally engaged to Kestner, a man of two-and-thirty, secretary to the Hanoverian legation. The discovery of this relation made no difference to Goethe; he remained the devoted friend to both. He visited Lotte and her children; he walked with Kestner about the streets till midnight; they kept their common birthday together in the German house on the 28th of August; Kestner felt no jealousy; Goethe was content with Lotte's friendship; her heart was large enough for both. But the position was too critical to last. On September 10 they met in the German house for the last time. Lotte spoke of the other world, and of the possibility of returning from it. It was arranged between them that whoever died first should appear to the others. This conversation confirmed Goethe's purpose; he determined to go away. He made no adieu, but wrote a line to Kestner to say that he could not have borne to stay a moment longer. Merck had probably persuaded him to this step. To divert his mind he took him to Ehrenbreitstein and introduced him to Sophie la Roche, the friend of Wieland's youth, and to her daughter Maximiliane, with whom Goethe was charmed. The places in the neighborhood of Coblentz were visited. Goethe returned to Frankfort by the river in a yacht. Here he was possessed with the memory of Lotte. He fastened her silhouette over his bed. Kestner came to Frankfort in September; Goethe and Schlosser went together to Wetzlar in November. Here he heard of the death of Jerusalem, a young man attached to the Brunswick legation. He had been with Goethe at the university of Leipsic, but he had seen little of him at Wetzlar. Of a moody temperament, disheartened by failure in his profession, and soured by a hopeless passion for the wife of another, he had borrowed a pair of pistols from Kestner under pretence of a journey, and had shot himself on the night of October 29.

Werther.

Goethe obtained a full narrative of the circumstances from Kestner, and immediately afterwards began his *Werther*, in which the circumstances above related are all interwoven. Goethe tells us that it was written in four weeks, but this can hardly have been the case. We have notices of its slow progress during the whole of the summer of 1773. In 1774 it is far advanced enough to be shown to some intimate friends. It is not till the middle of September, 1774, that two copies of the book are sent in the greatest secrecy to Sophie la Roche and Lotte Buff. In October it spread over the whole of Germany. It was enthusiastically beloved or sternly condemned. It was printed, imitated, translated into every language of Europe, criticised in every periodical, with the fullest meed of praise or scorn. It made the round of the world, and penetrated even to China. The *Werther* fever wrung the hearts of men and women with imaginary sorrows; floods of tears were shed; young men dressed in blue coats and yellow breeches shot themselves with *Werther* in their hands.. It opened the floodgates of pent-up sentimentalism which had been stirred by the philosophy of the time, and which the calamities of the next generation were sternly to suppress. It may be imagined that Kestner and Lotte were not well satisfied with the liberty which Goethe had taken with them. They were married on April 4, 1773, and Goethe provided the wedding ring. Notwithstanding the coolness which the publication of *Werther* produced between them, the correspondence between Goethe and Kestner continued to the end of the century. Lotte saw Goethe in Weimar in 1816, when she was 63 years old; she was still beautiful, but her head shook with palsy. She died in 1828. The second part of *Werther* represents the agony of a jealous husband. This was inspired by Bretano, an Italian merchant resident in Leipsic, a widower with five children, who had married Maximiliane, the daughter of Sophie la Roche. Goethe loved her as an elder brother, but her husband scarcely approved of the intimacy. Merck tells us that his ideas went very little beyond his business, and that it was dispiriting to have to look for his young girl friend among barrels of herrings and piles of cheeses. "Goethe," he says, "much consoles her for the smell of oil and cheese, and for her husband's manners." *Götz* and *Werther* formed the solid foundation of Goethe's fame. They were read from one end of Germany to the other. It is difficult to imagine that the same man can have produced both works, so different are they in matter and in style. *Werther* represents the languid sentimentalism, the passionate despair, which possessed an age vexed by evils which nothing but the knife could cure, and tortured by the presence of a high ideal which revealed to it at once the depth of its misery and the hopelessness of a better lot. *Götz* was the first manly appeal to the chivalry of German spirit, which, caught up by other voices, sounded throughout the fatherland like the call of a warder's trumpet, till it produced a national courage founded on the recollection of an illustrious past, which overthrew the might of the conqueror at the moment when he seemed about to dominate the world. *Werther* is the echo of Rousseau, the lamentation of a suffering world; *Götz* is the prototype of Stein, the corner stone of a renovated empire. *Götz*, in its short, sharp dialogue, recalls the pregnant terseness of mediæval German before it was spoilt by the imitators of Ciceronian Latinity. *Werther*, as soft and melodious as Plato, was the first revelation to the world of that marvellous style which, in the hands of a master, compels a language which is as rich as Greek to be also as musical.

Satires.

These two great works were not the only occupations of Goethe at this time. In Wetzlar he had translated Goldsmith's *Deserted Village*, and had written a number of small poems addressed to Lotte. The spring of 1773, which witnessed the publication of *Götz*, saw him actively employed as an advocate. His relations with his father became easier. His literary success brought him a number of friends,—the young Counts Stolberg, and Von Schönborn, a friend of Klopstock's. He also began to correspond with Lavater the physiognomist and with Klopstock himself. To the latter half of this year are to be referred a number of satirical poems, aimed at prevailing follies of the time, clever and amusing, but of little permanent value. In *Peter Brey* he satirized the meddler Leuchsenring, who, with soft tread and lamblike manners, interfered with the family relations of Herder. *Satyros* is directed against the prophets of the school of nature, who bid us return to nature without remembering how coarse and repellent some aspects of nature are. Bahrdt had translated the Bible into modern cultivated German; Goethe wrote a prologue to this newest of divine revelations, in which the four evangelists appear each with his attendant animal. Of yet another kind is the *Fair of Plundersweilern*, in which the hucksters and booth-keepers represent the motley variety of human life and the characteristics of modern littérateurs. It is a foretaste of the second part of *Faust*. *Harlequin's Marriage* is only preserved in fragments; it was perhaps too coarse and personal to be published. The most important of these writings is *Gods, Heroes, and Wieland*, a dialogue in the style of Lucian written at a sitting over a bottle of Burgundy, in which Alcestis, Mercury, Hercules, Euripides, and other ancient worthies appear to Wieland in all their original greatness, and upbraid him with the mean and paltry representation of them which he had given to the world. Wieland was the apostle of an emasculated antiquity. Goethe would make the gods speak in their own large utterance if they spoke at all. Wieland revenged himself by recommending the satire in his paper, the *Deutsche Merkur*, as a delicate piece of persiflage worthy of the study of his readers. In November Goethe's sister Cornelia was married to Schlosser and left Strasburg. Goethe felt the loss deeply. She lived but a short time. Her married life was tortured with perpetual suffering, and she died in 1777.

Clavigo.

The beginning of 1774 is marked by a new passion and a new work. Crespel had invented a plan for enlivening their social meetings; each man was to draw lots for a partner, and for the time to consider her as his wife. Three times Goethe drew the name of Anna Sibylla Münch, a pleasant girl of sixteen, daughter of a merchant. One of the favorite topics of the day was the trial of Beaumarchais, which ended on February 16, 1774. Immediately afterwards his *Mémoires* or pleadings were published, and from the fourth of these the play of *Clavigo* was arranged. It represents a young writer of ambition deserting the woman to whom he is engaged and breaking her heart. The fifth act, in which Clavigo kills himself, is Goethe's own. The real Clavigo died, a distinguished man of letters, in 1806. The piece was written in eight days, and published on June 1. It had a great success, and still keeps the stage. But Goethe's best friends were disappointed with it. Merck told him not to write such trash, as others could do that as well. In reality there is no period of Goethe's life in which his literary activity was so prodigious, or when he was more fully occupied with literary plans which had reference to the deepest problems of human nature. To this time belong the conceptions of *Cæsar*, *Faust*, *Mahomet*, the *Wandering Jew*, and *Prometheus*. The first was soon given up; of the second the first monologue, the dialogue between Faust and Mephistopheles, and part of the scenes with Gretchen, were now written. He has told us in his *Autobiography* what he intended to make of *Mahomet*. In five acts he was to show us how the purity of prophetic zeal is recognized by love, rejected by envy, sullied by human weakness, spiritualized by death. To write this drama he had studied the Koran through and through; only a few fragments were completed. Of the *Wandering Jew* very little remains to us. The design, conceived in Italy, of making a great work on the subject was never carried out. The *Prometheus* was completed in two acts. The monologue of *Prometheus* included in the *Lyrical Poems*, was written at the same time; but it is doubtful whether it was intended to form part of the drama. These works are to be referred to the study of the ethics of Spinoza, for whom he now began to feel a deep reverence, which continued throughout his life. The calm repose of Spinoza's mind spread over his own like a breath of peace; his systematic and well-ordered reasoning was the best antidote to Goethe's passionate waywardness. Goethe now acquired a wider view of all the relations of the moral and natural world; he felt that he had never seen the world so clearly. His time at Frankfort was also largely occupied with art. His room was covered with the works of his pencil, and a number of poems on the subject of the artist's life arose from the same influence.

Rhine journey.

The summer of 1774 was spent in a journey to the Rhine. On July 12 Basedow, the educational reformer, came to Frankfort; three days afterwards Goethe went with him to Ems, where he found Lavater, who had been with him in the previous month. The three went down the Lahn together, and reached Coblentz on July 18. Here the famous dinner took place at which Lavater explained the secrets of the Apocalypse to a clergyman, Basedow demonstrated the uselessness of baptism to a dancing master, while Goethe, the worldling between the two prophets, made the best of his time with the fish and the chicken. They then went down the Rhine to Elberfeld, where Goethe found his old Strasburg friend Jung-Stilling, and back to Pempelfort, near Düsseldorf, the house of Fritz Jacobi, where Goethe also met Jacobi's wife Betty, his sister Charlotte, his aunt Johanna Fahlmer, and his friend W. Heinse. Their letters are full of the effect which he produced upon them. Heinse says—"I know of no man in the whole history of learning who, at such an age, was so completely full of original genius." Jacobi writes—"Goethe is the man whom my heart required; my character will now gain its proper stability; the man is complete from head to foot." Again he says that you could not be an hour with him, without seeing that it would be ridiculous to suppose that he could think or act otherwise than he really thinks and acts. No change could make him fairer or better; his nature has followed its own development, as the growth of a seed, or of a flower on a tree. Nor were these impressions evanescent. Forty years afterwards he writes of these times—"What hours! what days! I seemed to have a new soul. From that moment forth I would never leave you."

Frankfort.

Goethe returned to Frankfort at the beginning of August. The autumn brought new friends, drawn to him by the fame of the newly published *Werther*. Among these was Klopstock, twenty-five years older than Goethe, and author of the *Messiah*, the acknowledged head of German poets. On December 11 Goethe was surprised by the visit of a stranger, whom he at first took for Fr. Jacobi. It was Karl Ludwig von Knebel, who was travelling with the two young princes of Saxe-Weimar, the reigning duke Karl August, then just seventeen, and his younger brother Constantine. They were on their way to France with their tutor, Count Görz, and they could not pass through Frankfort without making the acquaintance of the new genius who had risen upon their country. Goethe went to see them, was warmly received, and talked with them about the condition and prospects of Germany. This meeting decided the future course of Goethe's life. Knebel thought Goethe "the best of men, the most lovable of mankind." The princes invited him to visit them at Mainz, where they would stay longer than at Frankfort. The visit lasted from December 13 to 15, when they went on to Carlsruhe, where the duke was to meet his intended bride. Goethe took the opportunity of reconciling himself with Wieland, who lived in Weimar. On his return he found Fräulein von Klettenberg dead. "My Klettenberg is dead," he writes, "before I had an idea that she was dangerously ill. Dead and buried in my absence! She who was so dear, so much to me." Frederike was lost to him, Charlotte, Maximiliane, and his sister married. Some attachment was a necessity of his nature. He now came under the influence of Lili Schönemann, the daughter of a rich banker, whose father was dead, but whose mother conducted the business, and held one of the most brilliant salons in Frankfort. This passion seemed to be of a more lasting nature than the others. Goethe was drawn into the whirl of society. He is described as moving in brilliantly-lighted rooms, in a gold-laced coat, passing from party to concert, from concert to ball, held captive by a fair-haired girl with a pair of bright eyes. Such was Goethe in the carnival time. To Lili's influence we owe several of his smaller poems, *Neue Liebe neues Leben*, *Herz mein Herz was soll das geben*, *Heidenröslein*, and two little vaudevilles, *Erwin und Elmire* and *Claudine von Villa Bella*. The first contains some pretty songs, notably "*Das Veilchen*," set to music by Mozart. It is founded on the ballad of "Edwin and Angelina" in the *Vicar of Wakefield*. The latter half belongs to an earlier period, and is complete in itself. *Claudine von Villa Bella* has one good character, the prodigal son Crugantino; and the ballad which is sung at the crisis of the plot was written during the Rhine journey with Jacobi. To this period also belongs *Stella*, a comedy for lovers, a strange wild play, full of extravagant passion. The weak-minded hero Fernando marries two wives one after the other. They meet together in an inn, and he is reduced to extremity of misery. He loves them both, and they both love him. Finally, the first wife Stella surrenders her rights, and they agree all to live together. The play in this form suggested to Canning the parody of the *Rovers, or the Double Arrangement*. In 1806 Goethe altered the close by making Fernando shoot himself and Stella take poison. It is seldom performed, but Stella is a fine character for a great actress. It is said to be founded on an occurrence in the Jacobi family.

Lili.

Stella.

Swiss journey.

Neither family approved of the engagement between the youthful couple. Goethe's parents thought Lili too much of a fine lady; they had a suspicion, which was well founded, that her wealth had no very sure foundation. Frau Schönemann did not think that Goethe, with all his genius, would make a good husband for her child. Cornelia Schlosser was strongly opposed to the match. Goethe tore himself away, and went for a tour in Switzerland. His companions were the brothers Stolberg, noisy, wild young noblemen, who in May had stayed at Goethe's house. They gave Goethe's mother the name of Frau Aya, which she ever afterwards retained. On his journey Goethe visited the duke of Saxe-Weimar and his betrothed at Carlsruhe, his sister at Emmendingen, Lavater at Zurich. He bore with him the constant memory of Lili; he wore a golden heart which she had given him round his neck. He climbed the St. Gotthard on her birthday, and looked with longing eyes to the promised land of Italy. But a stronger power drew him home again, and he returned. At Strasburg he met his old friends, and saw Zimmermann, the writer on solitude. He showed him a profile of Frau von Stein who lived at Weimar, with which Goethe was enchanted.

Return.

He returned to Frankfort on July 20. August was spent delightfully with Lili at Offenbach; his letters speak of nothing but her. September and the fair-time at Frankfort brought back his troubles. His position is described in the poem *Lili's Park*. He is the half-tamed bear who is held by magic bands amongst the birds and the fish, and yet sees a door left a little open for escape, and swears that he has the power to pass it. During this last period of his passion he translated part of the Song of Solomon. He wrote some scenes in *Faust*—the walk in the garden, the first conversation with Mephistopheles, the interview with the scholar, the scene in Auerbach's cellar. *Egmont* was also begun under the stimulus of the American Rebellion. A way of escaping from his embarrassments was unexpectedly opened to him. The duke of Weimar passed through Frankfort both before and after his marriage, which took place on October 3. He invited Goethe to stay at Weimar, and it was arranged that one of the duke's household, who was expected every day with a new carriage, should bring him with him. He took leave of every one, including Lili. But the carriage did not come; a second leave-taking was impossible. He remained all day in the house working at *Egmont*, going out only at night. Once he stood by Lili's window, heard her sing his songs, and saw her shadow on the curtain. He could not linger longer in the town. He started for Heidelberg hoping to meet the carriage, determined if it did not come to go on to Italy. He was summoned hastily back by a messenger, found the carriage at Frankfort, and entered Weimar in the early morning of November 7, 1775. It was not for his happiness or for Lili's that they should have married. She afterwards thanked him deeply for the firmness with which he overcame a temptation to which she would have yielded.

Weimar.

At this time the smaller German courts were beginning to take an interest in German literature. Before the Seven Years' War the whole of German culture had been French. Even now German writers found but scant acceptance at Berlin or Vienna. The princes of the smaller states, shut out from the great world of politics, surrounded themselves with literature and art, and with men who would be likely to give an interest to their lives. The duke of Brunswick had made Lessing his librarian at Wolfenbüttel, and had not objected to the publication of *Emilia Galotti*. Emmerich Joseph, the worldly elector and archbishop of Mainz, was devoted to Munich and the theatre, and made his stage one of the best in Europe. The margrave of Baden had invited Klopstock to his court, and delighted to associate with himself the author of the *Messiah*, the "poet of religion and of his country." The duke of Würtemberg paid special attention to education; he promoted the views of Schubart, and founded the school in which Schiller was educated. Hanover offered a home to Zimmermann, and encouraged the development of Schlegel. Darmstadt was specially fortunate. Caroline, the wife of the landgrave, had surrounded herself with a literary circle, of which Merck was the moving spirit. She had collected and privately printed the odes of Klopstock, and her death in 1774 seemed to leave Darmstadt a desert. Her daughter Louise, the youngest of eight children, seemed to have inherited something of her mother's qualities, veiled by a serious and retiring temper. She married on October 3, 1775, the young duke of Weimar, who was just of age. She reigned over that illustrious court respected and admired, but repelled rather than attracted by its brilliancy and eccentricity. The place which she would naturally have occupied was taken by the duchess Amalia, mother of the grand duke. She was of the house of Brunswick, and after two years of marriage had been left a widow at nineteen with two sons. She committed their education to Count Görz, a prominent character in the history of the time. She afterwards summoned Wieland to instruct the elder, and Knebel to instruct the younger. The *Deutsche Merkur*, founded in 1773 to diminish the influence of the school of Klopstock, gave Weimar importance in the literary world. The duchess was a great lover of the stage, and the best play writers of Germany worked for Weimar. The palace and the theatre were burnt down in 1774, and the duchess had to content herself with amateurs. After her son's marriage she lived in the simple country houses which surround the capital, the lofty Ettersburg, the low-lying Tiefurt, the far-seeing height of Belvedere. Each of these was awakened to new life by the genius of Goethe. The duke, eighteen years of age, was simple in his tastes, a hater of etiquette and constraint, true, honest, and steadfast, fond of novelty and excitement, of great courage and activity; his impulses, rarely checked, led him rather to chivalrous enterprise than to undesirable excess. His brother, Prince Constantine, had perhaps more talent but less character than the grand-duke. He took but little part in the Weimar life, and died in 1793.

Goethe in Weimar.

Upon this society Goethe, in the strength and beauty of youth, rose like a star. From the moment of his arrival he became the inseparable and indispensable companion of the grand-duke. He subdued the affections of all he met with. Wieland said that his soul was as full of him as a dewdrop of the morning sun. He was, take him all in all, the greatest, best, most noble human being that God had ever created. The first months at Weimar were spent in a wild round of pleasure. Goethe was treated as a guest. In the autumn, journeys, rides, shooting parties, in the winter, balls, masquerades, skating parties by torch-light, dancing at peasants' feasts, filled up their time. Evil reports flew about Germany; the court of Weimar had a bad name; Klopstock wrote letters of solemn advice, and forbade his young friend Stolberg to accept an appointment which the duke had offered to him. We do not know, and we need not examine, how much of these reports was true. Goethe wrote to Klopstock that if Stolberg came he would find them no worse, and perhaps even better, than he had known them before. We may believe that no decencies were disregarded except the artificial restrictions of courtly etiquette. Goethe and the duke dined together and bathed together; the duke addressed his friend by the familiar *thou*. Goethe slept in his chamber, and tended him when he was ill. In the spring he had to decide whether he would go or stay. In April the duke gave him the little garden by the side of the Ilm, with its lofty roof, in which he lived for the next eight years. In June he invested him with the title, so important to Germans, of geheim-legationsrath, with a seat and voice in the privy council, and an income of £180 a year. By accepting this he was bound to Weimar for ever. We may here mention the different grades of service through which Goethe passed. In January, 1779, he undertook the commission of war; on September 5, 1779, he became geheim-rath; in September, 1781, he received an addition to his salary of £30. This was afterwards raised by £60 more, and in 1816 he received £450, with an additional allowance for the expense of a carriage. In April, 1782, he was ennobled by the emperor, and took for his arms a silver star in an azure field; in June of the same year he became president of the chamber *ad interim*. We know that Goethe devoted himself with industry and enthusiasm to the public business; he made himself acquainted with every part of his master's territory; he did his best to develop its resources; he opened mines and disseminated education; he threw himself with vigor into the reconstruction of the tiny army. A complete account of his labors in this field cannot be known until the secrets of the Goethe house at Weimar, now hermetically closed, are opened to the curious. We shall then probably find that Goethe cannot be fairly charged with want of patriotism, or coldness to the national interest, and that his apparent indifference to the rising of 1813 must be considered in connection with his resistance to the encroachments of Austria at an earlier time.

Frau von Stein.

Goethe's life was at no time complete without the influence of a noble-hearted woman. This he found in Charlotte von Stein, a lady of the court, wife of the master of the horse. She was thirty-three years of age, mother of seven children. His letters to her extend over a period of fifty years. Until his journey to Italy he made her acquainted with every action, every thought of his mind, all the working of his brain. He calls her by every endearing epithet—the sweet entertainment of his inmost heart, the dear unconquerable source of his happiness, the sweet dream of his life, the anodyne of his sorrows, his happiness, his gold, his magnet, whom he loves in presence and absence, sleeping and waking, from whom he can never bear to be parted. Many of Goethe's writings were from this time inspired by the necessities of the court. One group of them is formed by the succession of masks or ballets which were performed to celebrate the birthday of the grand-duchess Louise. *The Four Seasons, The Procession of Laplanders, the Nine Female Virtues, The Dance of the Planets*, are sufficiently explained by their names. Others were called for by the amateur theatre, which now was forced to supply the place of the regular drama. The stage was often set in the open air, the seats cut out of turf; the side scenes, of trimmed box, still exist at Belvedere and Ettersburg. The actors were the duchess-mother and her sons, the civil servants and the officers, the ladies in waiting and the pages. Goethe was very good in comic parts; in solemn tragedy, as in his own *Orestes*, he could best interpret the dignity of the ancient stage. Musæus, head-master of the public school, was set to play low comedy; Knebel represented the dignified hero. The chief professional support of the stage was Corona Schröter, whom the duke and Goethe personally carried off from Leipsic. On this visit he saw, after a long absence, Catherine Schönkopf, Oeser, and other friends of his youth. Goethe represented most of his earlier pieces on the Weimar stage. He wrote nothing of great importance for it till the first sketch of his *Iphigenie*. But several smaller pieces owe their origin to this cause. *Proserpina* and *Die Geschwister* are melodramas; *Jery und Bätely* and *Die Fischerin* are little operas composed to suit the Weimar taste. *Scherz, List, und Rache* is an imitation of the Italian style.

Journeys. Besides numerous visits to the court of the Thuringian princes, sojournings at Dornberg and at Ilmenau, that retired nook of the Weimar fatherland which still attracts many a pilgrim lover of Goethe, the first ten years at Weimar were interrupted by longer journeys. One of these was the winter Harz journey in December, 1777, undertaken suddenly to make the acquaintance of Plessing, a self-torturing hypochondriac, who had written to the poet for advice. With Goethe's help Plessing recovered from his melancholy, visited him at Weimar, and entertained him as professor at Duisburg on his return from the campaign in France. A visit to Dessau inspired the improvements of the park and grounds at Weimar, which now make it so attractive. The close of 1779 was occupied by a winter journey to Switzerland, undertaken with the duke and a small retinue. Two days were spent at Frankfort with Goethe's parents. Sesenheim was visited, and left with satisfaction and contentment. At Strasburg they found Lili happily married, with a new-born child. At Emmendingen Goethe stood by his sister's grave, and saw her successor Johanna Fahlmer, Jacobi's aunt. The Swiss journey began at Basel. The chief object of it was to forward the health and education of the young duke. It was a bold plan to execute in October and November. From Bern they made the tour of the Bernese Oberland. From Geneva, by the advice of De Saussure, they visited Mont Blanc and the valley of Chamouni; they crossed the Furka, not without danger, in the middle of November, descended the St. Gotthard to Lucerne, and visited Lavater at Zurich, the seal and summit of their tour. From this time Lavater lost his influence over Goethe, and in 1786 he would gladly have run away from Weimar to avoid him. In December they went by the Lake of Constance and the falls of the Rhine to Stuttgart, where, on December 14, Goethe saw Schiller for the first time. He was a student at the Academy, and in Goethe's presence received the prize.

The return to Weimar, on January 13, was the beginning of a new era. The period of genius and eccentricity was at an end; that of order and regularity succeeded. As an outward sign of the change, the duke cut off his pigtail, an example which was long without imitators. Wieland said that the Swiss winter journey was the greatest of Goethe's dramas. In the same serious mood Goethe began to write history. He chose for his subject Duke Bernhard of Saxe-Weimar, the knight-errant of the Reformation. He spent much time and trouble in collecting materials, but at length reasonably concluded that his strength lay elsewhere. At this time also he began to write *Tasso*, and adapted the *Birds* of Aristophanes to modern circumstances. His deeper thoughts were concentrated in *Wilhelm Meister*. Countess Werther, the sister of the great minister Baron von Stein, whom he visited at Neunheiligen was transferred in living portraiture to its pages. His efforts for the development of the duke's dominion naturally led him to the study of science. The opening and direction of mines induced him to study geology; the classification of ancient forms of life led him to osteology and anatomy. Goethe was always fond of children. The young Herders and Wielands spent much time in his garden, sometimes digging for Easter eggs which had been carefully concealed. In the spring of 1783 Fritz, the son of Charlotte von Stein, then ten years old, came to live with him in his garden house. In the autumn they took a journey together in the Harz. At Ilmenau was written the touching poem of that name on the duke's birthday. Goethe reviews in it their common friendship and activity as far as it has yet gone, and in a few days afterwards, as he slept in the hut on the Gickelhahn, he wrote in pencil the world-known lines in which he anticipates for himself that rest and silence which then held enchained the summits of the hills and the birds of the wood. In the following year another journey was undertaken in the Harz for the study of mineralogy. But this was only a relaxation from more serious affairs. In 1785 the Fürstenbund or league of princes was formed, under the supremacy of Frederick the Great, to resist the ambition of Austria under Joseph II. The duke of Saxe-Weimar took an important part in forming this league, and in the negotiations which preceded it. Goethe was his indispensable adviser, and must on this occasion, if not on others, have taken a keen interest in politics and in the independence of Germany.

Leaves Weimar. The year 1786 marks an epoch in Goethe's life. He had now been ten years in Weimar, and he must have felt that his own inward development, and the work which he was most fitted to do in the world, were not advancing as favorably as they should. He had written little of first-rate importance. His *Lyrics* were of intense beauty and of deep meaning, but they were short and fugitive. He had brought with him from Frankfort the sketches of *Faust* and *Egmont*, but little had been done to them since. His occasional writings for the amateur theatre, or for court festivities, were not such as to add to his solid reputation in Germany. *Iphigenie* was the one great work of poetry which belongs entirely to this period, but that had not received its final form. *Tasso* was conceived, but only two acts were written, and these in prose. *Wilhelm Meister* is the most exact expression of this portion of Goethe's life; but loftily as it now towers above the level of his dramas, it did not then satisfy the author, nor was it in a state to be published. For the completion of these Goethe required leisure and repose, impossible to obtain in the distraction and pleasures of the court. This became more apparent to him as he set himself to collect his scattered writings. Four volumes were soon completed, but the preparation of the other four convinced him how much labor many of his poems still required for perfection. Another cause of discontent was his relation to Frau von Stein. It could not have been more intimate. She was all to Goethe and more than Gretchen, Frederike, Lili, or his sister Cornelia had been. He communicated to her every thought and every action of his life. The relation was blameless, to a character like Goethe's it was natural; but it became every year more difficult and more full of danger. The ardent devotion which sat well on the impetuosity of youth was less becoming and less possible to the man of middle age. Yet the tie could not be severed without a struggle, and the wrench could not be effected without an enforced absence. To these necessities, the need of quiet for composition, and for deliberately rearranging the circumstances of his life, was added the stress of other impulses. Goethe had all his life been fascinated by the practice of art. Indeed it was not until he had discovered at Rome the limitation of his powers that he definitely renounced the hope of becoming an artist. He tried almost every branch in turn. He drew in pencil and in sepia, sketched, painted, in oil, engraved on copper and wood, and etched. For these occupations he had but little leisure; at this time he attributed his slow improvement rather to want of labor than to want of power. He saw infinite possibilities of advance in a life of freedom spent under the inspiration of sunny skies, and amidst the environment of the highest art.

Science. Of still deeper interest and importance were his scientific researches. In these he aspired to detect the secrets of nature; he succeeded in seeing, as in a vision, the great scheme of evolution applied to all phenomena of the natural and moral world, which the labors of many workers have revealed to us in our own day. He longed for time and leisure to perfect these ideas, to base them on solid fact. Goethe has not added much of positive value to the treasury of scientific truth, but he deserves the credit of having discerned the right method of inquiry when it was obscure to many, and of having thrown that glow of imagination over dry and technical inquiry, without which no great discoveries can be made. His inquiries into the nature of light belong to a later time. He began with physiognomy under the auspices of Lavater. From this he was led to the study of anatomy, and especially to the comparison of the skeletons of men and animals. In this department he made a real discovery, that the intermaxillary bone which exists in the lower animals is found in the human subject in a rudimentary state,—that it is seen distinctly in youth, but as years advance is united with the body of the skull. The discovery that the skull itself is only a development of the vertebræ of the spine was made a little later. He was led to this further step by picking up the head of a sheep on the shore of the Lido at Venice. The care of his garden cottage naturally led him to the study of plants. He soon found himself attracted to wide and comprehensive generalizations. The *Metamorphoses of Plants* was not published till 1790, but the idea which had possession of his mind was a solid contribution to the science of botany. Goethe sought to discover an original or standard flower, from which, as from a Platonic ideal type, all existing flowers were deflexions and aberrations. In this he followed an unscientific method, but he clearly saw that all the different parts of the plant, except the stem and the root, might be regarded as modifications of the leaf; that leaf, calyx, corolla, bud, pistil, and stamen were all referable to the same type; and that whether a plant produced leaves, or flowers, or fruit, depended on the differentiation of the nutrition which it received. Less fortunate were his speculations in geology, to which he devoted a very large portion of his time and thoughts. It is something that he recognized the importance and reality of that science, then in its infancy, which has had to undergo more than its due share of obloquy and distrust. But he was of necessity a follower of Werner, who based his classification of rocks rather on the minerals which they contained than upon an examination of the fossil remains of organic life. All these causes contributed together to one end. His desire to complete the great poetical works which he had begun, to disentangle his life from the complexities which had entwined themselves around it, to give a fair trial to his impulses towards art, to afford opportunity for the careful and systematic interrogation of nature, and, above all, a longing to possess his soul in peace, and solemnly to probe in silence the depths of his own being, conspired together to drive him from Weimar to the land which he had yearned after from boyhood. The resolution, slowly formed, was boldly executed. In the summer of 1785 he had visited Carlsbad for the first time, passed a pleasant month in the company of the duchess Louise, Herder, and Frau von Stein. In July, 1786, he paid it a second visit. After five weeks of brilliant society, very favorable to his health, spent in revising his works for the press, he stole secretly away. The duke alone knew that he designed an absence of some duration. In the strictest incognito, in the guise of a German merchant, he drove alone to the land of the citron and the orange.

Italy. Goethe's Italian journey, the most momentous epoch in the development of his intellectual life, lasted from September 3, 1786, to June 18, 1788. Assuming the common German name of Müller, in the strictest incognito he journeyed by way of Munich, where he studied the picture gallery and the collection of antiquities; by the Lake of Garda, where he began his metrical version of the *Iphigenie;* by Verona, where he saw the first specimen of Roman building in Italy in the stupendous amphitheatre; by Vicenza, where he was attracted by the grace and harmony of the classical Palladio; by Padua, where he neglected the frescoes of Giotto, but rose to a clear conception of the form of the *original plant* by the marks on the leaves of a palm in the botanical garden; to Venice, where for the first time he was able to taste the charm and richness of southern life. As he proceeded further, Ferrara spoke to him of Tasso; Bologna showed him the great masters of the academic school who have now grown pale and dim before the predecessors of Raphael; Florence interested him a little; Assisi drew his attention, not to the triple church of Saint Francis, the unrivalled museum of religious art, but to the little ruined temple which no modern traveller would notice but for the name of Goethe; Spoleto again delighted him with the remains of ancient architecture. Rome. He reached Rome on October 23. His first stay was till February. The constant companion of his studies was the painter Tischbein, who helped him to disentangle the many difficulties of the old Rome and the new. He lived chiefly among the German artists and men of letters who frequented the caffè Greco. Among these were Angelica Kaufmann and Moritz, who deepened his knowledge of German versification, and prepared him for the composition of *Iphigenie.* Although Goethe occupied himself chiefly with drawing, he was able to announce on June 6 that this work was finished. The second *Iphigenie,* written in verse, was the first important fruit of the Italian journey. It is in very strong contrast with *Götz von Berlichingen.* It is written in the strictest classical form. Although based on the *Iphigenia in Tauris* of Euripides, it has little in common with it. In Euripides Thoas is represented as a cruel barbarian, against whom it is justifiable to employ every artifice of fraud or violence. In Goethe the characters are ennobled by a higher principle, and the struggle between truth and falsehood is made a prominent motive of the piece. When Thoas discovers that, according to the oracle of Apollo, the return of Orestes's sister to Greece will satisfy the anger of the gods, he gives his consent, and his last words are a friendly farewell. Towards the end of February Goethe left Rome for Naples. Here he was attracted less by the remains of antiquity, even the new revelations of Herculaneum and Pompeii, than by the prospects of nature, the bay, the islands, the volcano, the thousand beauties which make the gulf unrivalled in the world, and by the multitudinous and teeming life which throngs the endless quays that line the shore. Sorrento stimulated him to the revisal of *Torquato Tasso,* *Tasso.* but he did not complete the drama till his return from Italy. It did not appear in print till the spring of 1790. The play had a special fascination for him as a picture of his own distracted life. He could depict with feeling the struggle between the actual and the ideal, the ill-assortment of a passionate poet with the jealous and artificial environment of a court. Sicily. At the end of March Goethe sailed to Sicily; rolled up in his cloak he meditated the composition of his *Tasso.* Sicily struck him, as it must strike all travellers who have studied the ancient world, as a revelation of Greece. It is, if one may say so, more Greek than Greece itself. Its mountains, streams, trees, flowers, the form of its boats and pottery, the habits of the people, the quivering smile of the bright blue sea fringed with golden sand, represent completely the Greece of the *Odyssey* and of the choruses of Euripides. Goethe was overmastered by this powerful influence. He sketched and began *Nausicaa,* the story of the *Odyssey* in dramatic form, which always remained a fragment. He returned to Rome in June. The rest of the year was spent in the city and its neighborhood, in the serious study of drawing, for which unfortunately he had but little talent, and in the composition of *Egmont,* *Egmont.* a work begun with the approval of his father in the early Frankfort days. It was finished in September, 1787, and appeared in the Easter of the following year. Although *Egmont* still keeps the stage, it has very grave faults. It is an unfortunate mixture of the natural and ideal treatment. The license with which the scenes are transposed in modern performances shows how much the work lacks symmetry and cohesion. Schiller criticised it severely as being untrue to history. He described the close, where all difficulties are solved by the appearance of Clärchen, as a *deus ex machina* or a *salto mortale* into the world of opera. The music of Beethoven has contributed to it a charm of art which was necessary to its completeness. Besides this, Goethe rewrote for publication his early vaudevilles of *Erwin und Elmire* and *Claudine von*

Villa Bella. The carnival of 1788 was of importance to his experience. He wrote some scenes of *Faust:* especially the scene in the witches' kitchen was composed in the Borghese gardens. At the end of April he took a sad farewell of Italy, and arrived at Weimar in the middle of June.

Return to Weimar.

Christiane Vulpius.

From this time his life takes a new color. He had learned in Italy not only new principles of art—not only that a work of art, whatever of Gothic ornament it may possess, must be solid, firm, and simple in its construction as a Grecian temple—but he had also learned that life itself should be a work of art. He was determined henceforth to be himself, to break the bonds which had confined him and the distractions which had confused him, to possess his soul sacred and inviolable for the purposes of his life. He was relieved of the presidency of the chamber and of the war commission, but in a manner which did him the greatest honor. His relations with Frau von Stein, which had been one reason of his leaving Weimar, began to cool. One of their last friendly meetings was in a journey to Rudolstadt, where Goethe met Schiller. Neither knew the influence which the other would have upon his life. Their relations were those of shyness, and partly even of dislike. Goethe's friendship with Frau von Stein was to receive a final blow. In the autumn of 1788, walking aimlessly through the park, he met Christiane Vulpius, a young girl who presented him with a petition in favor of her brother. She had golden curling locks, round cheeks, laughing eyes, a neatly rounded figure; she looked, as has been said, "like a young Dionysus." Goethe took her into his house, and she became his wife in conscience, and the mother of his children. He did not marry her till 1806, when the terrors of the French occupation made him anxious for the position of his eldest son. She had but little education, and he could not take her into society; but she made him a good and loving wife, and her quick mother-wit made her available as an intellectual companion. To these days of early married life belong the Roman elegies, which, although Italian and pagan in form, in color, and in sensuality, were written in Germany from home experiences.

Campaigns.

We must pass rapidly over the next six years, until Goethe's genius received a new impulse and direction by his friendship with Schiller. In the spring of 1790 he travelled to Venice to meet the duchess Amalia. The Venetian epigrams, still more outspoken in sensuality than the Roman, were the fruit of this journey. In the autumn of the same year he accompanied the duke to Silesia, the first of those military journeys which strike so discordant a note in the harmonious tenor of his existence. The year 1791 offered a quiet contrast to the movement of the year before. He began to take a more special interest in the university at Jena, in which his young friend Fritz von Stein had now entered as a student, and his time was more and more occupied with the study of colors, the least happy and successful of his scientific labors. In the autumn of 1791 Goethe was able to devote himself regularly to a task which had informally occupied his first years in Weimar. The new theatre was completed, and Goethe was made director of it. It was in this capacity that he was best known to the citizens of Weimar. He had the final decision on every detail of piece, scenery, and acting: in later years his seat was in a large arm-chair in the middle of the pit, and applause was scarcely permitted until he gave the signal for it. The German stage owes perhaps as much to Goethe as to Lessing. The *répertoire* of the Weimar theatre was stocked with pieces of solid merit which long held their place. Shakespeare was seriously performed, and the actors were instructed in the delivery of blank verse. Stress was laid on the excellence of the *ensemble* as against the predominance of particular stars. The theatre was considered as a school not only of elevating amusement but of national culture. Goethe wrote the *Gross Cophta* for the Weimar stage, a piece founded on the history of Cagliostro and the diamond necklace. He was fascinated by the story as a foreboding of the coming horrors of the Revolution. In these events he was destined to take a more active part than he expected. In August, 1792, he accompanied the duke to the campaign in the Ardennes. Passing by Frankfort, where he visited his mother, he joined the allied armies at Longwy. He beguiled the tedious siege of Verdun by writing an account of his theory of colors in a leaky tent; and on the disastrous day of Valmy, which he recognized as the birth of a new era, he sought the thickest of the fight that he might experience the dangerous rapture of the cannon-fever. He retreated with the Prussian army, spent five weeks with his friend Jacobi at Pempelfort, and on his return to Weimar at the end of the year found that the duke had built him a spacious house in the square where the joint statues of Goethe and Schiller now stand, in eternal memory of their friendship. In 1793 he went with his master to the siege of Mainz. He continued his optical studies during the bombardment, witnessed the marching out of the garrison, and was one of the first to enter the conquered town. He received leave to withdraw, and went to his mother at Frankfort, and persuaded her to sell the old house and its contents, and to provide a more convenient home for her old age. There was some talk of her coming to Weimar. In the autumn of this year the duke left the Prussian service, and Goethe could look forward to a period of peace. He was chiefly occupied with the management of the theatre, and for this he wrote two pieces, both of which had reference to the politics of the time. The *Bürgergeneral* is a satire on the Revolution, and was long a stone of offence to Goethe's friends, who thought that he should have hailed with delight the birth of a new era. The *Aufgeregten*, left unfinished, sketched the outbreak of the Revolution in a country town, and would have declared the author's views with greater distinctness. But the feelings of scorn and contempt which he felt for the cowardice, cunning, and perfidy of mankind were expressed in a work of greater magnitude. He had good reason to deplore the misery of the time. His mother's home in Frankfort was broken up; Schlosser, his brother-in-law, had retired to Auerbach; Jacobi was flying to Holstein. Goethe took the old German epic of *Reynard the Fox*, with which he had long been familiar, and which, under the guise of animals, represents the conflicting passions of men, and rewrote it in flowing German hexameters.

Friendship with Schiller.

Thus far he had produced but little since his return from Italy. He was now to undergo the most powerful influence which had as yet affected his life. His friendship with Schiller was now to begin, an alliance which, in the closeness of its intimacy and its deep effect on the character of both friends, has scarcely a parallel in literary history. If Schiller was not at this time at the height of his reputation, he had written many of the works which have made his name famous. He was ten years younger than Goethe. The *Räuber* plays the same part in his literary history as *Götz* plays in that of Goethe. This had been followed by *Fiesco* and *Kabale und Liebe.* The second period of Schiller's life had begun with his friendship with Körner, and his residence in Saxony. Here he wrote the *Hymn of Joy*, and completed *Don Carlos.* In 1787 he settled at Weimar. He found the place deserted, the duke in the Prussian camp, Goethe in Italy. He applyed himself to history, wrote the *Revolt of the Netherlands*, and studied the literature and art of Greece. In 1789, mainly upon Goethe's recommendation, he was made professor of history at the university of Jena, although he was afraid lest the scholars should discover that they knew more history than the teacher. He made a successful marriage, and worked seriously at his *History of the Thirty Years' War.* In 1794 Schiller had arranged with the publisher, Cotta of Augsburg, whose name is from this time indissolubly connected with the history of German literature, for the production of a new literary journal. It was to be called the *Horen*, and the most distinguished German writers were to contribute to it. Goethe accepted the invitation willingly. The work was designed to mark an epoch in German taste, and it did so. It soon had two thousand subscribers. Among those who promised to contribute were not only Matthisson, Herder, Knebel, Fritz Jacobi, and Gleim, but the brothers Humboldt, the veteran Kant, the youthful Fichte, who had just begun to lecture in Jena, and, at a later period, the brothers Schlegel. Schiller opened the first number of the journal with his letters on the "Æsthetic Education of the Human Race." Goethe contributed the "Unterhaltungen deutscher Ausgewanderten," a series of stories told by a number of German emigrants who had been driven to cross the Rhine by the invasion of the French. The most remarkable of these stories is the "Märchen," a wild and mystic tale, which has been the subject of as much controversy and of as many interpretations as the second part of *Faust.* Goethe also published in the *Horen* the "Römische Elegien," the flavor of which even Karl August found a little too strong. The first effect of Schiller's influence on Goethe was the completion of *Wilhelm Meisters Lehrjahre.*

Wilhelm Meister.

He had conceived the plan of the work twenty years before, and the first six books had been written before the Italian journey. It was now finished by the addition of two more books. It stands in the first rank of Goethe's writings. He has aimed in it to attain to perfect objectivity of tone, to represent men as they are, and to pass no judgment upon them. The hero passes with weak irresolution through a number of ordinary circumstances, apparently the sport of fortune and the plaything of chance, yet all these experiences have their definite result in the training of his character. Like the son of Kish, he goes forth to seek his father's asses and finds a kingdom. The unearthly charm of the child Mignon, the dark fate which shrouds the aged harper like the doom of Œdipus, the uncertain yearning after a happier home in brighter climes, give a deeper undertone to the prevailing lightness of the story. The style is exquisitely soft and flowing. It has the sweetness and simplicity of *Werther* but is more mellow and more mature. The sixth book is occupied with the *Bekentnisse einer schönen Seele*, a piece of the autobiography of Goethe's early friend Fräulein von Klettenberg, altered to suit its new surroundings. The *Musen Almanach* for 1796, edited by Schiller, was enriched by some of Goethe's most exquisite poems—*Die Nahe des Geliebten*, *Meeres Stille*, and *Glückliche Fahrt*. The storm of criticism which was aroused by the *Horen*, and the little success which, after the first numbers, it met with from the public, determined the two friends to retaliate upon their aggressors. The poems of Martial contain a number of epigrams written in two lines, describing the numberless little presents or *xenia*, which it was customary for friends to exchange at Rome during the time of the Saturnalia.

Xenien.

The name was borrowed by the two poets, and the *Xenien* was a convenient vehicle for the expression of their opinion on every subject. The newspapers of the day were the first object of attack, but they soon went farther afield. The epigrams were written in Schiller's rooms at Jena. It is impossible to fix the authorship of the *Xenien;* one conceived the idea, the other wrote the lines; one wrote the hexameter, the other the pentameter; they intended the authorship as well as the ownership of the copyright to be one and indivisible. Notwithstanding this, the collection has been broken up. There is no guarantee that the epigrams which appear in the separate works of either poet were really written by the authors to whom they are ascribed: some are reprinted in the works of both; some have remained unprinted altogether. They appeared in the *Musen Almanach* for 1797, together with the Venetian elegies mentioned above. It is needless to say that they roused the writers whom they attacked to unspeakable fury, and were the occasion of a copious literature.

Hermann und Dorothea.

A more solid result of the friendship between the poets was the production of *Hermann und Dorothea*. It is a German idyll; the story is taken from the sufferings of Lutherans driven out in the early part of the 18th century from the province of Salzburg, but Goethe has given it the character of his own time. He had seen much of the suffering produced by the French Revolution, and he wished this poem to be a reflexion in a tiny mirror of the storms and convulsions of the great world. In its literary form it is a descendant of Voss's *Luise*. It was conceived at Ilmenau in August, 1796, and finished in the following spring. Schiller tells us how it was composed with extraordinary ease and rapidity. During nine days Goethe produced 150 lines a day. You have only to shake the tree, as Schiller said, and ripe apples will tumble down about you. The lines thus hastily written underwent a careful revision. Contemporaneous with *Hermann und Dorothea* is the production of *Wallensteins Lager* by Schiller, which was written with the advice and assistance of his brother poet. The completion of this cycle of plays falls two years later.

Ballads.

The year 1797 is the year of ballads. In his garden house at Jena Schiller worked diligently at this vein, that perhaps for which he was best suited, and in which he most nearly rivals Goethe. Goethe wrote *Die Braut von Korinth*, *Gott und die Bayadere*, and *Der Zauberlehrling;* and the whole collection was published in the *Musen Almanach* for 1798. The latter half of this year was occupied with a tour in Switzerland. Before its commencement he visited his mother at Frankfort for the last time, and presented to her his wife and his son. It was a year of extraordinary activity. Besides the ballads and his researches in the morphology of plants and insects, he translated a great part of the autobiography of Benvenuto Cellini, wrote a number of essays on the question of æsthetics, and worked at his long neglected *Faust*. Of this he wrote the dedication, the "Prologue in Heaven," and the "Golden Marriage of Oberon and Titania"—so powerful was the effect of intellectual sympathy and stimulus. The six years which succeeded Goethe's return from his third Swiss tour, although they embrace the period in which he and Schiller were in daily co-operation, have left us little of permanent worth from the older poet. On the other hand, they are the years of Schiller's greatest activity. The great trilogy of *Wallenstein*, perhaps the highest point of Schiller's genius, was followed by *Maria Stuart*, the *Jungfrau von Orleans*, the *Braut von Messina*, and *Wilhelm Tell*. From the end of 1799 Schiller was permanently settled in Weimar; a dramatic school was founded, and the representation of these classical dramas was the glory of the Weimar stage. During these years Goethe was occupied with *Faust*, with his researches into the theory of colors and of biological development, with the conduct of the theatre and the practical encouragement of art. In 1798 the *Horen* died a natural death, and was succeeded by the *Propyläen*, a journal of literature and criticism, which, although it contained many essays by Goethe, never exceeded a circulation of 300. In the spring of 1799 the study of Homer incited Goethe to sketch a long epic poem on the subject of Achilles. Schiller did his best to encourage the work. The first canto was rapidly completed, but it had no successor. Goethe contented himself with translating the works of others, and prepared the *Mahomet* and *Tancred* of Voltaire for the Leipsic stage. In the first days of the new century he suffered a dangerous attack of scarlatina. His friends feared for his life. Frau von Stein recalled her forgotten friendship, and showed kindness to his son. After his recovery he sketched out what was the most important work of these years, a trilogy on the subject of the French Revolution; of this only the first part, the *Natürliche Tochter*, was completed. The story was a true one of a princess of the French house of Conti. The play is written with the full beauty of Goethe's style, and some passages and effects are worthy of his highest genius. But as a whole it fails. It has the quality, which in a drama must be a fault, so characteristic of Goethe's later writing, of too great universality of treatment. The characters are not living beings but abstractions, and the language is vague and general rather than clear and defined. The play was performed at Weimar on April 2, 1803. Two masterpieces of Schiller—the *Braut von Messina* and the *Jungfrau von Orleans*—preceded and followed it by a few weeks.

Madame de Stael.

At the end of this year Madame de Stael arrived in Weimar accompanied by Benjamin Constant. She had heard of the fame of this new Parnassus, and she was bent on proclaiming the intellectual superiority of Germany to the world. Goethe at first fled from her, as Byron did at a later period. He hid himself in Jena, but was recalled by order of the duke. The result of the conversations in the salons of Weimar is contained in her book *De l'Allemagne*. In March she was suddenly recalled by the death of her father, the minister Necker. Goethe was at this time the centre to which the most distinguished men of all kinds in Germany naturally turned. He was most intimate with Zelter the musician, with whom he maintained a full correspondence; with Wilhelm von Humboldt, the statesman-scholar; with F. A. Wolf, the founder of the science of philology; with Gottfried Hermann, the best authority on Greek metres.

Schiller's death.

But the friendship which was worth all these was soon to be severed. In the beginning of 1805 Goethe was convinced that either he or Schiller would die in that year. In January they were both seized with illness; Schiller had finished his *Phädra* and begun to work at his *Demetrius*. Goethe was translating the *Neveu de Rameau* of Diderot. Schiller was the first to recover, and visiting Goethe in his sick room, fell on his neck and kissed him with intense emotion. On April 29 they saw each other for the last time. Schiller was on his way to the theatre whither Goethe was too ill to accompany him. They parted at the door of Schiller's house. Schiller died on the evening of the 9th of May. No one dared to tell Goethe the sad news, but he saw in the faces of those who surrounded him that Schiller must be very ill. On the morrow of

Schiller's death, when his wife entered his room, he said, "Is it not true that Schiller was very ill yesterday?" She began to sob. He then cried, "He is dead!" "Thou hast spoken it thyself," she answered. Once more he cried, "He is dead!". and turning aside covered his weeping eyes with his hands. He at first intended to have completed *Demetrius* as a memorial of his friend, but a happier inspiration was to arrange a performance of Schiller's great poem of *The Bell*, and to crown it by an epilogue. Since that time Schiller and Goethe have been inseparable in the minds of their countrymen, and have reigned as twin stars in the literary firmament. If Schiller does not hold the first place, it is at least true that he is more beloved, although Goethe may be more admired. It would be invidious to separate them. But it is evident that the best fruits of Schiller's muse were produced when he was most closely under Goethe's influence, and the foreign student of German culture has ground for believing that at some future time the glory of the lesser luminary will be absorbed in that of the greater, and the name of Goethe will represent alone and unrivalled the literature of his age and country.

Napoleon. Schiller was happy in the occasion of his death. He did not see the troubles which immediately afterwards burst upon Thuringia. On October 14, 1806, the battle of Jena was fought. The court had fled from Weimar; only the duchess Louise remained. In the evening of the defeat Weimar was plundered by the conquering troops. Many of Goethe's friends lost everything they possessed. His property and perhaps his life was saved by the firmness of Christiane, and afterwards by the billeting of Marshal Augereau in his house. On the 15th Napoleon entered the town, but Goethe did not go to see him. The duchess obtained her husband's pardon by her entreaties. It was not till the autumn of 1808 that Napoleon and Goethe, perhaps the two greatest men then living in Europe, met and conversed. It was at the congress of Erfurt, where the sovereigns and princes of Europe were assembled. Goethe's presence was commanded by the duke. He was attracted at least as much by the prospect of seeing Talma as of meeting Napoleon. He was invited to an audience on October 2; Talleyrand, Berthier, and Savary were present. The emperor sat at a large round table eating his breakfast. He beckoned Goethe to approach him, and said to him, "Vous êtes un homme!" He asked how old he was, expressed his wonder at the freshness of his appearance, said that he had read *Werther* through seven times, and made some acute remarks on the management of the plot. Then, after an interruption, he said that tragedy ought to be the school of kings and peoples; that there was no subject worthier of treatment than the death of Cæsar, which Voltaire had treated insufficiently. A great poet would have given prominence to Cæsar's plans for the regeneration of the world, and shown what a loss mankind had suffered by his murder. He invited Goethe to Paris; that was the centre of great movements; there he would find subjects worthy of his skill. They parted with mutual admiration. The bust of Napoleon was a prominent ornament in Goethe's study.

Faust. In the same year, 1808, an edition of Goethe's works in thirteen volumes was published by Cotta at Tübingen. It is remarkable as containing the first part of *Faust* in its complete form. The principal portions of the drama had already been published as a fragment in 1790. It had then attracted but little attention. Heyne wrote of it—"There are fine passages in it, but with them there are such things as only he could give to the world who takes other men to be blockheads." Wieland and Schiller were apparently dissatisfied with it. It had perhaps the appearance of patchwork, as it was made up of fragments which had been written at very different periods of his life. The idea of writing *Faust* seems to have come to Goethe in his earliest manhood. He was brooding over it at the same time with *Götz von Berlichingen*, but at Strasburg he spoke to Herder of neither. He apparently began to write it down at the same time as *Werther* in 1774, and we find mention of its progress in the two following years; indeed, all the important parts of the fragment which appeared in 1790 were known to Jacobi before 1776. He took the work with him to Italy, where he added little to it except the scene in the witches' kitchen. The dedication, the "Prologue in Heaven," which presents to the reader the idea of the whole work, the prelude on the stage, copied from the Indian drama, the lyrical intermezzo, the scene with Wagner before the city gate, and the scene with Mephistopheles in the study were written before 1800. In that year he was busy with Helena for the second part, and he added nothing afterwards to the first except the "Walpurgis Night" and the scene of Valentine's death. *Faust* justly stands at the head of all Goethe's works, and it deserves a very high place among the best works of every age. Founded on a well-known popular tale, indebted for its interest and pathos to incidents of universal experience, it deals with the deepest problems which can engage the mind of man. In this combination of qualities it is perhaps superior to any one of Shakespeare's plays. The plot is as simple and as well known to the audience as the plot of a Greek tragedy. The innocence and the fall of Gretchen appeal to every heart; the inward struggles of Faust, like those of Hamlet, and the antagonism of the sensual and moral principles interest the reader just in proportion as his own mind and nature have been similarly stirred. Each line is made to stand for eternity; not a word is thrown away; the poem has entered as a whole into the mind and thought of modern Germany; nearly every expression has become a household word. Characters are sketched in a single scene; Valentine lives for us as clearly as Faust himself. Deeper meanings are opened up at every reading, and the next age will discover much in it which is concealed from this. Goethe, writing of *Faust* in his eightieth year, says, with truth, "The commendation which the poem has received far and near may be perhaps owing to this quality, that it permanently preserves the period of development of a human soul which is tormented by all that afflicts mankind, shaken also by all that disturbs it, repelled by all that it finds repellent, and made happy by all that it desires. The author is at present far removed from such conditions; the world likewise has to some extent other struggles to undergo; nevertheless the state of man, in joy and sorrow, remains very much the same, and the latest born will still find cause to acquaint himself with what has been enjoyed and suffered before him in order to adapt himself to that which awaits him."

Wahlverwandtschaften. In 1809 he finished *Die Wahlverwandtschaften* (The Elective Affinities), a story which is always cited to prove the immoral tendency of his works. A married couple, Edward and Charlotte, are thrown into constant companionship with two unmarried persons, the Captain and Ottilie. A cross attraction takes place similar to that which is often seen in chemical experiments. Edward unites himself with Ottilie, Charlotte with the Captain. The psychological changes by which this result is produced are portrayed with a masterly hand. The moral may be held by some to exalt the preponderance of fatality in human affairs, and the uselessness of contending against irresistible circumstances. Others may believe that the story is intended to show the disastrous calamities which may be wrought by a weak and self-indulgent will. Ottilie, though she cannot resist her passion, has strength enough to starve herself to death; Edward is the prototype of Arthur Donnithorne and Tito Melema. The work is replete with earnest purpose and terrible warning.

Farbenlehre. In 1810 Goethe finished the printing of his *Farbenlehre* (Theory of Colors), a work which had occupied his mind ever since his journey to Italy. His theories were rejected and disregarded by his contemporaries, but he left them with confidence to the judgment of posterity. Goethe's labors in this domain fall into two natural divisions—one in which he tries to prove that the hypotheses of Newton are unsatisfactory, and another in which he promulgates a theory of his own. In his first work, published in 1791 and 1792, he describes with great accuracy and liveliness the experiments which he has made. They consist chiefly of the appearances presented by white discs on a black ground, black discs on a white ground, and colored discs on a black or white ground when seen through a prism. There are two points which he considers fatal to Newton's theory,—that the centre of a broad white surface remains white when seen through a prism, and that even a black streak on a white ground can be entirely decomposed into colors. The scientific friends to whom he communicated these observations assured him that there was nothing in them opposed to Newton's theory,—that they were even confirmations of it. He would not be convinced, and took no pains to acquire that exact knowledge of mathematics and geometrical reasoning without which the more abstruse problems of physical optics could not be intelligible. He went on further to formulate a theory of his own. His views on the subject are contained in their shortest form in a letter addressed to Jacobi from the camp at Marienburg in July, 1793. They are divided into six heads, of which the following is an abstract. (1.) Light is the simplest matter we have knowledge of, the least capable of analysis, the most homogeneous. It is not a compound body. (2.) Least of all is it compounded of colored lights. Every colored light is darker than colorless light. Brightness cannot be compounded of darkness. (3.) Inflexion, refraction, reflexion, are three conditions under which we often observe apparent colors, but they are rather occasions for their appearance than the cause of it. (4.) There are only two pure colors, blue and yellow; red may be regarded as a property of both of them. There are two mixed colors, green and purple; the rest are gradations of these colors, and are not pure. (5.) Colorless light cannot be produced out of colored lights, nor white from colored pigments. (6.) The colors which appear to us arise solely out of a modification of the light. The colors are excited in the light, not developed out of the light. These views he afterwards extended and explained, but very slightly modified. In Goethe's opinion, yellow was light seen through a thickened medium; blue was darkness seen through an illuminated medium; all other colors were derived from these two. The theory of the *Farbenlehre* has not yet received the recognition which Goethe anticipated for it. In his own day he had some adherents,—the most distinguished perhaps was the philosopher Hegel, whose views, however, of natural philosophy have caused many inquirers to recoil from his theory of metaphysics. Goethe complained that no physicist believed in him, and as that is still true in an age which has been devoted more than any other to physical inquiries, we may conclude that the principle upon which his theories are based is radically wrong.

The year 1809, in which *Die Wahlverwandtschaften* was written, was for Goethe the beginning of a new era. He was then fresher and brighter than he had been for ten years before. He had lived through a troubled period of oppressive sorrow. The death of Schiller, the violation of his beloved Weimar, the deaths of the duchess Amalia and of his mother, his own bodily and mental sufferings, had given a tone of sadness to his poetry. As if to put the finishing stroke to the efforts of his life, he married the mother of his children, arranged and published his collected works, and completed his theory of colors. The unfinished drama of *Pandora* is a symbol of this time. The part which is completed refers only to past experiences of sadness; the continuation was to have lifted the curtain of future hope.

It was natural at the beginning of a new course of life that Goethe should write an account of his past existence. The study of his collected poems made it apparent to him how necessary it was to furnish a key by which they might be understood. These various causes led to the composition of *Dichtung und Wahrheit* (Poetry and Truth) an autobiographical history of the poet's life from his birth till his settlement at Weimar. This work is the cause of much embarrassment to the poet's biographers. Where it ought to be the most trustworthy source of information, it is most misleading. It is probable that Goethe intended it to be an accurate and circumstantial account of his life. But the inner life of an individual is more clear to him than the outer. The stages of our self-development are better remembered than the exact circumstances which produced them, still less than the order of time in which they followed each other. Goethe took pains to ascertain facts which he had forgotten. But he was so conscious that imagination would play a large part in the composition that in the title he gave poetry the precedence before truth. The indefatigable industry of German investigation has laid open before us every detail of the poet's life and every phase of his feeling. *Dichtung und Wahrheit*, if it has lost its rank as a history, still keeps its place as a classic. The simple loving delineation of the childhood of genius is as fresh as ever, and is of more universal interest from being less particular. The first five books of this autobiography appeared in 1811, the next five in 1812, the third instalment at Easter, 1814, and the conclusion after Goethe's death. The period during which this was his principal work witnessed the greatest political event of the first half of our century, the rising of the German people against the power of Napoleon. In this Goethe took no share, and with it he apparently felt little sympathy. He made no impassioned orations to his countrymen like Fichte; he wrote no inspiring lays like Körner. The ballads which he composed in 1813 are harmless enough,—*Der wandelnde Glocke, Der getreue Eckhart, Der Todtentanz.* He saw Stein and Arndt at Dresden in 1813, but disappointed them by his impassive manner. He said to Körner's father at the same time, "Yes, shake your chains! The man is too great for you. You will not break them, but only drive them deeper into your flesh." The reasons for this apparent coldness are perhaps more simple than they appear at first sight. Goethe was a man of thought rather than of action. Although a fair portion of his long life was given to the practical business of his adopted country, his heart was always in speculation or artistic production. While inspecting mines he was spinning theories of geological formation; while working for the war commission he gladly ran away to the castle of Dornburg to bury himself amongst his deserted papers. The pressure of court business at Weimar drove him to the solitude of Italy. In the defiles of the Argonne, and in the trenches before Mainz, he was scheming and arranging his theory of colors. A bombardment was valued by him less as an attack upon the enemy than as a series of interesting experiments in optics. Added to this natural indifference to the details of human affairs was his belief in the predominance of force, and in the necessary evolution of the history of the world. Napoleon was to him the greatest living depository of power. Nations, whether conquered or victorious, separated or united, obeyed a common law against which individual will strove in vain. Goethe was thus incapacitated for politics, both by his qualities and his defects. This habit of abstract contemplation grew upon him in later life. Those who condemn him on this ground should remember that he hailed in no grudging spirit the formation of a united Germany, and that his works have been the most potent agency in making all Germans feel that they are one. Few would wish to exchange the self-conflict of *Faust*, or even the wayward wanderings of *Meister*, for the hectic extravagance of Körner or the unsubstantial rhetoric of Posa.

Autobiography.

The war of liberation.

West-östliche Divan.

It was hardly to be expected that at the age of sixty-five Goethe should strike out new lines of poetical activity. However, in the *West-östliche Divan*, he made the first attempt to transplant Eastern poetry to a German soil, and set an example which has been followed by Heine and Mirza Schaffy. In 1811 he first became acquainted with the works of Hafiz in Hammer's translation. At a time when North and South and West were splitting in sunder, when thrones were breaking up and empires trembling, he sought a willing refuge in the restoring fountain of the Eastern poet. The book *Timur* has an obvious reference to the expedition of Napoleon in Russia, but the large majority of the poems are amatory, and are addressed to an imaginary Suleika, whose name is given to one of the books. Once more in his old age Goethe came under the sovereignty of a woman. She was Marianne von Willemer, the newly married wife of a Frankfort banker, Jacob von Willemer, who was an old friend of Goethe's and of his brother-in-law Schlosser. Goethe made her acquaintance in a journey which he took in the Rhine country with Sulpiz Boiserée, who had succeeded in interesting Goethe in early German art, a subject to which he was himself devoted. The correspondence between Goethe and Marianne was published in 1877. It extends almost to the day of his death, and includes letters from Eckermann giving an account of his last moments. Not only were most of the *Divan* poems addressed to Suleika, but several of those included in the collection are by Marianne herself, and will bear comparison with those of Goethe. In these poems the Oriental form is not very strictly observed. The fondness of the Orientals for the repetition of single rhymes is not attended to, and if sometimes remembered is soon forgotten. Their Eastern color depends rather on the suggestion of Eastern scenery and the introduction of Eastern names. This, however, gives the poet a greater license to levity, to fatalism, and to passion than would have been possible in poems of a purely German character.

The last twelve years of Goethe's life, when he had passed his seventieth birthday, were occupied by his criti-

The closing years.

cisms on the literature of foreign countries, by the *Wanderjahre*, and the second part of *Faust*. He was the literary dictator of Germany and of Europe. He took but little interest in the direction in which the younger German school was moving, and was driven to turn his eyes abroad. He conceived an intense admiration for Byron, which was increased by his early death. Byron appears as Euphorion in the second part of *Faust*. He also recognized the greatness of Scott, and was one of the first to send a greeting to the Italian Mazzini. He conceived the idea of a world-literature transcending the narrow limits of race and country, which should unite all nations in harmony of feeling and aspiration. German writers claim that his design has been realized, and the literature of every age and country can be studied in a tongue which Goethe had made rich, flexible, and serviceable for the purpose. The *Wanderjahre*, although it contains some of Goethe's most beautiful conceptions, The Flight into Egypt, The Description of the Pedagogic Province, The Parable of the Three Reverences, is yet an ill-assorted collection of all kinds of writings, old and new. Its author never succeeded in giving it form or coherency, and his later style, beautiful as it is, becomes in these years vague and abstract. Still without this work we should not be acquainted with the full richness and power of his mind.

Meister's Wanderjahre.

Second part of *Faust*.

The second part of *Faust* has been a battlefield of controversy since its publication, and demands fuller attention. Its fate may be compared with that of the latest works of Beethoven. For a long time it was regarded as impossible to understand, and as not worth understanding, the production of a great artist whose faculties had been impaired by age. By degrees it has, by careful labor, become intelligible to us, and the conviction is growing that it is the deepest and most important work of the author's life. Its composition cannot be called an afterthought. There is no doubt that the poet finished at the age of eighty the plan which he had conceived sixty years before. The work in its entirety may be described as the first part of *Faust* "writ large." This is a picture of the macrocosm of society as that was of the microcosm of the individual. The parallelism between the two dramas is not perfect, but it reveals itself more and more clearly to a patient study. Some points of this similarity have been well expressed by Rosenkranz (quoted by Bayard Taylor):—"Both parts are symmetrical in their structure. The first moves with deliberate swiftness from heaven through the world to hell; the second returns therefrom through the world to heaven. Between the two lies the emancipation of Faust from the torment of his conscious guilt, lies his Lethe, his assimilation of the past. In regard to substance, the first part begins religiously, becomes metaphysical, and terminates ethically; the second part begins ethically, becomes æsthetic, and terminates religiously. In one, love and knowledge are confronted with each other; in the other, practical activity and art, the ideal of the beautiful. In regard to form, the first part advances from the hymnal shout to monologue and dialogue; the second part from monologue and dialogue to the dithyrambic, closing with the hymn, which here glorifies not alone the Lord and His uncomprehended lofty works, but the human in the process of its union with the divine, through redemption and atonement." The first act, with its varied scenes of country, castle, garden, galleries, and halls, answers to the two prologues of the first part; the second act introduces us again to Faust's study and his familiar Wagner. The classical Walpurgis Night has its prototype in the first part. The third act is devoted to Helena, who is the heroine of the second part as Gretchen is of the first. The marriage of Faust and Helena typifies the union of the classical and romantic schools, and their child is Euphorion, who is symbolical of Byron. In the fourth act Faust is raised instead of being degraded by his union with Helena. He wishes for a sphere of beneficent activity, and obtains it by war. The fifth act is devoted to the complete regeneration of the soul of Faust. Even the sight of all that he has accomplished does not satisfy him. It is not until he is blind to outward objects that one moment of divine rapture reveals to him the continuance of his work in coming generations, and convinces him that he has not lived in vain. In this one moment of supreme happiness he dies. The struggle for the possession of Faust's soul, indicated in the first part, is fully elaborated in the second. Mephistopheles is shown to have worked out the good in spite of himself, and Margaret appears transfigured as the revelation to man of the divine love.

With the completion of Faust, Goethe felt that the work of his life was accomplished. He still continued to work with regularity. He ordered and arranged his writings, he labored at his *Tages- und Jahresheften*, an autobiographical journal of his life. He bated not one jot of heart or hope, and took the liveliest interest in every movement of literature and science. When the news of the July Revolution of 1830 reached Weimar, Goethe was excited beyond his wont, not on account of the triumph of liberal principles, but because the controversy between Cuvier and Geoffrey St. Hilaire had been decided in favor of the latter. Still he had much to darken his latter days. His old friends were falling fast around him. His wife had died in 1816, after a union of thirty years. He felt her loss bitterly. The duchess Amalia had died eight years before, not long after the death of his own mother. He now had to undergo bitterer experiences when he was less able to bear them. Frau von Stein, with whom he had renewed his friendship if not his love, died in January, 1827; and in June, 1828, he lost the companion of his youth, the grand-duke Karl August, who died suddenly, away from Weimar, on his return from a journey. Goethe received the news with outward calmness, but said forebodingly, "Now it is all over," and went to mourn and labor at the castle of Dornburg, where everything reminded him of the days of their early friendship. The duchess Louise survived her husband till February, 1830. When Goethe died in 1832 none of the old Weimar set were left except Knebel, who lived two years longer. A greater blow than these was the death of his only son, whom, in spite of his moral weakness, his father deeply loved. He died at Rome in October, 1830, and is buried close by the pyramid of Caius Cestius, where Goethe himself once desired to be laid. We have a full account of the last nine years of Goethe's life from the writings of Eckermann, who became his secretary in 1823, lived with him till his death, and has noted down his conversations and his habits with the minuteness and fidelity of a Boswell.

His death.

We must pass on to the closing scene. On Thursday, March 15, 1832, he spent his last cheerful and happy day. He was visited by the grand-duchess and other friends. He awoke the next morning with a chill. From this he gradually recovered, and on Monday was so much better that he designed to begin his regular work on the next day. But in the middle of the night he woke up with a deathly coldness, which extended from his hands over his body, and which it took many hours to subdue. It then appeared that the lungs were attacked, and that there was no hope of his recovery. Goethe did not anticipate death. He sat fully clothed in his arm-chair, made attempts to reach his study, spoke confidently of his recovery, and of the walks he would take in the fine April days. His daughter-in-law Ottilie tended him faithfully. On the morning of the 22d his strength gradually left him. He sat slumbering in his arm-chair holding Ottilie's hand. Her name was constantly on his lips. His mind occasionally wandered, at one time to his beloved Schiller, at another to a fair female head with black curls, some passion of his youth. His last words were an order to his servant to open the second shutter to let in more light. After this he traced with his forefinger letters in the air. At half-past eleven in the day he drew himself, without any sign of pain, into the left corner of his arm-chair, and went so peacefully to sleep that it was long before the watchers knew that his spirit was really gone. He is buried in the grand-ducal vault, where the bones of Schiller are also laid.

Goethe differs from all other great writers, except perhaps Milton, in this respect, that his works cannot be understood without a knowledge of his life, and that his life is in itself a work of art, greater than any work which it created. This renders a long and circumstantial biography a necessity to all who would study the poet seriously. At the same time he is so great that we are even now scarcely sufficiently removed from him to be able to form a correct judgment of his place in literary history. He is not only the greatest poet of Germany; he is one of the greatest poets of all ages. Posterity must decide his exact precedence in that small and chosen company which contains the names of Homer, Dante, and Shakespeare. He was the apostle of self-culture. Always striving after objective truth, and sometimes attaining to it, he exhibited to the world every phase of his plastic mind in turn, and taught both by precept and example the husbandry of the soul. The charge of selfishness so often brought against him cannot be maintained. His nature responded to every influence of passing emotion. Like a delicate harp, it was silent if not touched, and yet gave its music to every wooing of the wilful wind. The charge of unsympathetic coldness roused the deep indignation of those who knew him best. He learned by sad experience that the lesson of life is to renounce. Rather than cavil at his statuesque repose, we should learn to admire the self-conflict and self-command which moulded the exuberance of his impulsive nature into monumental symmetry and proportion. His autobiography has done him wrong. It is the story not of his life, but of his recollections. He needs no defence, nothing but sympathetic study. As Homer concentrated in himself the spirit of antiquity, Dante of the Middle Ages, and Shakespeare of the Renaissance, so Goethe is the representative of the modern spirit, the prophet of mankind under new circumstances and new conditions, the appointed teacher of ages yet unborn.

Bibliography.—A complete bibliography of Goethe literature would fill a very large space. We must content ourselves with an indication of the principal sources from which a knowledge of his life may be derived. The most important source of all is his own works. The *Dichtung und Wahrheit*, the *Italienische Reise*, the *Campagne am Rhein*, and the *Tages- und Jahresheften* have an especial autobiographical value. Next to these come the poems, and lastly the letters. Many of these are lost for ever, many remain unpublished. For the first period of his life *Der Junge Goethe*, in three volumes, published by Hirzel, with an introduction by Michael Bernays, is indispensable. It contains his letters and poems in chronological order. A commentary on this work by Wilhelm Scherer, entitled *Aus Goethes Frühzeit* was published in 1879. Otto Jahn published *Goethes Briefe an seiner Leipziger Freunde.* Schöll and A. Hober have collected the letters of the Strasburg period. Goethe's correspondence with Schiller and with Zelter was published during his lifetime. Besides these we have his letters to Herder, Merck, Kestner and Lotte, Lavater, Knebel, Countess Stolberg, Jacobi, Karl August, and Frau von Stein. Lately have appeared his letters to Marianne von Willemer, and some of those addressed to J. G. Schlosser. We are without his letters to Behrisch, Lerse, and Zimmermann; and we have only a few of those addressed to Horn and Sophie la Roche. Goethe's real letters to Bettina von Arnim are in the main unpublished; those which bear the name have been largely falsified, but have a substratum of truth. We have also a few volumes of Goethe's scientific correspondence, published by his descendants. Help to the understanding of his poetry is given by the letters of Wieland, Caroline Flachsland, and his Weimar friends. The letters addressed to him by Frau von Stein exist, but have not been made public. The first life of Goethe was published by Döring in 1828, of which a second enlarged edition appeared after the poet's death in 1833. Then followed Viehoff in 4 volumes, 1847–1853. The best life of Goethe is that of Schäfer, which appeared first in 1851, and the third edition of which dates from 1877. It is contained in two volumes of moderate size, and is written with scarcely a superfluous word. The account of Goethe and Schiller by Karl Goedeke in his *Grundriss der Deutschen Dichtung* is admirable, and so is the little book *Goethes Leben und Schriften*, published by him in 1874. The life of Goethe has been popularized in England by G. H. Lewes, in a work which is as much read in German as in English. A complete biography of Goethe cannot be written until the archives of the Goethe Haus at Weimar are thrown open for consultation. The knowledge of Goethe's works in England is due as much as anything else to the writings of Thomas Carlyle. The commentaries on Goethe's works are endless in number. The most active laborer in this field has been H. Düntze, who has left no side of Goethe's activity and no period of his life unexplored. We must also mention the brilliant lectures on Goethe by Hermann Grimm (Berlin, 1877), and the excellent sketch of his life and works published by W. Hayward in 1878. The following works deserve particular mention:—

Aus Goethes Knabenzeit 1757–59, *Mittheilungen aus einem Original manuscript der Frankfurter Stadtbibliothek*, erläutert und herausgegeben von Dr. H. Weismann, Frankfurt, 1846; *Briefe an J. H. Merck von Goethe, Herder, Wieland, und andern bedeutenden Zeitgenossen*, hrsg. von K. Wagner, Darmstadt, 1835; *Briefe aus dem Freundeskreise von Goethe, Herder, Höpfner, und Merck*, hrsg. von Dr. K. Wagner, Leipsic, 1847; *Briefe Goethes an Frau von Stein aus den Jahren*, 1776–1826, hrsg. durch A. Schöll, 3 vols., Weimar, 1848–1851; *Briefe Goethes an die Gräfin Auguste zu Stolberg*, Leipsic, 1839; *Briefe Goethes an Lavater, aus den Jahren 1774–83*, hrsg. von Heinr. Herzel, Leipsic, 1833; *Briefe Goethes an Leipziger, Freunde*, hrsg. von O. Jahn, Leipsic, 1849; *Briefe Goethes in den Jahren 1768–1832*, hrsg. von H. Döring, Leipsic, 1836; *Brief-wechsel d. Groszherzogs Karl August v. Sachsen-Weimar-Eisenach mit Goethe in dem Jahren von 1775 bis 1828*, 2 vols., Weimar and Leipsic, 1863; *Briefwechsel zwischen Goethe u. F. H. Jacobi*, hrsg. v. Max Jacobi, Leipsic, 1847; *Briefwechsel zwischen Goethe und Zelter in den Jahren 1796–1832*, hrsg. von Fr. W. Reimer, 8 parts, Berlin, 1833–34–36; *Briefwechsel zwischen Goethe u. Marianne von Willemer* (*Suleika*), hrsg. mit Lebensnachrichten, etc., von Th. Creizenach, Stuttgart, 1877; H. Döring, *Goethes Leben*, Weimar, 1828, 2d ed., Jena, 1833; and Goedeke, *Goethes Leben u. Schriften*, Stuttgart, 1874, *Goethes Sammlungen*, 3 parts, Jena, Leipsic, 1848, 1849; Dr. Karl Mendelssohn-Bartholdy, *Goethe u. Felix Mendelssohn Bartholdy*, Leipsic, 1871; *Neue Mittheilungen aus Johann Wolfgang von Goethes handschriftlichem Nachlasse*, 8 parts, Leipsic, 1874–76; Dr. J. W. Schäfer, *Goethes Leben*, 2 vols., 8th ed., Leipsic, 1877; H. Viehoff, *Goethes Leben*, 3 parts, Stuttgart, 1847–49; Franz Wegele, *Goethe als Historiker*, 1876; Zellenck, *Die Beziehungen Göthes zu Spinoza*, 1878; Edmund Hoefer, *Goethe und Charlotte von Stein*, Stuttgardt, 1878; *Briefe Goethes an Sophie la Roche und Bettina Brentano*, hrsg. von C. Loeper, Berlin, 1879 (a most valuable little book); Graf Ferdinand von Dürkheim, *Lilis Bild geschichtlich entworfen*, 1879; C. A. H. Burkhardt, *Goethe und der Componist Ph. Chr. Kayser*, Leipsic, 1879; Vinc. Prökl, *Goethe in Eger*, Vienna, 1879. (O. B.)

GOETZ, **Hermann** (1840–1876), a musical composer, presents one of those instances, too frequent in the history of art, of success long sought for, and cut short by death when achieved at last. He was born at Königsberg in Prussia in 1840, and began his regular musical studies at the comparatively advanced age of seventeen. He entered the music-school of Professor Stern at Berlin, and studied composition chiefly under Ulrich and Hans von Bülow. In 1863 he was appointed organist at Winterthur in Switzerland, where he lived in obscurity for a number of years, occupying himself with composition during his leisure hours. One of his works was an opera, *The Taming of the Shrew*, the libretto skilfully adapted from Shakespeare's play. After much delay it was produced at Mannheim (October, 1874), and its success was as instantaneous as it has up to the present proved lasting. It rapidly made the round of the great German theatres, and spread its composer's fame over all the land. But Goetz did not live to enjoy this happy result for long. In December, 1876, he died at Zurich from overwork. A second opera, *Francesca da Rimini*, on which he was engaged at the time of his death, remained a fragment; but it has since been finished according to his directions by a friend, and was performed for the first time at Mannheim a few months after the composer's death. Besides his dramatic work, Goetz also wrote various compositions for chamber-music, of which a trio (Op. 1) and a quintet (Op. 16) have been given with great success at the London Monday Popular Concerts. Still more important is the *Symphony in F*, on which the composer's great reputation in England is mainly founded. As a composer of comic opera Goetz lacks the sprightliness and artistic *savoir faire* so rarely found amongst Germanic nations. His was essentially a serious nature, and passion and pathos were to him more congenial than humor. The more serious sides of the subject are therefore insisted upon more successfully than Katherine's ravings and Petruchio's eccentricities. There are, however, very graceful passages, *e. g.*, the singing lesson Bianca receives from her disguised lover. Goetz's style, although influenced by Wagner and other masters, shows signs of a distinct individuality. The design of his music is essentially of a polyphonous character, and the working out and interweaving of his themes betray the musician of high scholarship. But breadth and beautiful flow of melody also were his, as is seen in the symphony, and perhaps still more in the quintet for pianoforte and strings above referred to. The most important of Goetz's posthumous works are a setting of the 137th Psalm for soprano solo, chorus, and orchestra, a "Spring" overture (Op. 15), and a pianoforte sonata for four hands (Op. 17).

GOG (גּוֹג) occurs in two passages of Scripture (Ezek. xxxviii.–xxxix., and Rev. xx.) as the name of a great anti-theocratic power destined to manifest itself in the world immediately before the final dispensation is ushered in. In the later passage, Gog and Magog are spoken of as co-ordinate; in the earlier, Gog is given as the name of the person or people, and Magog as that of the land of its origin. Notwithstanding this discrepancy, it is obvious that the passages are intimately related, and that both depend upon Gen. x. 2, where, however, Magog alone is mentioned. Here he is the second son of Japhet, and, on the assumption that a geographical order underlies these ethnographical tables, his locality is to be sought between Gomer and Madai or Media. According to Josephus, who is followed by Jerome, the Scythians were primarily intended by this designation; and this opinion has been almost universally accepted in modern times. The name Σκύθαι, it is to be observed, however, is often but a vague word for any or all of the numerous and but partially known tribes of the north; and any attempt to assign a more definite locality to Magog can only be very hesitatingly made. According to some, the Maiotes about the Palus Mæotis are meant; according to others the Massagetæ; according to Kiepert, the inhabitants of the northern and eastern parts of Armenia. In Ezekiel, Gog is regarded as a terrible ruler in the extreme north, being prince of Rosh, Mesech, and Tubal, as well as governor in the land of Magog, and having the support of Persia, Ethiopia, and Phut, as well as of Gomer and the house of Togarmah. It may be considered as certain that the imagery employed in this prophetic description was suggested by the Scythian invasion which about the time of Isaiah had devastated Asia (Herod. i. 103 ff.). As might have been expected from the prominence given to that description in the Old Testament, Gog figures largely in Jewish and Mahometan as well as Christian eschatology. In the district of Astrakhan a legend is still to be met with, to the effect that Gog and Magog were two great races, which Alexander the Great subdued and banished to the inmost recesses of the Caucasus, where they are meanwhile kept in by the terror of twelve trumpets blown by the winds, but whence they are destined ultimately to make their escape and destroy the world. The legends that attach themselves to the effigies of Gog and Magog which are at present to be seen in Guild Hall, London, are only remotely connected, if at all, with the statements of Scripture. According to the *Recuyell des Histoires de Troye*, Gog and Magog were the survivors of a race of giants descended from the thirty-three wicked daughters of Diocletian; after their brethren had been slain by Brute and his companions, Gog and Magog were brought to London (Troy-novant), and compelled to officiate as porters at the gate of the royal palace. It is known that effigies similar to the present existed in London as early as the time of Henry V.; but it is uncertain at what date this legend first began to attach to them. According to Geoffrey of Monmouth (*Chronicles* i. 16), Goëmot or Goëmagot (either corrupted from or corrupted into "Gog and Magog") was a giant who, along with his brother Corineus, tyrannized in the western horn of England until slain by foreign invaders.

GOGO, or GHOGHÁ, a town in Ahmadábád district, Bombay, 193 miles north-west of Bombay. About three-quarters of a mile east of the town is an excellent anchorage, in some measure sheltered by the island of Perim, which lies still further east. The natives of this are reckoned the best sailors in India; and ships touching here may procure water and supplies, or repair damages. It is a safe refuge during the south-west monsoon, or for vessels that have parted from their anchors in the Surat roads, the bottom being an entire bed of mud, three-quarters of a mile from the shore, and the water always smooth. Gogo has of late years lost its commercial importance. Its rival, Bhaunagar, is 8 miles nearer to the cotton districts. North of the town is a black salt marsh, extending to the Bhaunagar creek. On the other sides is undulating cultivated land, sloping to the range of hills 12 miles off. South of the town there is another salt marsh. The land in the neighborhood is inundated at high spring tides, which renders it necessary to bring fresh water from a distance of 4 or 5 miles. The average annual value of the exports for five years ending 1871–72 was £56,227 and of the imports £103,083. Population (1872), 9571.

GOGOL, NIKOLAI VASILIEVICH (1809–1852), was born in the province of Poltava, in South Russia, March 31, 1809. Educated at the Niejin gymnasium, he there started a manuscript periodical, "The Star," and wrote several pieces including a tragedy, *The Brigands*. Having completed his course at Niejin, he went in 1829 to St. Petersburg, where he tried the stage but failed. Next year he obtained a clerkship in the department of appanages, but he soon gave it up. In literature, however, he found his true vocation. In 1829 he published anonymously a poem called *Italy*, and, under the pseudonym of V. Alof, an idyll, *Hans Kuchel Garten*, which he had written while still at Niejin. The idyll was so ridiculed by a reviewer that its author bought up all the copies he could secure, and burnt them in a room which he hired for the purpose at an inn. Gogol then fell back upon South Russian popular literature, and especially the tales of Cossackdom on which his boyish fancy had been nursed, his father having occupied the post of "regimental secretary," one of the honorary officials in the Zaporogian Cossack forces. In 1830 he published in a periodical the first of the stories which appeared next year under the title of *Evenings in a Farm near Dikanka: by Rudy Panko*. This work, containing a series of attractive pictures of that Little-Russian life which lends itself to romance more readily than does the monotony of "Great-Russian" existence, immediately obtained a great success,—its light and color, its freshness and originality, being hailed with enthusiasm by the principal writers of the day in Russia. Whereupon Gogol planned, not only a history of Little-Russia, but also one of the Middle Ages, to be completed in eight or nine volumes. This plan he did not carry out, though it led to his being appointed to a professorship in the university of St. Petersburg, a post in which he met with small success, and which he resigned in 1835. Meanwhile he had published his *Arabesques*, a collection of essays and stories; his *Taras Bulba*, the chief of the *Cossack Tales* translated into English by George Tolstoy; and a number of novelettes, which mark his transition from the romantic to the realistic school of fiction, such as the admirable sketch of the tranquil life led in a quiet country house by two kindly specimens of *Old-world Gentlefolks*, or the description of the petty miseries endured by an ill-paid clerk in a Government office, the great object of whose life is to secure the "cloak" from which his story takes its name. To the same period belongs his celebrated comedy, the *Revizor*, or Government Inspector. His aim in writing it was to drag into light "all that was bad in Russia," and to hold it up to contempt. And he succeeded in rendering contemptible and ludicrous the official life of Russia, the corruption universally prevailing throughout the civil service, the alternate arrogance and servility of men in office. The plot of the comedy is very simple. A traveller who arrives with an empty purse at a provincial town is taken for an inspector whose arrival is awaited with fear, and he receives all the attentions and bribes which are meant to propitiate the dreaded investigator of abuses. The play appeared on the stage in the spring of 1836, and achieved a full success, in spite of the opposition attempted by the official classes whose malpractices it exposed. The aim which Gogol had in view when writing the *Revizor* he afterwards fully attained in his great novel, *Mertvuiya Dushi*, or Dead Souls, the first part of which appeared in 1842. The hero of the story is an adventurer who goes about Russia making fictitious purchases of "dead souls," *i. e.*, of serfs who have died since the last census, with the view of pledging his imaginary property to Government. But his adventures are merely an excuse for drawing a series of pictures, of an unfavorable kind, of Russian provincial life, and of introducing on the scene a number of types of Russian society. Of the force and truth with which these delineations are executed the universal consent of Russian critics in their favor may be taken as a measure. From the French version of the story a general idea of its merits may be formed, and some knowledge of its plot and its principal characters may be gathered from the English adaptation published in 1854, as an original work, under the title of *Home Life in Russia*. But no one seems to be able fully to appreciate Gogol's merits as a humorist, who is not intimate with the language in which he wrote as well as with the society which he depicted. In 1836 Gogol for the first time went abroad. Subsequently he spent a considerable amount of time out of Russia, chiefly in Italy, where much of his *Dead Souls* was written. His residence there, especially at Rome, made a deep impression on his mind, which during his later years, turned towards mysticism. The last works which he published, his *Confession* and *Correspondence with Friends*, offer a painful contrast to the light, bright, vigorous, realistic, humorous writings which had gained and have retained for him his immense popularity in his native land. Asceticism and mystical exaltation had told upon his nervous system, and his feeble condition showed itself in his literary compositions. In 1848 he made a pilgrimage to Jerusalem, and on his return settled down at Moscow, where he died, March 3, 1852, not having quite completed his forty-third year.

GOITO, a large village of Italy, in the province of Mantua and district of Volta, situated on the right bank of the Mincio, about 14 miles from Castiglione, on the highway between Brescia and Mantua. Its position has made it figure from time to time in the records of Italian warfare. In 1701 it was taken by the allies, in 1706 by the prince of Hesse, and in 1796 by the French. It was the scene of a severe conflict between the French and the Austrians in 1814; and in 1848 it saw the defeat of the Austrians by the Piedmontese. The population of the commune in 1871 was 5274.

GOITRE (from *guttur*, the throat; synonyms, Bronchocele, Derbyshire Neck), a term in medicine applied to a swelling in the front of the neck caused by an enlargement of the thyroid gland. This structure, which lies between the skin and anterior surface of the windpipe, and in health is not large enough to give rise to any external prominence, is liable to occasional variations in size, more especially in females, a temporary enlargement of the gland being not uncommon at the catamenial periods, as well as during pregnancy. In the disease now under consideration, however, the swelling is well marked, and is not only unsightly, but may by its growth occasion much discomfort, and even give rise to serious symptoms from its encroachment on the windpipe and other important parts in the neck. The size to which goitrous growths may attain is extraordinary, Alibert recording cases of goitre where the tumor not only enormously enlarged the neck but hung down over the breast, or even reached as low as the middle of the thigh.

In districts where the disease prevails the goitre usually appears in early life, often from the eighth to the twelfth year. Its growth is at first slow, but after several years of comparative quiescence a somewhat sudden increase is a not unfrequent occurrence. In the earlier stages of the disease the condition of the gland is simply an enlargement of its constituent parts, which retain their normal soft consistence; but in the course of time other changes supervene, and it may become the seat of cystic formations, or acquire hardness from increase of connective tissue or calcareous deposits. Occasionally the enlargement of the gland is uniform, but more commonly one of the lobes, generally the right, is the larger. In some rare instances the disease has been noticed to be limited almost entirely to the isthmus which connects the two lobes of the gland. The growth is unattended with pain, and is not inconsistent with a fair measure of health.

Goitre is a marked example of an endemic disease. There are few parts of the world where it is not found prevailing in certain localities, these being for the most part valleys and elevated plains in mountainous districts. The wide distribution of this disease has naturally led to extensive inquiry and to abundant speculation as to its origin. It is unnecessary to mention the numerous theories which have been advanced on the subject. Many of these have already been referred to under CRETINISM (*q. v.*). The most generally accepted view among physicians is that which ascribes the malady to the use of drinking water impregnated with the salts of lime and magnesia, in which ingredients the water of goitrous districts would appear always to abound. This theory alone, however, is inadequate, as is evident from the often-observed fact that in localities not far removed from those in which goitre prevails, and where the water is of the same chemical composition, the disease may be entirely unknown. Hence among the best authorities the tendency now is to regard goitre as the result of a combination of causes, among which local telluric or malarial influences concur in an important manner with those of the drinking water in developing the disease. It is noteworthy that goitre can often be cured by removal from the district where it prevails, as also that it is apt to be acquired by previously healthy persons who settle in goitrous localities; and it is only in such places that the disease exhibits any hereditary tendencies.

In the treatment of goitre the first step is the removal, if possible, of the patient from the affected locality, and attention to general hygienic rules. The employment of burnt sponge as a cure for goitre was in general use until Dr. Coindet of Geneva showed that its acknowledged virtues were in all probability due to the iodine which it contained, and proposed as a substitute this latter agent in a pure state. Dr. Coindet's views were amply borne out, and iodine and its preparations have been universally adopted as the most potent remedy in this disease, and have superseded all other medicines. Small and gradually increased doses of the drug, either in the form of iodide of potassium or what is known as Lugol's solution appear to be the best methods of administration. The external application of iodine to the goitre, in the form of liniment or ointment, is of scarcely less value than its internal employment, and would seem to be sometimes capable of effecting a cure alone, as is evident from the method of treatment adopted with singular success in India and originally proposed by the late Major Holmes. This consists in applying to the goitre, by means of a spatula, an ointment of biniodide of mercury for about ten minutes soon after sunrise, and placing the patient with his goitre exposed to rays of the sun for six or seven hours. Blistering of the surface generally follows, a second application of the ointment is made, and the patient sent home. This is often found sufficient to effect the cure, but the treatment can, if necessary, be repeated.

The name "Exophthalmic Goitre" is applied to another form of enlargement of the thyroid gland, differing entirely in its pathological connection from that above described. In this affection the bronchocele is but one of three phenomena, which together constitute the typical characteristics of the disease, viz., palpitation of the heart and great vessels, enlargement of the thyroid gland, and protrusion of the eyeballs. This group of symptoms is generally known by the names of Graves's disease or Von Basedow's disease, in reference to the physicians by whom the malady was originally recognized and described. Although occasionally observed in men, this affection occurs much more commonly in females and in comparatively early life. It is generally preceded by ill health in some form, more particularly impoverishment of blood, and nervous or hysterical disorders, and is occasionally seen in cases of organic heart-disease. It has sometimes been suddenly developed as the effect of fright or violent mental emotion. The first of the symptoms to appear is usually the palpitation of the heart, which is aggravated by the slightest exertion, and may be so severe as not only to shake the whole frame but even to be audible at some distance from the patient. An uncomfortable sensation of throbbing is felt throughout the body, and many of the larger blood-vessels are seen to pulsate strongly like the heart. The enlargement of the thyroid gland generally comes on gradually, and rarely increases to any great size, thus differing from true goitre, as originally noticed by Dr. Graves. The enlarged gland is of soft consistence, and communicates a thrill to touch from its dilated and pulsating blood-vessels.

Accompanying the goitre a remarkable change is observed in the appearance of the eyes, which attract attention by their prominence and the startled expression thus given to the countenance. In extreme cases the eyes protrude from their sockets to such a degree that the eyelids cannot be closed, and injury may thus arise to the constantly exposed eyeballs. Apart from such risk, however, the vision is rarely affected in this disease. Much difference of opinion prevails as to the immediate cause of the protrusion of the eyes, but it is generally ascribed to the increase of the fatty tissue and distension of the blood-vessels of the orbits. It occasionally happens that in undoubted cases of the disease one or other of the three above-named phenomena is absent, generally either the goitre or the exophthalmos. The palpitation of the heart is the most constant symptom. Sleeplessness, irritability, disorders of digestion, diarrhœa, and uterine derangements are common accompaniments.

The pathology of exophthalmic goitre is still somewhat uncertain, but there are strong reasons to believe that it is essentially a nervous ailment, and that the symptoms depend on a morbid state of the sympathetic nerve in the neck, which is well known to play an important part in the vaso-motor functions—that is, in controlling the action of the heart and regulating the calibre of the blood-vessels. In numerous instances of exophthalmic goitre a diseased state of this nerve has been found *post mortem*, although it must be admitted that in some cases no morbid change could be detected. The experiments of Bernard, Brown-Sequard, Schiff, and others upon the functions of the sympathetic nerve lend strong support to this view of the pathology of the disease. Exophthalmic goitre is not directly a fatal malady, but, on the other hand, complete recovery is a less frequent result than partial improvement, the patient continuing to suffer from chronic ill-health. The disturbed condition of the heart's action leads in some instances to permanent disease of that organ in the form of dilatation of its cavities. In the treatment of exophthalmic goitre the most successful results have been attained by the use of digitalis, which has the effect of giving tone to the heart and contracting the dilated blood-vessels. The tincture of digitalis, in doses of 5 to 10 drops twice or thrice daily, is perhaps the best form of administration. Where anæmiá is present iron is indicated, and may be combined with the digitalis, although in some cases it is found to be unsuitable. In allaying the palpitation benefit is said to have frequently followed the application of ice to the cardiac region as well as to the thyroid gland. Iodine, which is so valuable in cases of true goitre, is generally admitted to be of no service in this disease, and is rather held to be injurious. (J. O. A.)

GOLCONDA, a fortress and ruined city, situated in the Nizám's Dominions, 7 miles west of Hyderabad city. In former times Golconda was a large and powerful kingdom of the Deccan, which arose on the downfall of the Báhmani dynasty, but was subdued by Aurungzebe in 1687, and annexed to the dominions of the Delhi empire. The fortress of Golconda, situated on a rocky ridge of granite, is extensive, and contains many enclosures. It is strong and in good repair, but is commanded by the summits of the enormous and massive mausolea of the ancient kings about 600 yards distant. These buildings, which are now the chief characteristics of the place, form a vast group, situated in an arid, rocky desert. They have suffered considerably from the ravages of time, but more from the hand of man, and nothing but the great solidity of their walls has preserved them from utter ruin. These tombs were erected at a great expense, some of them being said to have cost as much as £150,000. Golconda fort is now used as the nizám's treasury, and also as the state prison. The diamonds of Golconda have obtained great celebrity throughout the world; but they were merely cut and polished here, being generally found at Partial, near the south-eastern frontier of the nizám's territory.

GOLD, the color, lustre, and power of resisting oxidation, which this metal possesses, have caused it to be valued from the earliest ages. Allusions to gold are frequent in the Old Testament, and the refining of the precious metals by cupellation seems to have been a favorite illustration with the Jewish poets.[1] Jewellery and vessels found in Egyptian tombs afford evidence of the perfection attained in working gold at a period earlier than the government of Joseph,[2] and drawings on tombs of about this epoch clearly indicate the method of conducting the operations of washing, fusing, and weighing the metal. Excavations in Etruria have brought to light beautiful ornaments of gold, enriched with minute grains of the metal, the workmanship of which was unrivalled until Castellani studied and revived the methods employed by Etruscan artists.[3] The Greeks were familiar with natural alloys of silver and gold named *electrum*, rough nuggets of which were frequently stamped, and formed the earliest coins in Lydia.[4] The color of this electrum is pale yellow to yellowish white, and it contains from 20 to 40 per cent. of silver.

With regard to the history of the metallurgy of gold, it may be mentioned that, according to Pliny, mercury was employed in his time both as a means of separating the precious metals and for the purposes of gilding. Vitruvius also gives a detailed account of the means of recovering gold, by amalgamation, from cloth into which it had been woven.

Properties.—Gold is the only metal of a yellow *color*, which is, however, notably affected by small quantities of other metals; thus the tint is sensibly lowered by small quantities of silver, and heightened by copper. The surface color of particles of gold is often apparently reddened by translucent films of brown iron ore. It is nearly as soft as lead. The *hardness* varies, however, with the composition. Crystallized specimens from Oregon and Fraser River, containing respectively 835 and 910 parts of gold in 1000, are slightly harder than calc spar but sensibly softer than fluor spar, or much harder than the pure metal. When pure, gold is the most *malleable* of all metals. One grain may be beaten into leaves which cover a surface of 56 square inches, and are only $\frac{1}{282000}$th of an inch thick. Faraday has shown that the thicknsss of gold leaves may be still further reduced by floating them on a dilute solution of cyanide of potassium. When very thin, leaf gold appears yellow by reflected and green by transmitted light. If, however, certain gold films are heated, the light transmitted is ruby red; the pressure of a hard substance on the film so changes its state of aggregation that green light is again transmitted.[5] The metal is extremely *ductile;* a single grain may be drawn into a wire 500 feet in length, and an ounce of gold covering a silver wire is capable of being extended more than 1300 miles. Gold can readily be welded cold, and thus the finely divided metal, in the state in which it is precipitated from solution, may be compressed between dies into discs or medals. According to G. Rose,[6] the *specific gravity* of gold in the finely divided state in which it is precipitated from solution by oxalic acid is 19·49. The specific gravity of cast gold varies from 18·29 to 19·37, and by compression[7] between dies the specific gravity may be raised from 19·37 to 19·41; by annealing, however, the previous density is to some extent recovered, as it then is found to be 19·40. Its *atomic weight* is variously given as follows:—196·67 (Berzelius), 196·3 (Levol), 196.5 (Wurtz), 196·0 (Watts). The number adopted in this work (CHEMISTRY, vol. v., p. 458) is 196·2. Different observers have given the following temperatures as its *melting point:* —1425° C. (Daniell), 1200° C. (Pouillet), 1380° C. (Guyton de Morveau). Riemsdijk,[8] after comparing the several results, concludes that it may be considered to be 1240° C. The *electric conductivity* is given by Matthiessen as 73·99 at 15·1° C., pure silver being 100; this depends greatly on its degree of purity,—the presence of a few thousandths of silver lowering its conductivity by 10 per cent. The *specific resistance* of the metal in electro-magnetic measure, according to the centimetre-gramme-second system of units, is 2154. Its *conductivity for heat* is 53·2 (Wiedemann and Franz), pure silver being 100. Its *specific heat* is 0·324 (Regnault). Its *coefficient of expansion* for each degree between 0° and 100° C. is 0·000014661, or for gold which has been annealed 0·000015136 (Laplace and Lavoisier). The *specific magnetism* of the metal is 3·47 (Becquerel). Details as to its *tenacity* and *rigidity* are given in the article ELASTICITY. With regard to its *volatility*, Gasto Claveus[9] states that he placed an ounce of pure gold in an earthen vessel in that part of a glass-house where the glass is kept constantly melted, and retained it in a state of fusion for two months without the loss of the smallest portion of its weight. Kunkel describes a similar experiment, which was attended with the same result. Homberg,[10] however, observed that when a small portion of gold is kept at a violent heat, part of it is volatilized. Both Macquer and Lavoisier showed that when gold is strongly heated, fumes arise which gild a piece of silver held in them. Its volatility has also been studied by Elsher, and, in the presence of other metals by Napier.[11] Hellot affirms that when an alloy of 7 parts of zinc and 1 part of gold is heated in air, the whole of the gold rises in the fumes of oxide of zinc which are produced. Gold is dissipated by sending a powerful charge of electricity through it when in the form of leaf or thin wire. In the gold *spectrum* Huggins has observed twenty-three lines, and the wave lengths of the three most important of these are 5231, 5835, and 6276 respectively. Some preliminary observations on the spectrum of the vapor at the temperature of the oxyhydrogen flame, made by Lockyer and Roberts,[12] showed that there was a distinct absorption both at the blue and at the red end.

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[1] Percy's *Metallurgy of Lead*, p. 177.

[2] Jacquemart, *History of Furniture*, translation, p. 331.

[3] *Archæological Journal*, 1861, p. 365.

[4] "Notes on the Ancient Electrum Coins," by Barclay V. Head, *Numismatic Chronicle*, part iv., 1875, p. 245.

[5] *Phil. Trans.*, 1857, p. 145.

[6] *Pogg. Ann.*, vol. lxxiii. p. 1, and lxxv. p. 408.

[7] *Eighth Ann. Report of Deputy Master of the Mint*, 1877, p. 41.

[8] *Archives Néerlandaises*, t. iii., 1868.

[9] Quoted by Dr. T. Thomson, *System of Chemistry*, 5th edition, 1817, vol. i., p. 484.

[10] *Mem. Paris Academy*, 1702, p. 147.

[11] *Chem. Soc. Journ.*, vol. x. p. 229, vol. xi. p. 168.

[12] *Proc. Roy. Soc.*, 1875, p. 344.

The solvents for gold are given in the article CHEMISTRY, vol. v., p. 458. It may be added that finely-divided gold dissolves when heated with strong sulphuric acid and a little nitric acid. Dilution with water, however, precipitates the metal as a violet or brown powder from the solution so obtained. Gold is also attacked when strong sulphuric acid is submitted to electrolysis with a gold positive pole.[1] W. Skey has shown[2] that in substances which contain small quantities of gold, the precious metal may be removed by the solvent action of a tincture of iodine or bromine in water. Filter paper soaked with the clear solution is burnt, and the presence of gold is indicated by the color of the ash.

Occlusion of Gas by Gold.—Graham has shown[3] that gold is capable of occluding 0·48 of its volume of hydrogen, and 0·20 of its volume of nitrogen. Varrentrapp has also pointed out that "cornets" from the assay of gold may retain gas if they are not strongly heated. Artificial crystals of gold may be formed when the molten metal is slowly cooled.

Occurrence and Distribution.—Gold is found in nature chiefly in the metallic state, or as native gold, and less frequently in combination with tellurium, lead, and silver, forming a peculiar group of minerals confined to a few localities in Europe and America. These are the only certain examples of natural combinations of the metal,—the minute although economically valuable quantity often found in pyrites and other sulphides being probably only present in mechanical suspension, although for practical purposes it may be spoken of as combined. The native metal occurs tolerably frequently in crystals belonging to the cubic system, the octahedron being the commonest form, but other and complex combinations have been observed. Owing to the softness of the metal, large crystals are rarely well defined, the points being commonly rounded. In the irregular crystalline aggregates branching and moss-like forms are most common, and in Transylvania thin plates or sheets with diagonal structures are characteristic. These have recently been shown by Vom Rath to be repeated combinations of distorted tetrahexahedra. During the preparation of a mass of pure gold in the Mint at London, some fine crystals which appear to be aggregations of octahedra were obtained; and dendritic crystals of gold, prepared artificially, have been described by Chester. It is possible also to obtain gold in crystals by heating its amalgam; according to Knaffl, an amalgam of 1 part of gold with 20 parts of mercury is maintained at a temperature of 80° C. for eight days. It is then heated to 80° C. with nitric acid of specific gravity 1·35, when dull crystals will be left, which become brilliant when more strongly heated. More characteristic, however, than the crystallized are the irregular forms, which, when large, are known as "nuggets" or "pepites," and when in pieces below ¼ to ½ ounce weight as gold dust, the larger sizes being distinguished as coarse or nuggety gold, and the smaller as gold dust proper. Except the larger nuggets, which may be more or less angular, or at times even masses of crystals, with or without associated quartz or other rock, gold is generally found bean-shaped or in some other flattened form, the smallest particles being scales of scarcely appreciable thickness, which, from their small bulk as compared with their surface, subside very slowly when suspended in water, and are therefore readily carried away by a rapid current. These form the "float gold" of the miner. The physical properties of native gold are generally similar to that of the melted metal and its alloys as described above. The composition varies considerably in different localities, as shown in the preceding table.

Analyses of Native Gold from various localities.

Locality.	Gold.	Silver.	Iron.	Copper.	Authority.
EUROPE.					
British Isles—					
Vigra & Clogau......	90·16	9·26	trace	trace.	Forbes.
Wicklow (river).....	92·32	6·17	·78	...	Mallet.
Transylvania	60·49	38·74	...	0·77	G. Rose.
ASIA.					
Russian Empire—					
Brezovsk	91·88	8·03	trace	·09	G. Rose.
Ekaterinburg.........	98·96	0·16	·05	·35	...
AFRICA.					
Ashantee..................	90·05	9·94	...	...	...
AMERICA.					
Brazil......................	94·0	5·85	...	...	D'Arcet.
Central America.......	88·05	11·96	...	...	Fremy and Pelouze.
Titiribi....................	76·41	23·12	...	0·87	Rose.
California................	90·12	9·01	...	...	...
Mariposa..................	81·00	18·70	...	...	F. Claudet.
Cariboo	84·25	14·90	...	·03	Claudet.
AUSTRALIA.					
South Australia........	87·78	6·07	6·15	...	A. S. Thomas.
Ballarat....................	99·25	0·65	...	...	Claudet.

Of the minerals containing gold the most important are sylvanite or graphic tellurium, of composition $(AgAu)Te_2$, with 24 to 26 per cent.; calaverite, $AuTe_2$, with 42 per cent.; and nagyagite or foliate tellurium, of a complex and rather indefinite composition, with 5 to 9 per cent. of gold. These are confined to a few localities, the oldest and best known being those of Nagyag and Ofenbanya in Transylvania; but latterly they have been found in some quantity at Red Cloud, Colorado, and in Calaveras county, California,—the nearly pure telluride of gold, calaverite, being confined to these places.

The minerals of the second class, usually spoken of as auriferous, or containing gold in sensible quantity, though not to a sufficient amount to form an essential in the chemical formulæ, or even in many instances to be found in the quantities ordinarily operated upon in analyses, are comparatively numerous, including many of the metallic sulphides. Prominent among these are galena and iron pyrites,—the former, according to the observations of Percy and Smith, being almost invariably gold-bearing to an extent that can be recognized in operating upon a pound weight of the lead smelted from it, the proportion increasing to some extent with the amount of silver.[4] The second is of greater practical importance, being in some districts exceedingly rich, and, next to the native metal, is the most prolific source of gold. Magnetic pyrites, copper pyrites, zinc blende, and arsenical pyrites are other and less important examples,—the last constituting the gold ore formerly worked in Silesia. A native gold amalgam is found as a rarity in California, and bismuth from South America is sometimes rich in gold. Native arsensic and antimony are also very frequently found to contain gold and silver.

The association and distribution of gold may be considered under two different heads, namely, as it occurs in mineral veins, and in alluvial or other superficial deposits which are derived from the waste of the former. As regards the first, it is chiefly found in quartz veins or reefs traversing slaty or crystalline rocks, usually talcose or chloritic schists, either alone or in association with iron, copper, magnetic and arsenical pyrites, galena, specular iron ore, and silver ores, and more rarely with sulphide of molybdenum, tungstate of calcium, bismuth, and tellurium minerals. Another more exceptional association, that with bismuth in calcite from Queensland, was described by the late Mr. Daintree. In Hungary, the Urals, and northern Peru, silicates and carbonates of manganese are not uncommonly found in the gold and silver bearing veins. In the second or alluvial class of deposits the associated minerals are chiefly those of great density and hardness, such as platinum, osmiridum, and other metals of the platinum group, tinstone, chromic, magnetic, and brown iron ores, diamond, ruby, and sapphire, zircon, topaz, garnet, etc., which represent the more durable original constituents of the rocks whose disintegration has furnished the detritus. Native lead and zinc have also been reported among such minerals, but their authenticity is somewhat doubtful.

The distribution of gold-bearing deposits is world-wide; although the relative importance of different localities is very different, their geological range is also very extensive. In Europe the principal groups of veins are in slaty or crystalline schists, whose age, when it can be determined, is usually Palæozoic, Silurian, Devonian, or Carboniferous, and less commonly in volcanic formations of Tertiary age. The alluvial deposits, being more extensive, are less intimately connected with any particular series of rocks. Few of either are, however, of much importance as compared with the more productive deposits of America and Australia. In the United Kingdom gold-bearing quartz veins were worked during the Roman occupation at Ogofau, near Llanpumpsant, in Carmarthenshire; and in the year 1863 as much as 5300 oz. was produced from similar veins in Lower Silurian slates at Vigra and Clogau mines, near Dolgelly. In 1875 the mine was reopened, and in 1878 it produced 720 oz. Tetradymite, native bismuth, and several other characteristic associates of gold were also found in small quantity. In Cornwall small pieces of native gold have at intervals been found in alluvial or stream tin works; and similar but more important finds have been made in the granite district of Wicklow, and more recently at Helmsdale, in Sutherlandshire. The largest nugget of British origin weighs under 3 oz.

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[1] Spiller, *Chem. News*, x. 173.

[2] *Ibid.*, xxii. 245.

[3] *Phil. Trans.*, 1866, 433.

[4] *Phil. Mag.*, vii., 1854, p. 126.

On the continent of Europe the great rivers originating in the crystalline rocks of the Alpine region, such as the Rhine and Danube, are slightly auriferous in their alluvial deposits in several places; but the proportion of gold is extraordinarily minute, so that the working is only carried on by gipsies, or by the local peasantry at irregular intervals, the return for the labor expended being very small. The same remark applies to the Rhone and its affluents, and the rivers of the central granitic mass of France. In the Austrian Alps the gold quartz mines at the Rathausberg, near Gastein, at a height of about 9000 feet above the sea-level, and at Zell, in Tyrol, are of interest historically as having developed the system of amalgamation in mills, although they are economically of small importance at present. On the Italian side, in the Valanzasca and Val Toppa above Lago Maggiore, a group known as the Pestarena mines have yielded from 2000 to 3000 ounces annually for several years past; and more recently a discovery of great interest of a highly auriferous copper ore has been made at Ollomont in the Val d'Aosta. In Hungary the gold-bearing veins of Schemnitz occur in greenstones and trachytes of Tertiary age, the most powerful example, the *Spitaler-gang*, being filled with a mixture of quartz and brown iron ore known as zinnopal, and containing gold associated with silver ores, galena, and pyrites. In Transylvania, at Nagyag, the gold-bearing tellurium minerals previously noticed are found in small veins traversing greenstone trachyte. These are often very thin, as low as $\frac{1}{8}$th to $\frac{1}{16}$th of an inch, but each is carefully traced out, the rock being impregnated with gold and silver to a certain depth on each side. At Vörospatak, another Transylvanian locality, gold with a very large proportion of silver and associated with gypsum is worked in veins traversing a Tertiary sandstone, being almost the only known instance of such a mode of occurrence.

The Russian empire has the largest gold production among the countries of the Old World, most of the produce, however, being derived from its Asiatic territories. The more important localities are situated on the eastern slope of the Ural chain, extending in a nearly north and south line for more than 600 miles from 51° to 60° N. lat. The chief centres are Miask (55° N.), Kamensk (56° 30′ N.), Berezovsk (57° N.), Nijne Tagilsk (58° N.), and Bogoslowsk (60° N.), the known deposits, which include both veins and alluvial mines, extending for about one degree farther north. The geological age of the Ural veins is not very well defined—strata of the Silurian, Devonian, and Carboniferous periods, which form regular parallel alternations on the European slope, being present on the Asiatic side, but in much disturbed and contorted positions, in association with plutonic rocks, diorite, diabase, and granite, with which the gold veins are intimately connected. The latter are therefore of post-Carboniferous and probably of Permian date. At Berezovsk the mines cover an area of about 25 square miles, mainly composed of talcose, chloritic, and clay slates, vertical or sloping at high angles, and penetrated by dykes of beresite, a fine grained rock made up of quartz and white mica with some felspar and pyrites, the latter usually transformed into brown iron ore. These dykes, which have a general north-and-south direction, are vertical, and are from 20 to 70 feet and upwards in thickness, are traversed perpendicularly to their direction by veins of quartz from the thinnest string to a maximum of 3½ or 4 feet thick, in which gold is associated with brown iron ore or ochres, resulting from the decomposition of pyrites. The workings being essentially shallow, none of the associated sulphides, galena, disulphide of copper, etc., have as yet been found, as a rule, to be gold-bearing. The valuable parts of the veins are almost entirely restricted to the beresite dykes. The richest of the Ural mines are those of Smolensk, near Miask, and Ouspensk, near the village of Katchkar, in 52° N. The alluvial deposits which, though called sands, are but very slightly sandy clays, extend to the north beyond the inhabited regions, and to the south into the Cossack and Bashkir countries. The most valuable diggings are in the district of Miask, where the largest nuggets have been found, and in the Katchkar, which are remarkable for the great number of gems, pink topazes, emeralds, etc., found in connection with the gold. Magnetite, quartz, and platinum are very common in all the Ural gold sands; less common are hematite, titaniferous and chromic iron, pyrites, garnet, and, least of all, zircon, kyanite, and diamond. These alluvial deposits are of later Tertiary age, some of them containing traces of prehistoric human work; others are post-Pliocene, with the remains of the mammoth, tichorrhine, rhinoceros, and other mammalian fossils. Somewhat similar conditions prevail in the alluvial gold region of the Altai. Besides the veins and alluvial deposits, the Ural rocks, such as serpentine, diorite, beresite, agrairite, etc., are at times auriferous.

The gold deposits of the Caucasus, though immortalized in the tradition of Jason and the Argonauts, are now entirely abandoned, the last attempt at working them having been suspended in 1875.

In India gold is obtained in small quantities by native gold washers in various parts of the highlands of southern Bengal, and more recently quartz veins and alluvial deposits of considerable promise have been discovered in the district of Wynaad, in the southern part of the Madras presidency.

On the Atlantic slopes of North America the chief gold-bearing localities are on the Chaudière river, near Quebec, and in Nova Scotia. In both instances the quartz veins worked are contained in slates belonging to the Quebec group of the Lower Silurian period, those of the latter province being specially remarkable for their quasi-stratified character, as they penetrate the slates at a very low angle of inclination, and have been folded and corrugated together with the containing rocks by subsequent disturbances. Other deposits of old geological periods are found in Tennessee and North Carolina.

On the Pacific side of America gold is found under very different conditions, and on a much larger scale than on the Atlantic side. The whole distance from Mexico to Alaska may be said to be more or less auriferous, the most extensive deposits being in the great north-and-south valley of the Sacramento, which runs parallel to the coast, between the so-called Coast Mountains and the Sierra Nevada, the latter being distinguished further to the north in the Cascade range. Others of less extent are known in the Klamath, Columbia, and Fraser river basins; they extend in the last two far back into the interior, to the region between the Cascade range and the Rocky Mountains. In many of these valleys alluvial deposits are developed to an extent unparalleled elsewhere, the river channels being bordered by banks or benches of gravel and sand, rising in terraces to considerable heights on the flanks of the hills. For example, at the Methow a tributary of the Columbia, there are sixteen lines of such terraces, the highest about 1200 feet about the river; and at Colville, on the Columbia, traces of old terraces, much degraded by frost and rain, are seen at 1500 feet above the river. These gravels, which are of Pliocene and more recent origin, are in many places, though very unequally, auriferous, the richest points being found in the bars or shingle banks of the river after the summer floods, and in the channels of the smaller tributary streams, where the poorer material has been partially enriched by a process of natural washing. The most extensive, or rather the best known because most completely explored, deposits of this class are those of the Upper Sacramento valley, in California (see vol. iv. p. 621).[1] Others of considerable importance are worked in the Cariboo district on the Upper Fraser river, yielding very coarse gold. Another discovery of a singular character, the produce being a regular gold gravel, was made some years back at Salmon river in Oregon, but the de-

[1] See also Whitney, *On the Auriferous Gravels of the Sierra Nevada*, Cambridge, U. S., 1879.

posit, though exceedingly rich, was soon exhausted. Gold-bearing quartz veins are also common over a large part of California, notably in Grass Valley (vol. iv. p. 622), in strata that are supposed to be of Triassic age, the associated minerals being iron and arsenical pyrites, galena, etc. In Calaveras county, tellurium ores like that of Transylvania are characteristic of the gold veins. In the adjacent States of Nevada and Colorado, gold is so intimately associated with silver ores that it is for the most part only obtained from the ultimate process of refining the reduced silver. The same remark applies to the most of the mines of Mexico, and on the south-west coast of America, in Peru, Bolivia, and Chili. See SILVER.

Very rich gold quartz has been brought from Carabaya on Lake Titicaca; and recently considerable deposits both alluvial and in veins have been opened at Caratal in Venezuela and at St. Elie in French Guiana, which are interesting as proving the actual existence of Raleigh's Eldorado.

In Brazil the principal gold mines are upon veins in clay slate, and a peculiar class of rocks known as Jacotinga or Itabirite, and which are mixtures of quartz, chlorite, and specular iron ore, the latter often occurring in large mirror-like crystals several inches across. The gold occurs almost entirely in pyritic minerals, being most abundant in ordinary iron pyrites, and less so in magnetic and arsenical pyrites, free gold being rarely seen. See BRAZIL, vol. iv. p. 202.

In Africa the chief gold-bearing localities are on the west coast—gold dust derived from alluvial washings forming an article of export from many of the trading stations along the Guinea coast. Latterly, alluvial deposits have been worked in the mountains of Transvaal, in the Leydenburg district (25° S. lat., 31° E. long.), producing coarse nuggetty gold in masses up to 11 ℔ weight, and in a few cases gold-bearing quartz has been found in veins in talcose schist and quartzite, closely associated with eruptive masses of diorite. The age of these rocks is considered by Dunn[1] to be Silurian or Devonian, and the observed phenomena to be similar to those generally observed in Australia. The upper valley of the Nile produces a little gold in Abyssinia and Nubia, the latter being the land of gold of the old Egyptians. Very extensive ancient mines have been described by Linant Bey in the district known as Attaki or Allaki on the Red Sea, situated about 120 miles back from Ras Elba, the headland midway between Berenice and Sauwakin. These are probably the same mines that were described by Diodorus Siculus, and one of the oldest topographical documents known, a map or itinerary or the route to them from the Nile, is preserved at Turin. In the reign of Setee I., of the 19th dynasty, wells were opened along this route, in order that the mines, that were then of very great antiquity, might be reopened.[2] Similar ancient gold mines have recently been discovered by Burton in the land of Midian, on the east coast of the Gulf of Akaba.

The gold districts of Australia cover a very considerable area, extending from the east side of the continent for about 20° of latitude (18° to 38° S.), the more important deposits being those of Victoria in the south. The principal districts are in Victoria,—Ballarat, Castlemaine, and Sandhurst, lying west and north from Melbourne, and Beechworth near the Murray river to the north-east. In New South Wales the gold fields are scattered over the entire length of the colony from north to south, the more important districts lying between the 32d and 36th parallels of S. lat. on the western side of the Australian cordillera, on the upper tributaries of the Macquarie and Lachlan rivers, the centre being about the town of Bathurst. This is known as the western district. Another group, known as the northern district, is on the eastern side of the mountains near the Queensland boundary, in 29° S., Rocky River being the principal locality; while the southern district includes Braidwood, Adelaide, Tumbarumba, and other localities near the Murray river. In Queensland the chief localities are, commencing on the south, Gympie and Kilkevan near Maryborough, 26° S. lat.; a group extending about 50 miles north and south of Rockhampton, in 24° 30′ S. lat., all near the coast; Eastern River, Hurley, and Peak Downs, about 300 miles inland on the 23d parallel; and Clomenny and Gilbert on a stream running into the Gulf of Carpentaria, besides numerous others. In all those localities two principal kinds of deposits are observed, namely, auriferous quartz veins traversing slates of Silurian and Devonian age, which are in intimate relation with masses of diorite and other eruptive rocks; and gold-bearing drifts of Miocene or even newer Tertiary date, derived from the degradation of the older strata. According to Daintree,[3] no auriferous vein of any kind has been found in any Secondary or Tertiary strata, or in the igneous rocks erupted through any such newer formations; and as a result of his experience the same observer gives the following as the modes of occurrence of gold in Australia:—(1) In pyritic diorites and felstones in Queensland, and their alluvial drifts; (2) in pyritic granites in New South Wales; (3) in drifts from auriferous serpentine in Queensland, also in the two northern colonies; (4) in more or less regular veins with quartz and calcspar in the preceding rocks; (5) in quartz and other veins in Devonian and Upper Silurian strata in proximity to similar igneous rocks, which is the general character of the Victoria quartz veins; (6) in veins of metamorphic rocks of unknown age in Queensland; and (7) in quartz veins in Lower Silurian strata, without any apparent connection with igneous masses. The latter occur only in Victoria, and are of comparatively minor importance. In the northern territory of South Australia, alluvial gold mining has recently been developed to a considerable extent in the neighborhood of Port Darwin in the Gulf of Carpentaria, the export being from 2000 to 3000 oz. monthly.

Statistics.—There are no means of stating exactly the total gold produce of the world for any particular year, as in many of the larger producing countries no systematic returns are obtained, and in others where such returns are collected their publication is often delayed for a considerable time. The following figures, mostly derived from a recent statistical work, A. Soetbeer, *Edelmetall-Produktion*, 1879, with some additions from late official sources, will give some idea of the relative importance of the different countries. Previous to 1837 the first place was held by Russia, and the estimated average annual yield from all sources was, in the decennial period 1841–50, 1,760,500 ounces.

The contributions of the different countries are as follows:—

		oz.		oz.		oz.
United States	1876,	2,050,000[4]				
Russia	1876,	1,072,920	1877,	1,281,260		
New South Wales.	1876,	126,789	1877,	97,582		
Victoria	1876,	963,760	1877,	809,653	1878,	758,039
Queensland	1876,	410,330	1877,	468,418		
New Zealand	1876,	322,016	1877,	371,685	1878,	311,438
Venzuela					1878,	150,000
New Granada	1876,	112,500				
Africa	1875,	110,100				
Mexico	1875,	65,950				
Bolivia	1875,	64,300				
Austria-Hungary	1876,	61,214				
Brazil	1875,	55,300				
Japan	1876,	21,660				
Chili	1876,	12,860				
Nova Scotia	1876,	12,039				
Peru	1876,	11,570				

Since 1851 the yield has been very largely increased by the discovery of the Australian and Californian sources, the annual averages being—

In 1851–1855	6,350,180 ounces.
“ 1856–1860	6,624,850 “
“ 1861–1866	5,951,770 “
“ 1866–1870	6,169,660 “
“ 1871–1875	5,487,400 “

Proportion of Gold in Deposits.—A rich gold-bearing deposit is quantitatively very different from one to which the same term is applied when containing ores of other metals. In the latter the useful material must as a rule form a considerable proportion—one or more parts in the hundred—of the mass; while in the former, owing to the superior value of the product, it rarely attains as much as 1 per cent., and is generally very much less, the amount of gold contained in easily worked alluvial deposits being often extremely small. For example, the yield of the Siberian gold washings ranges from 12 grains to 1 dwt. 12 grains per ton;[5] while in the lodes, which are more difficult and expensive to work, the proportion is about 8 dwts. per ton. In the alluvial washings of California it is estimated at about two shillings worth, equal to about $\frac{1}{40}$th of an ounce,

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[1] *Quarterly Journal of the Geological Society*, xxxiii. p. 882.

[2] Mariette Bey, *Histoire Ancienne d'Egypt*, 1867, p. 96. The oldest notice of the mines goes back to the 12th dynasty.

[3] *Quarterly Journal of the Geological Society*, vol. xxxiv. p. 435.

[4] The two principal mines, on the Comstock lode, the Consolidated Virginia and California, produced, apart from silver, gold of the value in United States currency as follows:—

	1876.	1877.	1878.
Consolidated Virginia	$7,378,145	$6,270,000	$3,770.000
California	6,648,641	9,386,745	5,553,400

[5] 1 dwt. per ton corresponds to one part in 653,333 by weight, and about 1 in 5 or 6 millions by volume.

per ton of gravel. In Australia the alluvial ground worked in the colony of Victoria in 1878 is returned as averaging 25 grains (1 dwt. 1 gr.) per ton, or about double the above quantity.

In vein mining, which is more difficult and costly, a larger yield is necessary, but probably 5 dwts., or about £1 in value per ton, will in most places represent paying quantities from quartz containing free gold, *i. e.*, not associated with pyrites. The proportional yield and quantities of the different kinds of auriferous materials treated in the colony of Victoria during the last three months of 1878 were—

	Tons.	Yield per ton.		
		oz.	dwt.	gr.
Alluvial sand "washdirt"	173·379	1	1	59·6
Cement (gravel) requiring crushing	5871	...	4	21·4
Quartz	222·775	...	9	21
Quartz tailings	11·139	...	1	18
Pyrites and blanketing (ore collected on blanket tables)	1·599	2	6	13·7

In the less tractable minerals, such as arsenical pyrites occurring in the lower portions of the veins, as much as 1½ to 3 oz. may be required for profitable working. When associated with the ores of other metals, such as silver, lead, and copper, the extraction of the gold is in most cases an incidental and final operation in their metallurgical treatment, and may therefore be best considered in the articles on these metals.

Mining.—The various deposits of gold may be divided into two classes—"veins" and "placers." The vein mining of gold does not greatly differ from that of similar deposits of metals. It will only be necessary to refer here to certain details of the extraction of gold in such cases. In the placer or alluvial deposits, the precious metal is found usually in a water-worn condition imbedded in earthy matter, and the method of working all such deposits is based on the disintegration of the earthy matter by the action of a stream of water, which washes away the lighter portions and leaves the denser gold. In alluvial deposits the richest ground is usually found in contact with the "bed rock;" and, when the overlying cover of gravel is very thick, or, as sometimes happens, when the older gravel is covered with a flow of basalt, regular mining by shafts and levels, as in what are known as tunnel-claims, may be required to reach the auriferous ground. In the early days of gold washing in California and Australia, when rich alluvial deposits were common at the surface, the most simple appliances sufficed; the most characteristic being the "pan," a circular dish of sheet-iron with sloping sides about 13 or 14 inches in diameter. The pan, about two-thirds filled with the "pay dirt" to be washed, is held in the stream or in a hole filled with water. The miner, after separating the larger stones by hand, imparts a gyratory motion to the pan by a combination of shaking and twisting movements which it is impossible to describe exactly, so as to keep its contents suspended in the stream of water, which carries away the bulk of the lighter material, leaving a black residue consisting of magnetic iron ore and other heavy minerals, together with any gold which may originally have been present in the mass. The washing is repeated until enough of the enriched sand is collected, when the gold is finally recovered by careful washing or "panning out" in a smaller pan. In Mexico and South America, instead of the pan, a wooden dish or trough, variously shaped in different districts, and known as "batea," is used.

The "cradle," a simple appliance for treating somewhat larger quantities, varies in length from 3 feet 6 inches to 7 feet, but the shorter length is that usually adopted. Its nature will be evident from fig. 1, in which *a* is a movable hopper with a perforated bottom of sheet-iron in which the "pay dirt" is placed. Water is poured on the dirt, and the rocking motion imparted to the cradle causes the finer particles to pass through the holes in the hopper on to the screen *b*, which is of canvas, and thence to the base of the cradle, where the auriferous particles accumulate on the transverse bars of wood *c*, called "riffles." Washing by the cradle, which is now but little used except in preliminary workings, is tedious and expensive.

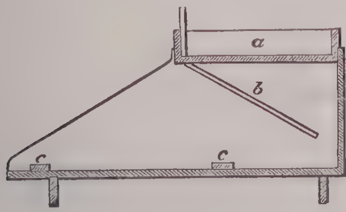

Fig. 1.—Cradle.

The "tom" is a sort of cradle with an extended sluice placed on an incline of about 1 foot in 12. The upper end contains a perforated riddle plate which is placed directly over the riffle box, and under certain circumstances mercury may be placed behind the riffles. Copper plates amalgamated with mercury are also used when the gold is very fine, and even in some instances amalgamated silver coins have been used for the same purpose. Sometimes the stuff is disintegrated with water in a "puddling machine," which is used, especially in Australia, when the earthy matters are tenacious and water scarce. The machine frequently resembles a brickmaker's wash-mill, and is worked by horse or steam power.

In workings on a larger scale, where the supply of water is abundant, as in California, sluices are generally employed. They are shallow troughs about 12 feet long, about 16 to 20 inches wide, and 1 foot in depth. The troughs taper slightly so that they can be joined in series, the total length often reaching several hundred feet. The incline of the sluice varies with the conformation of the ground and the tenacity of the stuff to be washed, from 1 in 16 to 1 in 8.

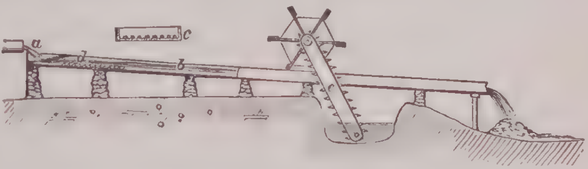

Fig. 2.—Sluice.

Fig. 2 represents one of the simplest forms of sluice as used in river diggings in the north-west of America. A rectangular trough of boards, whose dimensions depend chiefly on the size of the planks available, is set up on the higher part of the ground at one side of the claim to be worked, upon trestles or piers of rough stone-work, at such an inclination that the stream may carry off all but the largest stones, which are kept back by a grating of boards about 2 inches apart at *a*. The gravel, which in this particular instance is from 12 to 16 feet thick, and with an average breadth to the river of 25 to 30 feet, is dug by hand and thrown in at the upper end, the stones kept back being removed at intervals by two men with four-pronged steel forks. The floor of the sluice is laid with riffles made of strips of wood 2 inches square laid parallel to the direction of the current (as at *b*, and in cross sections at *c*), and at other points *d* with boards having transverse notches filled with mercury. These were known originally as Hungarian riffles. The bottom of the working, which is below the drainage level of the valley, is kept dry by a Chinese bucket pump *e*, attached to a rough undershot wheel driven by the current in the sluice. The sluice boxes are made in lengths, and united together spigot and faucet fashion, so that they may easily be removed and re-erected as the different parts of the claim are progressively exhausted.

In the larger and more permanent erections used in hydraulic mining, the upper ends of the sluices are often cut in rock or lined with stone blocks, the grating stopping the larger stones being known as a "grizzly." In order to save very fine and especially rusty particles of gold, so-called "under-current sluices" are used; these are shallow wooden tanks, 50 square yards and upwards in area, which are placed somewhat below the main sluice, and communicate with it above and below, the entry being protected by a grating so that only the finer material is admitted. These are paved with stone blocks or lined with mercury riffles, so that from the greatly reduced velocity of flow, due to the sudden increase of surface, the finer particles of gold may collect. In order to save finely-divided gold, amalgamated copper plates are sometimes placed in a nearly level position, at a considerable distance from the head of the sluice, the gold which is retained in it being removed from time to time. Sluices are often made dou ble, and they are usually cleaned up,—that is, the deposit rich in gold is removed from them,—once a week. The gold is then recovered by "panning."

The application of a jet of water to the removal of auriferous gravels by the so-called hydraulic system of mining has already been noticed at vol. iv. p. 621.[1] This method has for the most part been confined to the country of its invention, California, and the western territories of America, where the conditions favorable for its use are more fully developed than elsewhere,—notably the presence of thick banks of gravel that cannot be utilized by other methods, and abundance of water, even though considerable work may be required at times to make it available. The general conditions to be observed in such workings may be briefly stated as follows:—(1) The whole of the auriferous gravel, down to the "bed rock," must be removed,—that is, no selection of rich or poor parts is possible; (2) this must be accomplished by the aid of water alone, or at times by water supplemented by gunpowder; (3) the conglomerate must be mechanically disintegrated without interrupting the whole system; (4) the gold must be saved without interrupting the continuous flow of water; and (5) arrangements must be made for disposing of the vast masses of impoverished gravel.

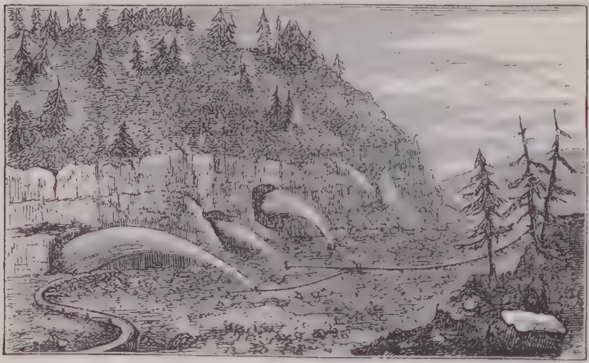
Fig. 3.—Hydraulic Gold Working.

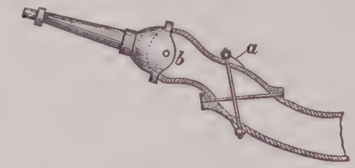

Fig. 4.

The general appearance of an hydraulic gold working is seen in fig. 3, the water being brought from a ditch on the high ground, and through a line of pipes to the distributing box, whence the branch pipes supplying the three jets diverge. The stream issues through a nozzle resembling that of a fire engine (fig. 4), which is movable in a horizontal plane around the vertical axis *a*, and in a vertical plane on the spherical joint and centre *b*, so that the direction of the jet may be varied through considerable angles by simply moving a handle. The material of the bank, being loosened by the cutting action of the water, crumbles into holes, or "caves in," and the superincumbent mass, often with large trees and stones, falls into the lower ground. The stream, laden with stones and gravel, passes into the sluices, where the gold is recovered in the manner already described. Under the most advantageous conditions the loss of gold may be estimated at 15 or 20 per cent., the amount recovered representing a value of about two shillings per ton of gravel treated. The loss of mercury is about the same, from 5 to 6 cwt. being in constant use per mile of sluice. About 1 cwt. is added daily in at least two charges. The average half-yearly consumption is estimated at about one hundred flasks of 74 ℔ each, after allowing for the amount recovered in clearing up and distillation of the amalgam. The latter operation is performed at intervals of seven or fourteen days in the upper lengths of the sluice, and half-yearly in the lower parts.

The dressing or mechanical preparation of vein stuff containing gold is generally similar to that of other ores, except that the precious metal should be removed from the waste substances as quickly as possible, even although other minerals of value that are subsequently recovered may be present. This is usually done by amalgamation with mercury. In all cases the quartz or other vein stuff must be reduced to a very fine powder as a preliminary to further operations. This may be done in several ways, *e. g.*, either (1) by the Mexican crusher or *arrastra*, in which the grinding is effected upon a bed of stone, over which heavy blocks of stone attached to cross arms are dragged by the rotation of the arms about a central spindle, motion being furnished by mules or other power, or (2) by the Chilian mill or *trapiche*, also known as the edge-runner, where the grinding-stones roll upon the floor, at the same time turning about a central upright,—contrivances which are mainly used for the preparation of silver ores; but by far the largest proportion of the gold quartz of California and Australia is reduced by (3) the stamp mill, which is similar in principle to that used in Europe for the preparation of tin and other ores, but has received special modification in many details. Fig. 5 represents the ordinary Californian pattern of a stamp mill. The stamp is a cylindrical iron pestle faced with a chilled cast-iron shoe, removable so that it can be renewed when necessary, attached to a round iron rod or lifter, the whole weighing from 600 to 800 ℔. The lift is effected by cams acting on the under surface of tappets *a*, and formed by cylindrical boxes keyed on to the stems of the lifter about one-fourth of their length from the top. As, however, the cams, unlike those of European stamp mills, are placed to one side of the stamp, the latter is not only lifted but turned partly round on its own axis, whereby the shoes are worn down uniformly. The bed or mortar A is of cast-iron. The height of lift may be between 8 and 10 inches, and the number of blows from 60 to 90 per minute. The stuff, previously broken to about 2 inch lumps in a Blake's rock-breaker, is fed in through the aperture *n* at the back of the "battery box," a constant supply of water being given from the channel *k*, and mercury in a finely divided state

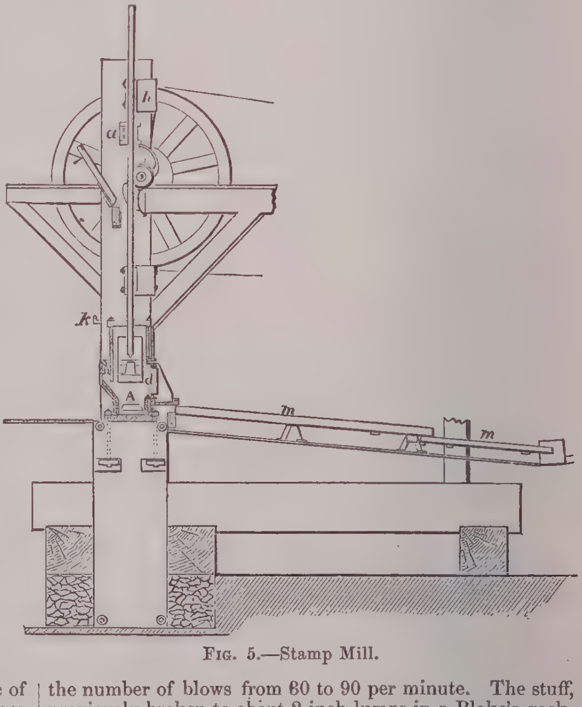

Fig. 5.—Stamp Mill.

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[1] Much valuable information on this subject will also be found in the *Fifth Annual Report of the United States Commissioners of Mining Statistics*, Washington, 1873, p. 390.

is added at frequent intervals. The discharge of the comminuted material takes place through the aperture *d*, which is covered by a thin steel plate perforated with numerous slits about $\frac{1}{50}$th inch broad and $\frac{1}{10}$th to $\frac{1}{8}$th inch long, a certain volume being discharged at every blow and carried forward by the flushing water over the apron or table in front, *m*, covered by copper plates filled with mercury. Similar plates are often used to catch any particles of gold that may be thrown back, while the main operation is so conducted that the bulk of the gold may be reduced to the state of amalgam by bringing the two metals into intimate contact under the stamp head, and remain in the battery. The tables in front are laid at an incline of about 8 degrees, and are about 13 feet long; they collect from 10 to 15 per cent. of the whole gold; a further quantity is recovered by leading the sands through a gutter about 16 inches broad and 120 feet long, also lined with amalgamated copper plates, after the pyritic and other heavy minerals have been separated by depositing in catch pits and other similar contrivances.

When the ore does not contain any considerable amount of free gold, mercury is not, as a rule, used in the battery. The pulverized stuff is received upon blanket tables or sluices. These are inclined boards covered with coarse woollen cloth or sacking. The heavier particles become entangled in the fibres of the cloth, while the lighter deposits are carried forward by the current. At intervals of a quarter to half an hour the surface of the blanket is completely covered, when it is removed, and its contents are washed off in a tub of water and reserved for further treatment. This consists of amalgamation, in a contrivance analogous to the Hungarian mill subsequently described, and subsequent treatment in pan amalgamators somewhat similar to the *arrastra* in character, but with grinding surfaces of iron instead of stone.

At Schemnitz, in Hungary, quartz vein stuff containing a little gold, partly free and partly associated with pyrites and galena, is, after stamping in mills similar to those described above, but without rotating stamps, passed through the so-called Hungarian gold mill, fig. 6. This consists of a cast-iron pan *a*, having a shallow cylindrical bottom *b*, holding 50 ℔ of mercury, in which a wooden runner *c*, nearly of the same shape as the inside of the pan, and armed below with several projecting blades, is made to revolve by gearing wheels placed either above, or, as in the figure, below. The connection of the runner with the driving shaft is effected by the three-armed crutch shown in plan at *e*, which sits on the square part of the shaft. By means of set screws analogous to those of a flour mill, the runner is adjusted at such a height that the knives just clear the surface of the mercury. The stuff from the stamps arrives by the gutter *f*, and, falling through the hole in the middle of the runner, is distributed over the mercury, when the gold subsides in virtue of its superior density, while the quartz and lighter materials are guided by the blades to the circumference and are discharged at *g*, usually into a second similar mill, and subsequently pass over blanket tables. The most advantageous speed is from 12 to 14 revolutions per minute. The action of this so-called mill is really more nearly analogous to that of a centrifugal pump, as no grinding action takes place in it. The amalgam is cleaned out about once a month. The average amount of gold collected from 50 tons of stuff stamped, is about 6 oz. in the mills, and in the subsequent dressing processes 1 ℔ of auriferous silver and 10 cwt. of lead. According to Rittinger, mercury that has been purified by distillation acts much more rapidly upon gold than such as has been saturated with the metal without losing its fluidity, although the amount that can be so dissolved is very small.

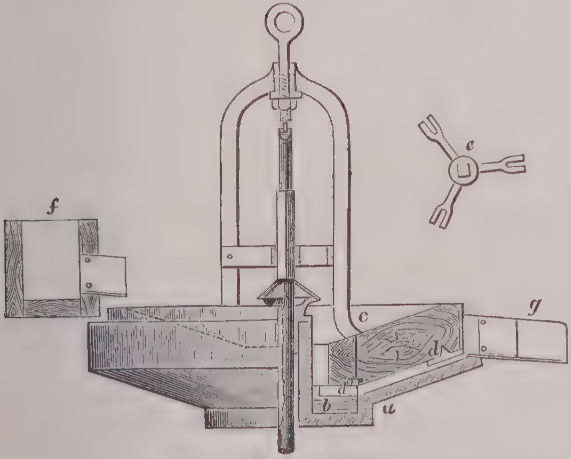

Fig. 6.—Hungarian Mill.

There are various forms of pan amalgamators of which space will not permit a description to be given. It may be stated, however, that experience of the great variety of pans that have from time to time been devised has led to the adoption of the more simple forms, in which the grinding is effected between horizontal flat surfaces instead of curved or conical bottoms, and in the pans now usually employed these flat grinding surfaces form an annular floor round a central cone through which a vertical shaft passes.

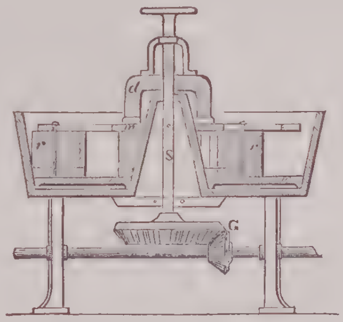

Fig. 7.—Knox Pan.

The Knox pan, fig. 7, may be considered to be fairly typical. It is of cast-iron, 4 feet in diameter, and 14 inches deep. It has a false bottom to form a hollow annular space through which steam can be introduced. The centre of the yoke *d* attached to the muller *m*, is keyed to a vertical wrought-iron shaft S, 2 inches in diameter, which can be brought in connection with the driving gear G. The blocks *r*, *r* are of wood. In working the pan 100 ℔ of skimmings are introduced, and water added until the pulp will just adhere to a stick. After three hours' grinding the pulp is heated with steam. About 5 ℔ of mercury are added for every charge, together with a cupful of equal parts of saltpetre and sal ammoniac. After three hours further working, water with a little caustic lime is added, and the pulp is discharged first through an upper and then through a lower hole.

One of the greatest difficulties in the treatment of gold by amalgamation, and more particularly in the treatment of pyrites, arises from the so-called sickening or flouring of the mercury; that is, the particles, losing their bright metallic surfaces, are no longer capable of coalescing with or taking up other metals. Of the numerous remedies proposed the most efficacious is perhaps sodium amalgam. It appears that amalgamation is often impeded by the tarnish found on the surface of the gold when it is associated with sulphur, arsenic, bismuth, antimony, or tellurium. Wurtz[1] in America (1864) and Crookes in England (1865) made independently the discovery that, by the addition of a small quantity of sodium to the mercury, the operation is much facilitated. It is also stated that sodium prevents both the "sickening" and the "flouring" of the mercury which is produced by certain associated minerals. Cosmo Newberry has investigated with much care the action of certain metals in impeding amalgamation.[2] Wurtz recommends two amalgams, one containing 2 and the other 4 per cent. of sodium, and in practice 1 per cent. or less of these is added to the mercury in the amalgamator. Crookes employs three kinds, which he calls A, B, and C amalgams; each contains 3 per cent. of mercury, but the B variety has, in addition to the sodium, 20 per cent. of zinc, and C is mixed with 10 per cent. of zinc, and 10 per cent. of tin. The addition of cyanide of potassium has been suggested to assist the amalgamation and to prevent "flouring," but Skey[1] has shown that its use is attended with loss of gold.

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[1] *American Journal of Science and Arts*, vol. xli., March, 1866.

[2] Ure's *Dictionary of Arts*, supplement to 7th ed., p. 412.

Separation of Gold from the Amalgam.—The amalgam is first pressed in wetted canvas or buckskin in order to remove excess of mercury. According to Rittinger, mercury will dissolve from 0·05 to 0·08 per cent. of native gold of standard 650 to 850 without lost of fluidity, the solubility of the gold increasing with its fineness; and until the point of saturation is reached, no separation of solid amalgam is possible. Lumps of the solid amalgam, about 2 inches in diameter, are introduced into an iron vessel lined with a paste of fire-clay and wood ashes, and provided with an iron tube that dips below the surface of water. The distillation is then effected by heating, care being taken that the retort does not become visibly red in daylight. The amalgam yields about 30 to 40 per cent. of gold. In California the amalgam is retorted in cast-iron pans placed in cast-iron cylinders 11 inches in diameter, 4 feet 6 inches long, supported on brick work. The bullion left in the retorts is then melted in black-lead crucibles, with the addition of small quantities of suitable fluxes.

The extraction of gold from auriferous minerals by fusion, except as an incident in their treatment for other metals, is very rarely practised. It was at one time proposed to treat the concentrated black iron obtained in the Ural gold washings, which consists chiefly of magnetite, as an iron ore, by smelting it with charcoal for auriferous pig-iron, the latter metal possessing the property of dissolving gold in considerable quantity. By subsequent treatment with sulphuric acid the gold could be recovered. Experiments on this point were made by Anossow in 1835, but they have never been followed in practice.

Gold in galena or other lead ores is invariably recovered in the refining or treatment of the lead and silver obtained. Pyritic ores containing copper are treated by methods analogous to those of the copper smelter. This is extensively done. In Colorado the pyritic ores containing gold and silver in association with copper are smelted in reverberatory furnaces for regulus, which, when desilverized by Ziervogel's method, leaves a residue containing 20 or 30 ounces of gold per ton. This is smelted with rich gold ores, notably those containing tellurium for white metal or regulus; and by a following process of partial reduction analogous to that of selecting in copper smelting "bottoms" of impure copper are obtained in which practically all the gold is concentrated. By continuing the treatment of these in the ordinary way of refining, poling, and granulating, all the foreign matters other than gold, copper, and silver are removed, and, by exposing the granulated metal to a high oxidizing heat for a considerable time, the copper may be completely oxidized while the precious metals are unaltered. Subsequent treatment with sulphuric acid renders the copper soluble in water as sulphate, and the final residue contains only gold and silver, which is parted or refined in the ordinary way. This method of separating gold from copper, by converting the latter into oxide and sulphate, is also used at Oker in the Harz.

Chlorination Process.—Plattner suggested that the residue from certain mines at Reichenstein, in Silesia, should be treated with chlorine after the arsenical products had been extracted by roasting. The process, which depends upon the fact that chlorine acts rapidly upon gold, but does not attack ferric oxide, is now adopted in Grass Valley, California, where the waste minerals, principally pyrites from tailings, have been worked for a considerable time by amalgamation. The roasting is conducted at a low temperature in some form of reverberatory furnace. Salt is added in the roasting to convert all the metals present, except iron, into chlorides. The auric chloride is, however, decomposed at the elevated temperature into finely-divided metallic gold, which is then readily attacked by the chlorine gas. The roasted mineral, slightly moistened, is next introduced into a wooden vat, pitched inside, and furnished with a double bottom, as is shown in fig. 8. Chlorine is led from a suitable generator beneath the false bottom, and rises through the moistened ore, resting on a bed of broken quartz below the false bottom, converting the gold into a soluble chloride, which is afterwards removed by washing with water. The precious metal is then precipitated as metallic gold by sulphate of iron. The process has been greatly improved in America by Küstel, Deetken, and Hoffmann; with proper care it is a very perfect one, and yields 97 per cent. of the gold originally present in the ore. It is stated not to cost more in California than 50s. a ton. Any silver originally present in the ore is of course converted into chloride of silver and remains with the residue, from which it may be extracted by the solvent action of brine or by amalgamation.

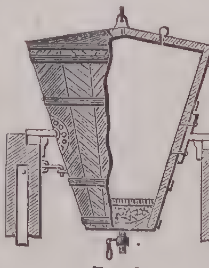

FIG. 8.

Refining or Parting Gold from other Metals.—Strabo states[2] that in his time a process was employed for refining and purifying gold in large quantities by cementing or burning it with an aluminous earth, which, by destroying the silver, left the gold in a state of purity. Pliny shows that for this purpose the gold was placed on the fire in an earthen vessel with treble its weight of salt, and that it was afterwards again exposed to the fire with two parts of salt and one of argillaceous rock, which, in the presence of moisture, effected the decomposition of the salt; by this means the silver became converted into chloride. In a similar process still practised in New Grenada the granulated argentiferous gold is mixed with one part of common salt and two parts of brick dust. In the presence of moisture, effected by the passage of aqueous vapor through the porous pots in which the mixture is heated, the salt acts on the brick dust, producing silicate of soda, and the evolution of hydrochloric acid affords a source of chlorine for the silver. The chloride of silver formed fuses readily and drops off, exposing a fresh surface of the alloy to the action of the gas.

Various methods for separating gold from silver or other alloys appear to have been in use from ancient times. Among these may be mentioned prolonged oxidation by exposure to air, and treatment with sulphur, sulphide of antimony, and corrosive sublimate. In the Harz, 2 ounces of the granulated alloy of gold and silver were mixed and heated with 1 ounce of sulphur, litharge being added to separate the gold remaining in the sulphide of silver.

Parting by Nitric Acid, the old process of refining, is now practised in England by only one firm, although in some refineries both the nitric acid and the sulphuric acid processes are combined, the alloy being first treated with nitric acid. It used to be called "quartation," from the fact that 4 parts of the alloy best suited for the operation of refining contain 3 parts of silver and one of gold. The operation may be conducted in vessels of glass or platinum, and each pound of granulated metal is treated with a pound and a quarter of nitric acid of specific gravity 1·32. It is the method employed in the assay of gold (see ASSAYING).

Refining by Sulphuric Acid is the process usually adopted for separating gold from silver on the large scale. It appears to have been proposed in France by Dizé at the beginning of the present century. It was actually in use in France in 1820, and was introduced into the Mint Refinery, London, by Mr. Mathison in 1829.[3] It is based upon the facts that concentrated hot sulphuric acid converts silver and copper into soluble sulphates without attacking the gold, the sulphate of silver being subsequently reduced to the metallic state by copper plates with the formation of sulphate of copper.

About 80 ℔ of the granulated alloy are boiled for three or four hours in a platinum vessel (fig. 9) with 2·5 times its weight of sulphuric acid of specific gravity 1·84. The sulphurous acids which arise are partially condensed before being allowed to pass into the air. When the acid has ceased to act on the metal, a small quantity of sulphuric acid of specific gravity 1·53 is added, and, after a second boiling, the contents of the vessel are allowed to settle. The supernatant liquid is then withdrawn from the gold, which falls to the bottom of the vessel, and is diluted until its density is 1·21 or 1·26. The silver is usually precipitated from solution by copper plates, but sometimes iron is used, and the silver is roughly dried and compressed by an hydraulic press before it is melted into ingots. The gold, which is often again treated with sulphuric acid, is then washed and melted into ingots that contain from 997 to 998 parts of gold in 1000. The operation of parting may be conducted in iron or platinum vessels; the use of the former was advocated by M. Tocchi, and they are still extensively employed. Magnificent vessels of platinum have, however, been made in England by Messrs. Johnson, Matthey & Co. The alloys best suited for the operation contain from 800 to 950 of silver and 50 to 200 of copper and gold, but the proportion of gold must not exceed 200 parts in 1000. Refiners obtain alloys in suitable proportions by mixing together auriferous silver and argentiferous gold, the proportions of the respective metals having been previously indicated by assay. By such an arrangement, silver which contains but the 0·0004 part of gold, or 2·25 grains in the troy pound, may be profitably treated.

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[1] *Transactions of the New Zealand Institute*, 1876.

[2] Fabbroni, *Ann. Chim.*, t. lxxii. p. 25.

[3] *Report on the Royal Mint*, 1837, Appendix, p. 59.

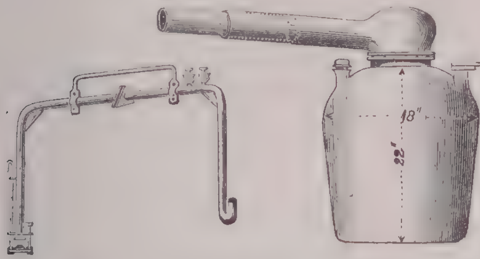

Fig. 9.—Refinery Siphon and Alembic.

Cost of Refining.—The charge to the public for refining depends in a great measure on the amount of metal to be operated upon and its richness. In England, however, it may be considered to be about 1d. per ounce for the silver and 4d. per ounce for gold. In France the charge is about 90 cents to 1 franc 25 cents for a kilogramme of silver.

The Lower Harz smelting works produce annually from 50 to 55 cwts. of test silver, of an average fineness of 950 silver and 50 gold per 1000; the proportion of the latter metal is, however, variable, being lowest (3 per 1000) in the silver obtained from clean lead ores, and highest (10 per 1000) in that separated from argentiferous copper ores,—that from the mixed copper and lead ores being of intermediate richness. The silver, in quantities of 25 kilogrammes, is refined upon small tests in a muffle, and when sufficiently purified is granulated by ladling it into water, whereby thin flattened granules suitable for dissolving are obtained.

The parting vessels (fig. 10) are of porcelain, which, to protect them against fracture by irregular heating, are covered with wire netting and plastered over with a mixture of clay and smithy scales. They are mounted in a frame and set loose in an iron pot with a hemispherical bottom, which is heated by a fire from below; the pot also serves to catch the contents of the porcelain vessel if the latter should be accidentally broken. The cover is perforated by a hole in the centre for the passage of a lead pipe to carry off the sulphurous acid fumes, and a smaller one at one side through which acid may be introduced. These, as well as other connections on the pipes carrying off the vapors, are secured by water-joints. The charge of about 200 ounces (6·25 kilogrammes) of granulated silver is treated with twice its weight of sulphuric acid marking 66° Baumé, and, by careful firing, is dissolved in six hours. The proper management of the heat is of importance, as neglect in the conduct of the operation may easily lead to a breakage of the pot. When the charge is completely dissolved the liquid is allowed to settle for some time, and is then poured off into a lead pan, where the silver sulphate solidifies. This, when redissolved by an addition of water and careful warming, is treated with strips of copper, the separation of the silver being facilitated by agitating the liquid. When the latter is found to be completely free from silver the heating is stopped, and the contents of the pan are allowed to settle for eighteen hours, when the copper solution is drawn off by a siphon and sent to the vitriol crystallizers. In the precipitation of 100 kilogrammes of silver about 30 kilogrammes of sheet-copper are expended.

The precipitated silver is washed with water in a copper vessel upon a linen filter until the reaction of copper in the washings ceases, and then moulded in cylindrical blocks by screw pressure, to express the residual water. These when fire-dried are melted in black-lead pots, holding 75 ℔, with the addition of a little soda nitre.

The parted gold remaining in the porcelain pot, though already sensibly finer than is usual when iron parting vessels are used, still contains silver, and is therefore boiled once more with sulphuric acid of 66° Baumé. Afterwards it is washed with water until silver can be no longer detected in the washings, when it is transferred to a porcelain dish and dried. When a quantity of about 10 ℔ of gold has been accumulated, it is mixed with a little borax glass, melted in a black-lead pot, and cast. The resulting bars average $\frac{985}{1000}$ fine.

Refining by Chlorine Gas.—F. Bowyer Miller[1] devised in 1867 the following method for separating silver from gold. The process which is the one now adopted in the Australian mints,[2] consists in converting the silver into chloride by the passage of a stream of chlorine gas through the molten alloy. Clay crucibles are employed after having been saturated with a strong solution of borax and allowed to dry. The chlorine is introduced through the gold by a clay pipe passing to the bottom of the crucible, and connected with the chlorine generator in which the necessary pressure is obtained by a pressure tube 8 feet high. The chloride of silver is easily poured off from the surface of the molten metal, and by carefully fusing with a little carbonate of soda, the small amount of gold it retains is separated and falls to the bottom of the crucible. The gold operated upon contains from 3 to 12 per cent. of silver, and the average fineness of the refined gold is 994. The operation is now conducted on a considerable scale in Australia, and in the years 1871 and 1872 no less than 1,100,000 ounces of gold were refined by its aid in Sydney alone. The absolute loss of gold does not exceed 14 parts in 100,000.

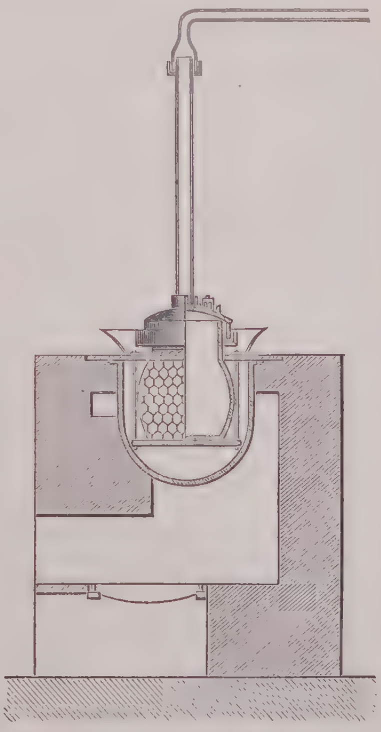

Fig. 10.

Toughening Brittle Gold.—It will be seen from p. 668 that minute traces of certain metals, which do not exceed the $\frac{1}{1920}$th part of the mass, render gold brittle and unfit for coinage. Miller showed that the removal of the deleterious metals might be effected by converting them into volatile chlorides by a stream of chlorine gas. The process was introduced into the English mint by Roberts,[1] who successfully treated over 40,000 ounces of brittle gold with but trifling loss of precious metal. Wagner has suggested[2] that bromine may replace chlorine in Miller's process. Brittle gold may also be toughened by throwing a small quantity of corrosive sublimate on to the surface of the molten metal, but this method is wasteful, and the fumes evolved are deleterious. The late Mr. Warington[3] proposed to toughen brittle gold by the addition of about 10 per cent. of black oxide of copper. The process is efficacious, but the crucibles become much corroded and even perforated; the standard fineness of the gold is, moreover, lowered by such copper as is reduced to the metallic state. If gold is but slightly brittle, it may be toughened by pouring it in a thin stream through atmospheric air into a crucible lined with borax, or by the addition of a small quantity of chloride of copper.

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[1] *Chem. Soc. Journ.*, v. xxi., 1868, p. 506.

[2] *Fourth Annual Report of Deputy-Master of Mint*, 1873, p. 62.

Preparation of Pure Gold.—Chemically pure gold may be prepared by several methods. The metal, either in the form of powder or "cornets" from the purest gold that can be obtained, is dissolved in nitro-hydrochloric acid. The excess of acid is driven off, alcohol and chloride of potassium added to precipitate platinum, and the chloride of gold is then dissolved in pure distilled water, the solution being diluted until each gallon does not contain more than half an ounce of the precious metal. The solution is allowed to stand for several weeks, and the supernatant liquid is carefully removed by a siphon from any chloride of silver that may have fallen to the bottom of the vessel. The gold may then be precipitated by a stream of carefully washed sulphurous anhydride, or by the addition of oxalic acid, formic acid, or ferrous sulphate. The spongy gold is washed with dilute hydrochloric acid, distilled water, ammonia water, and again with distilled water, after which it is melted in a clay crucible with a little bisulphate of potash and borax, and poured into a stone mould. Roberts[4] prepared by this method 70 ounces of gold of which the average purity was 999·96, the precipitant being oxalic acid. Gold precipitatad by oxalic acid from an acid solution containing copper is always contaminated with cupric oxalate. E. Purgotti[5] has, however, shown that by heating the solution with the addition of potash, a soluble double oxalate of copper and potash is formed, and the gold is left in the pure state.

Alloys of Gold.—The most important alloys are those with silver and copper. Those used for coinage at the present day contain from 800 parts of gold in 1000, the standard of the Norwegian 2-kroner piece, to 986·6, that of the Austrian reichs-ducaten, the alloying metal being mainly copper. In England, when gold coins were first introduced by Henry III., in 1257, they were of pure gold. Edward III., in 1345, was the first to use a standard 994·8, and in 1526 Henry VIII. issued crowns of the double rose of the standard 916·6 for concurrent issue with sovereigns, and other coins of the original standard 994·8. In 1544 the standard for all gold coins was reduced to 916·6, and again in 1546 to 833·4, the lowest point ever reached in England. Mary restored the old standard 994·8. Elizabeth directed that coins of both standards, 916·6 and 994·8, should be issued, and the latter was employed at intervals until 1640. Since then the lower standard, 916·6, has been solely used, and, as is shown by the following extract from the Coinage Act of 1870, 33 Vic. c. 10, is the one now in use:—

Denomination of Coin.	Standard Weight.		Least Current Weight.		Standard Fineness.	Remedy Allowance.		
						Weight per piece.		Millesimal Fineness.
	Imperial Weight. Grains.	Metric Weight. Grams.	Imperial Weight. Grains.	Metric Weight. Grams.		Imperial Grains.	Metric Grams.	
GOLD—								
Five-Pound	616·37239	39·91028	612·50000	39·68935	Eleven-twelfths fine gold, one-twelfth alloy; or millesimal fineness 916·66.	1·00000	0·06479	0·002
Two-Pound.............	246·54895	15·97611	245·00000	15·87574		0·40000	0·02592	
Sovereign	123·27447	7·98805	122·50000	7·93787		0·20000	0·01296	
Half Sovereign.........	61·63723	3·99402	61·12500	3.96083		0·10000	0·00648	

In America and in those countries which have formed the "Latin Convention," the standard of gold coin is 900, with a "remedy" of $\pm\frac{2}{1000}$. M. Peligot suggested[6] that by employing a triple alloy containing 58·1 per cent of gold, 36·1 of copper, and 5·8 of zinc, a coin might be produced which, while being of the value of 25 francs, would have the decimal weight of 10 grammes. The alloy is perfectly malleable and of good color. In England the following standards are used for plate and jewellery, 375, 500, 625, 750, and 916·6, the alloying metal being silver and copper in varying proportions. In France three alloys of the following standards are used for jewellery, 920, 840, and 750. A greenish alloy used by goldsmiths contains 70 per cent. of silver and 30 per cent. of gold. "Blue gold" is stated to contain 75 per cent. of gold and 25 per cent. of iron. The Japanese use for ornament an alloy of gold and silver, the standard of which varies from 350 to 500, the color of the precious metal being developed by "pickling" in a mixture of plum-juice, vinegar, and sulphate of copper. They may be said to possess a series of bronzes, in which gold and silver replace tin and zinc, all these alloys being characterized by patina having a wonderful range of tint. The common alloy, Shi-ya-ku-Do, contains 70 per cent. of copper and 30 per cent. of gold; when exposed to air it becomes coated with a fine black patina, and is much used in Japan for sword ornaments. Gold wire may be drawn of any quality, but it is usual to add 5 to 9 dwts. of copper to the pound.[7]

The "solders" used for red gold contain 1 part of copper and 5 of gold; for light gold, 1 part of copper, 1 of silver, and 4 of gold.

Alloys of Gold and Silver.—Electrum, the natural alloy of gold and silver, has already been described, p. 659. Matthiessen observed that the density of those alloys, the composition of which varies from $AuAg_6$ to Au_6Ag, is greater than that calculated from the densities of the constituent metals. These alloys are harder, more fusible, and more sonorous than pure gold. The alloys of the formulæ $AuAg$, $AuAg_2$, $AuAg_4$, and $AuAg_{20}$ are perfectly homogeneous, and have been studied by Levol.[8] Hatchett has shown,[9] by a series of careful experiments, that certain metals, even when present in such small quantities as the $\frac{1}{1920}$th part of the mass, render standard gold brittle and unfit for rolling. These metals are bismuth, lead, antimony, arsenic and zinc.

Gold and Zinc.—With regard to the latter metal, it may be remarked that, although its presence in small quantities renders gold brittle, it may be added to gold in larger quantities without destroying the ductility of the precious metal, for, as has been already stated, Peligot proved that a triple alloy of gold, copper, and zinc, which contains 5·8 per cent. of the last-named, is perfectly ductile. The alloy of 11 parts gold and 1 part of zinc is, however, stated to be brittle.

Gold and Tin.—Alchorne[10] showed that gold alloyed with $\frac{1}{37}$th part of tin is sufficiently ductile to be rolled and stamped into coin, provided the metal is not annealed at a high temperature. The alloys of tin and gold are hard and brittle, and the combination of the metals is attended with contraction; thus the alloy $SnAu$ has a density 14·243, instead of 14·828 indicated by calculation. Matthiessen and Bose[11] obtained large crystals of the alloy Au_2Sn_5, having the color of tin, which changed to a bronze tint by oxidation.

Gold and Iron.—Hatchett found that the alloy of 11 parts gold and 1 part of iron is easily rolled without annealing. In these proportions the density of the alloy is less than the mean of its constituent metals.

Gold and Palladium.—These metals are stated to alloy in all proportions. According to Chenevix,[12] the alloy composed of equal parts of the two metals is grey, is less ductile than its constituent metals, and has the specific gravity 11·08. The alloy of 4 parts of gold and 1 part of palladium is white, hard, and ductile. Graham has shown[13] that a wire of palladium alloyed with from 24 to 25 parts of gold does not exhibit the remarkable retraction which, in pure palladium, attends its loss of occluded hydrogen.

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[1] *First and Second Annual Reports of Deputy-Master of Mint*, p. 1870–2, p. 93 and 34 respectively.

[2] *Bull. Chem. Soc. Paris*, t. xxv., 1876, p. 138.

[3] *Chem. Soc. Journ.*, xiii. 1860, p. 31.

[4] *Fourth Annual Report of Royal Mint*, 1874, p. 46; *Committee of British Association Report*, 1873, p. 219.

[5] *Zeitschr. Anal. Chem.*, ix. 127.

[6] *Comptes Rendus*, t. lxxvi. p. 1441.

[7] Ure's *Dictionary of Arts*, 7th edition, 1875, vol. i. p. 96.

[8] *Ann. de Chim. et de Phys*; (3), t. xxxvi. p. 193, and t. xxxix. p. 163.

[9] *Phil. Trans.*, 1803, part 1, pp. 43–194.

[10] *Phil. Trans.*, 1784.

[11] *Proc. Roy. Soc.*, vol. xi. 1860–2, p. 433.

[12] Wurtz, *Dictionnaire de Chimie*, t. ii. p. 630.

[13] *Proc Roy. Soc.*, xvii. p. 503.

Gold and Platinum.—Clarke states that the alloy of equal parts of the two metals is ductile, and has almost the color of gold.

Gold and Rhodium.—Gold alloyed with ¼th or ⅓th of rhodium is, according to Wollaston, very ductile, infusible, and of the color of gold.

Gold and Iridium.—Small quantities of iridium do not destroy the ductility of gold, but this is probably because the metal is only disseminated through the mass, and not alloyed, as it falls to the bottom of the crucible in which the gold is fused.

Gold and Nickel.—Eleven parts of gold and 1 of nickel yield an alloy resembling brass.

Gold and Cobalt.—Eleven parts of gold and 1 of cobalt form a brittle alloy of a dull yellow color.

Assay of Gold.—It may be well to supplement the information given in the article ASSAYING with some additional details as to the assay of gold bullion, as practised in the Royal Mint, and of gold ores. The assay of bullion consists of six operations:—

(1.) The sample of metal taken for assay is flattened, and an assistant adjusts a portion of it to an exact weight by cutting or filing. This weight varies with different operators from 5 to 16 grains. The assayer then completes the adjustment on a more sensitive balance. The prepared assay piece is wrapped in lead foil, together with a certain amount of pure silver, which is generally equal to 2½ times the amount of gold assumed to be present. In the case of standard gold, the weight of lead employed is to the weight of the alloy taken for assay as 8 to 1, and the ratio of the weight of lead to the weight of copper present is 100 : 1. Much diversity of opinion exists as to the amount of lead that should be employed. The proportions recommended by D'Arcet[1] are considerably less than those advocated by Kandelhardt;[2] and it may be stated, with regard to the silver, that the last mentioned authority and Chaudet recommend the proportion of 1 of gold to 2½ of silver, but Pettenkofer states that the proportion need not exceed 1 to 1⅓, provided that the subsequent boiling in nitric acid is sufficiently prolonged. The amount of gold lost in cupellation has been shown by Rossler to increase with the amount of lead used, and to decrease as the amount of silver is increased.[3]

(2.) The necessary number of cupels are arranged on the bottom of the muffle (fig. 2, ASSAYING), and the packets containing the silver and gold are transferred from a numbered wooden range to corresponding cupels. The furnace operations are then performed as is described in ASSAYING (p. 636), and the result is that each cupel contains a button of silver and gold.

(3.) The button *a* (fig. 11) is flattened by striking it with a hammer on a polished anvil, first in the centre, and then on the edge, a third blow being given on the opposite edge which elongates the metal. After annealing in an iron tray, the flattened buttons *b* are reduced by laminating rolls to the thickness of a visiting card *c*. They are again annealed and rolled into a spiral or cornet *d*.

(4.) These cornets are then treated with nitric acid of specific gravity 1·2 either separately in parting flasks, or together in cups of platinum, which are introduced into a suitable vessel of platinum, an arrangement by which it will be evident much time may be saved. The boiling is then continued for fifteen or twenty minutes, when the cornets are washed with distilled water, and treated with nitric acid of specific gravity 1·3, and in this the cornets remain for about the same period, after which they are again washed in distilled water and dried.

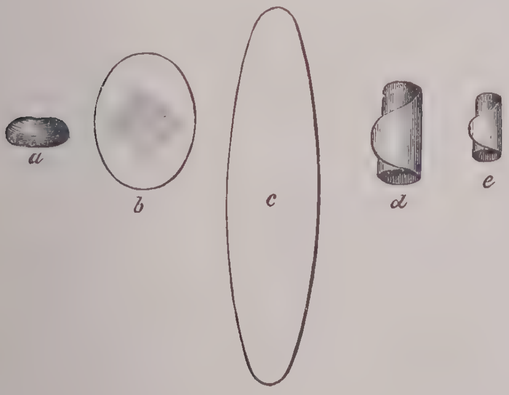

FIG. 11.

(5.) The cornets are annealed, separately, in little clay crucibles, or in the platinum cups in which they have been boiled, by heating them to bright redness. They then diminish considerably in bulk as *e* (fig. 11), and are of a pure yellow color.

(6.) The cornets are then weighed in comparison with "check assays" made on pure gold. These "checks" are necessary, as the accuracy of the result of an assay is liable to be affected either by retention of silver or copper, or by loss of gold by volatilization in the muffle, solution in the acid, or retention in the cupel. The weight of gold, therefore, indicated by the balance, may be either less or greater than the amount originally present in the alloy. The correction to be applied to a gold assay will be evident from the following formula:[4]—

1000 be the weight of alloy originally taken;
p the weight of the piece of gold finally obtained;
x the actual amount of gold in the alloy expressed in thousandths;
a the weight of gold (supposed to be absolutely pure) taken as a check, which approximately equals x;
b the loss or gain in weight experienced by a during the process of assay, expressed in thousandths;
k the variation of "check gold" from absolute purity, expressed in thousandths;

then the actual amount of fine gold in the check-piece $= a\left(1 - \frac{k}{1000}\right)$, and x the corrected weight of the assay will $= p - \frac{a\,k}{1000} \pm b$; b being added or subtracted according as it is a loss or gain.

If a be assumed to be equal to x this equation becomes

$$x = \frac{p \pm b}{1 + \frac{k}{1000}}.$$

Example.—Let $p = 901{\cdot}1$ thousandths.
$a = 920{\cdot}0$ "
$b = 0{\cdot}3$ " gain in weight.
$k = 0{\cdot}1$ "

Then by the first formula—

$$x = 901{\cdot}1 - \frac{920 \times 0{\cdot}1}{1000} - 0{\cdot}3;$$

For, as b is a gain in weight, it must be deducted, hence

$$x = 901{\cdot}1 - 0{\cdot}092 - 0{\cdot}3$$
$$= 900{\cdot}708.$$

And by the second formula—

$$x = \frac{901{\cdot}1 - 0{\cdot}3}{1 + \frac{0{\cdot}1}{1000}}$$
$$= 900{\cdot}708$$

Assay of Gold Ores.—500 grains of the finely powdered sample, which must be taken with the greatest care and accuracy, is passed through a sieve of fine wire gauze with at least 80 meshes to the linear inch. Any residue there may be of flattened particles of gold is set aside for subsequent treatment, usually by direct cupellation. Assay of the ore by *fusion with litharge* is best suited to ores which do not contain much iron pyrites. For auriferous quartz 500 grains of the ore are fused with 500 grains of red lead, 300 grains of sodic carbonate, 20 grains of powdered charcoal, and 250 grains of borax. The mixture is introduced into a clay crucible, which it should half fill, and is fused in an air furnace. The button of reduced lead may be removed, either by pouring the contents of the crucible into a mould, or by breaking the crucible when cold. If the ore contains much iron pyrites or is of the nature of "sweep," the name given to carbonaceous residues which accumulate in mints and goldsmiths' shops, it will be necessary to roast it in a shallow fire-clay dish placed in a muffle. In the case of pyrites containing about 7 dwts. to the ton, the operation would be conducted on about 1000 grains. The roasted ore is then fused with about the same mixture of fluxes as has been given for quartz.

Assay by Scorification.—Scorification resembles cupellation, but the oxide of lead produced in the operation, instead of sinking into a porous cup, is held in a flat saucer of fire-clay, and dissolves the earthy constitutents of the ore, leaving the precious metal to pass into another portion of lead which remains in the metallic state. About 200 grains of the roasted ore are placed in the scorifier, intimately mixed with 500 grains of granulated and 50 grains of borax lead; 500 grains of lead are then distributed over the surface of the mixture; the contents of the scorifier are fused in a muffle; air is admitted to oxidize the greater portion of the lead; and, at the conclusion of the operation, the litharge should be perfectly fluid and cover the molten lead. The slag may be freed from particles of precious metal by the addition at the conclusion of the operation of a small quantity of powdered anthracite, which reduces a portion of the litharge to metallic globules, which fall through the slag and unite with the lead button. The gold is then separated by cupellation, and the silver with which it is nearly always associated is removed by parting in nitric acid.

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[1] Bodemann's *Anleitung zur Berg- und Hüttenmännischen Probierkunst*, 2d ed., 1856, p. 360.

[2] *Gold-Probirverfahren*, p. 3.

[3] *Dingl. Polytech. Journ.*, 206, p. 185.

[4] *Fourth Annual Report of the Deputy-Master of the Mint*, 1873, p. 42.

Assay by means of the Spectroscope.—Lockyer and Roberts[1] state, as the result of a careful spectroscopic investigation of the alloys of gold and copper, that it is possible to distinguish between alloys of these metals which only differ in proportion by $\frac{1}{10000}$th part. Their experiments have been repeated in America by A. E. Outerbridge.[2] (W. C. R.—H. B.)

It will be convenient to give here, in connection with the article GOLD, rather than in their proper alphabetical place, the articles GOLDBEATING and GOLD LACE.

GOLDBEATING. The art of goldbeating is of great antiquity, being referred to by Homer; and Pliny states that one ounce of gold was extended to 750 leaves, each leaf being four fingers square, which is three times the thickness of the ordinary leaf gold of the present time. In all probability the art originated among Oriental communities, where the working of gold and the use of gold ornaments have been distinguishing characteristics from the most remote periods; and in India goldbeating is still carried on as a craft involving many mysteries and great difficulties. On the coffins of the Theban mummies specimens of original leaf-gilding are met with, where the gold is in so thin a state that it resembles modern gilding. The Incas of Peru do not appear to have been able to reduce gold further than to plates which could be nailed for ornamentation on the walls of their temples. In England goldbeating was confined to London until within the present century. It was introduced into Scotland and the United States within that period, and it is now practised in most towns of any considerable size; but so far as concerns Great Britain it is principally centred in London. One grain of gold has been beaten out to the extent of 75 square inches, and the same weight of silver to 98 square inches. Taking a cubic inch of gold at 4900 grains, this gold-leaf is the 367,650th part of an inch in thickness, or about 1200 times thinner than ordinary printing paper. The silver, though spread over a larger surface, was thicker, owing to the difference in its specific gravity; but, calculated by weight, silver is the most malleable metal with which we are acquainted, in that respect considerably exceeding gold. This experiment does not, however, determine the extent of the malleability of either metal, as the means employed to test it were found to fail before there was any appearance of the malleability of the metals being exhausted. In practice the average degree of tenuity to which the gold is reduced is not nearly so great as the example above quoted. A "book of gold" containing 25 leaves measuring each 3¼ inches, equal to an area of 264 square inches, generally weighs from 4 to 5 grains.

The gold used by the goldbeater is variously alloyed, according to the variety of color required. Fine gold is commonly supposed to be incapable of being reduced to thin leaves. This, however, is not the case, although its use for ordinary purposes is undesirable on account of its greater cost. It also adheres on one part of a leaf touching another, thus causing a waste of labor by the leaves being spoiled; but for work exposed to the weather it is much preferable, as it is more durable, and does not tarnish or change color. The external gilding on many public buildings, such, *e. g.*, as the Albert Memorial in Hyde Park, London, is done with pure gold. The following is a list of the principal classes of leaf recognized and ordinarily prepared by British beaters, with the proportions of alloy per ounce they contain.

Name of Leaf.	Proportion of Gold.	Proportion of Silver.	Proportion of Copper.
	Grains.	Grains.	Grains.
Red	456–460	...	20–24
Pale red	464	...	16
Extra deep	456	12	12
Deep	444	24	12
Citron	440	30	10
Yellow	408	72	...
Pale yellow	384	96	...
Lemon	360	120	...
Green or pale	312	168	...
White	240	240	...

The process of goldbeating is thus conducted. The gold, having been alloyed according to the color desired, is melted in a crucible, at a higher temperature than is simply necessary to fuse it, as its malleability is improved by exposure to a greater heat; sudden cooling does not interfere with its malleable properties, gold differing in this respect from some other metals. It is then cast into an ingot, and flattened, by rolling between a pair of powerful smooth steel rollers, into a ribbon of 1½ inch wide and 10 feet in length to the ounce. After being flattened it is annealed and cut into pieces of about 6½ grs. each, or about 75 per ounce, and placed between the leaves of a "cutch," which is about half an inch thick and 3½ inches square, containing about 180 leaves of a tough paper manufactured in France. Formerly fine vellum was used for this purpose, and generally still it is interleaved in the proportion of about one of vellum to 6 of paper. The cutch is beaten on for about 20 minutes with a 17-pound hammer, which rebounds by the elasticity of the skin, and saves the labor of lifting, by which the gold is spread to the size of the cutch; each leaf is then taken out, and cut into four pieces, and put between the skins of a "shoder," 4½ inches square and ¾ths of an inch thick, containing about 720 skins, which have been worn out in the finishing or "mould" process. The shoder requires about two hours' beating upon with a 9-pound hammer. As the gold will spread unequally, the shoder is beaten upon after the larger leaves have reached the edges. The effect of this is that the margins of larger leaves come out of the edges in a state of dust. This allows time for the smaller leaves to reach the full size of the shoder, thus producing a general evenness of size in the leaves. Each leaf is again cut into four pieces, and placed between the leaves of a "mould," composed of about 950 of the finest gold-beaters' skins, five inches square and three-quarters of an inch thick, the contents of one shoder filling three moulds. The material has now reached the last and most difficult stage of the process; and on the fineness of the skin and judgment of the workman the perfection and thinness of the leaf of gold depend. During the first hour the hammer is allowed to fall principally upon the centre of the mould. This causes gaping cracks upon the edges of the leaves, the sides of which readily coalesce and unite without leaving any trace of the union after being beaten upon. At the second hour, when the gold is about the 150,000th part of an inch in thickness, it for the first time permits the transmission of the rays of light. In pure gold, or gold but slightly alloyed, the green rays are transmitted; and in gold highly alloyed with silver, the pale violet rays pass. The mould requires in all about four hours' beating with a 7-pound hammer, when the ordinary thinness for the gold leaf of commerce will be reached. A single ounce of gold will at this stage be extended to 75 × 4 × 4 = 1200 leaves, which will trim to squares of about 3¼ inches each. The finished leaf is then taken out of the mould, and the rough edges are trimmed off by slips of the ratan fixed in parallel grooves of an instrument called a wagon, the leaf being laid upon a leathern cushion for that purpose. The sizes to which British leaf is cut are 3, 3⅛, 3¼, 3⅜, and 3½ inches. The leaves thus prepared are placed into "books" capable of holding 25 leaves each, which have been rubbed over with red ochre to prevent the gold clinging to the paper. The leaf is used for gilding picture frames, and for other ornamental purposes. See GILDING.

The fine membrane called goldbeaters' skin, used for making up the shoder and mould, is the outer coat of the cæcum or blind gut of the ox. It is stripped off in lengths about 25 or 30 inches, and freed from fat by dipping in a potash solution and scraping with a blunt knife. It is afterwards stretched on a frame; two membranes are glued together, treated with a solution of aromatic substances or camphor in isinglass, and subsequently coated with white of egg. Finally they are cut into squares of 5 or 5½ inches; and to make up a mould of 950 pieces the gut of about 380 oxen is required, about 2½ skins being got from each animal. A skin will endure about 200 beatings in the mould, after which it is fit for use in the shoder alone.

The dryness of the cutch, shoder, and mould is a matter of extreme delicacy. They require to be hot-pressed every time they are used, although they may be used daily, to remove the moisture which they acquire from the atmosphere, except in extremely frosty weather, when they acquire so little moisture that then a difficulty arises from their over-dryness, whereby the brilliancy of the gold is diminished, and it spreads very slowly under the hammer. On the contrary, if the cutch or shoder be damp, the gold will become that which is technically termed hollow or sieve-like; that is, it is pierced with innumerable microscopical holes; and in the moulds in its more attenuated state it will become reduced to a pulverulent state. This condition is more readily produced in alloyed golds than in fine gold. It is necessary that each skin of the mould should be rubbed over with calcined gypsum (the fibrinated variety) each time the mould may be used, in order to prevent the adhesion of the gold to the surface of the skin in beating. Dentist gold is gold leaf carried no further than the cutch stage, and should be perfectly pure gold.

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[1] *Phil. Trans.* 1874, vol. clxiv. p. 495.

[2] *Journal of the Franklin Institute*, 1874.

By the above process also silver is beaten, but not so thin, the inferior value of the metal not rendering it commercially desirable to bestow so much labor upon it. Copper, tin, zinc, palladium, lead, cadmium, platinum, and aluminium can be beaten into thin leaves, but not to the same extent as gold or silver.

GOLD AND SILVER LACE. Under this heading a general account may be given of the use of the precious metals in textiles of all descriptions into which they enter. That these metals were used largely in the sumptuous textiles of the earliest periods of civilization there is abundant testimony; and to this day, in the Oriental centres whence a knowledge and the use of fabrics inwoven, ornamented, and embroidered with gold and silver first spread, the passion for such brilliant and costly textiles is still most strongly and generally prevalent. The earliest mention of the use of gold in a woven fabric occurs in the description of the ephod made for Aaron (Exod. xxxix. 2, 3)—"And he made the ephod of gold, blue, and purple, and scarlet, and fine twined linen. And they did beat the gold into thin plates, and cut it into wires (strips), to work it in the blue, and in the purple and in the scarlet, and in the fine linen, with cunning work." In both the *Iliad* and the *Odyssey* distinct allusion is frequently made to inwoven and embroidered golden textiles. Many circumstances point to the conclusion that the art of weaving and embroidering with gold and silver originated in India, where it is still principally prosecuted, and that from one great city to another the practice travelled westward,—Babylon, Tarsus, Baghdad, Damascus, the islands of Cyprus and Sicily, Constantinople and Venice, all in the process of time becoming famous centres of these much prized manufactures. Alexander the Great found Indian kings and princes arrayed in robes of gold and purple; and the Persian monarch Darius, we are told, wore a war mantle of cloth of gold, on which were figured two golden hawks as if pecking at each other. There is reason, according to Josephus, to believe that the "royal apparel" worn by Herod on the day of his death (Acts xii. 21) was a tissue of silver. Agrippina, the wife of the emperor Claudius, had a robe woven entirely of gold, and from that period downwards royal personages and high ecclesiastical dignitaries used cloth and tissues of gold and silver for their state and ceremonial robes, as well as for costly hangings and decorations. In England, at different periods, various names were applied to cloths of gold, as ciclatoun, tartarium, naques or nac, baudekin or baldachin, Cyprus damask, and twssewys or tissue. The thin flimsy paper known as tissue paper is so called because it originally was placed between the folds of gold "tissue" to prevent the contiguous surfaces from fraying each other. At what time the drawing of gold wire for the preparation of these textiles was first practised is not accurately known. The art was probably introduced and applied in different localities at widely different dates, but down till mediæval times the method graphically described in the Pentateuch continued to be practised with both gold and silver.

Fabrics woven with gold and silver continue to be used on the largest scale to this day in India; and there the preparation of the varieties of wire, and the working of the various forms of lace, brocade, and embroidery, is at once an important and peculiar art. The basis of all modern fabrics of this kind is wire, the "gold wire" of the manufacturer being in all cases silver gilt wire, and silver wire being, of course, composed of pure silver. In India the wire is drawn by means of simple draw-plates, with rude and simple appliances, from rounded bars of silver, or gold-plated silver, as the case may be. The wire is flattened into the strip or ribbon-like form it generally assumes by passing it, fourteen or fifteen strands simultaneously, over a fine, smooth, round-topped anvil, and beating it as it passes with a heavy hammer having a slightly convex surface. From wire so flattened there is made in India *soniri*, a tissue or cloth of gold, the web or warp being composed entirely of golden strips, and *ruperi*, a similar tissue of silver. Gold lace is also made on a warp of thick yellow silk with a weft of flat wire, and in the case of ribbons the warp or web is composed of the metal. The flattened wires are twisted around orange (in the case of silver, white) colored silk thread, so as completely to cover the thread and present the appearance of a continuous wire; and in this form it is chiefly employed for weaving into the rich brocades known as kincobs or kinkhábs. Wires flattened, or partially flattened, are also twisted into exceedingly fine spirals, and in this form they are the basis of numerous ornamental applications. Such spirals drawn out till they present a waved appearance, and in that state flattened, are much used for rich heavy embroideries termed karchobs. Spangles for embroideries, etc., are made from spirals of comparatively stout wire, by cutting them down ring by ring, laying each C-like ring on an anvil, and by a smart blow with a hammer flattening it out into a thin round disk with a slit extending from the centre to one edge. Fine spirals are also used for general embroidery purposes. The demand for various kinds of loom-woven and embroidered gold and silver work in India is immense; and the variety of textiles so ornamented is also very great. "Gold and silver," says Dr. Birdwood in his *Handbook to the British-Indian Section, Paris Exhibition*, 1878, "are worked into the decoration of all the more costly loom-made garments and Indian piece goods, either on the borders only, or in stripes throughout, or in diapered figures. The gold-bordered loom embroideries are made chiefly at Sattara, and the gold or silver striped at Tanjore; the gold figured *mashrus* at Tanjore, Trichinopoly, and Hyderabad in the Deccan; and the highly ornamented gold-figured silks and gold and silver tissues principally at Ahmedabad, Benares, Murshedabad, and Trichinopoly."

Among the Western communities the demand for gold and silver lace and embroideries arises chiefly in connection with naval and military uniforms, court costumes, public and private liveries, ecclesiastical robes and draperies, theatrical dresses, and the badges and insignia of various orders. To a limited extent there is a trade in gold wire and lace to India and China. The metallic basis of the various fabrics is wire round and flattened, the wire being of three kinds—1st, gold wire, which is invariably silver gilt wire; 2d, copper gilt wire, used for common liveries and theatrical purposes; and 3d, silver wire. These wires are drawn by the ordinary processes, and the flattening, when done, is accomplished by passing the wire between a pair of revolving rollers of fine polished steel. The various qualities of wire are prepared and used in precisely the same way as in India,—round wire, flat wire, thread made of flat gold wire twisted round orange-colored silk or cotton, known in the trade as "orris," fine spirals and spangles, all being in use in the West as in the East. The lace is woven in the same manner as ribbons, and there are very numerous varieties in richness, pattern, and quality. Cloth of gold, and brocades rich in gold and silver, are woven for ecclesiastical vestments and draperies.

The proportions of gold and silver in the gold thread for the lace trade varies, but in all cases the proportion of gold is exceedingly small. An ordinary gold lace wire is drawn from a bar containing 90 parts of silver and 7 of copper, coated with 3 parts of gold. On an average each ounce troy of a bar so plated is drawn into 1500 yards of wire; and therefore about 16 grains of gold cover a mile of wire. It is estimated that about 250,000 ounces of gold wire are made annually in Great Britain, of which about 20 per cent. is used for the headings of calico, muslin, etc., and the remainder is worked up in the gold lace trade.

GOLDAST, Melchior Haiminsfeld (1576–1635), an historical writer and collector whose works did great service to the study of the older documents of Germany, was born, January 6, 1576 (or 1578), of poor Protestant parents, near Bischofzell in Thurgau. His university career at Ingoldstadt and Altdorf was cut short by his poverty; but at length, in 1603, after he had spent some time at St. Gall and Geneva, partly suppported by the learned and benevolent jurist Bartholomeus Schobinger, he obtained the post of secretary to Henry, duke of Bouillon, and with him he went to Heidelberg and Frankfort-on-the-Main. But Goldast, though able and laborious, had fallen into an unsettled way of life, and in 1604 we find him in the service of the Baron Hohensax—then the possessor of that unique manuscript of old German poems which now forms one of the treasures of the National Library at Paris, and which Goldast was the first to make partially accessible by the press. Before long he was back in Switzerland, and by 1606 he was again in Frankfort living by his pen, and finding his efforts to obtain a regular post frustrated by Lipsius and Scioppius, whom he had offended by his outspokenness. In 1611 he was appointed councillor at the court of Saxe Weimar; in 1615 he entered the service of the count of Schaumburg at Bückeburg, and in 1625 returned to Frankfort. As the transport of his books from Bückeburg to Frankfort was attended with danger, owing to the warlike operations then on foot, he entrusted them to the town of Bremen, and they now form part of the municipal library. Appointed in 1627 councillor to the emperor and to the elector of Treves, Goldast soon after passed into the service of the landgrave of Hesse-Darmstadt, who raised him to be chancellor of the university of Giessen. He died at Giessen in the beginning of 1635. Nothing perhaps proves the value of Goldast's labors better than the fact that, in consideration of the service he has rendered, the modern historical and philological investigator is willing to condone the almost unpardonable sin of direct literary forgery of which he has been accused and convicted.

Among his more important works are his *Paræneticorum veterum* (Lille, 1604), which contained the *Kunig Tyro von Schottland*, the *Winsbeken*, and the *Winsbekin*; *Rerum Alamannicarum Scriptores*, Frankf. 1606, 3 vols., new ed. by Senckenberg, *ibid.*, 1730; *Monarchia S. Romani imperii*, Frankf. 1621; *Commentarii de regno Bohemiæ*, Hanover, 1627, new ed. by H. Schmink, Frankf. 1719. He edited the works of Pirkheimer and De Thou; and a volume of correspondence, *Virorum Cll. ad Goldastum epistolæ*, was published in 1688. See Senckenberg's *Goldasti Memoria*, prefixed to *Rer. Alamann. Scrip.*, 1730; Bayle's *Dictionary*; and Von Raumer, *Geschichte der germanischen Philologie*, Munich, 1870.

GOLDBERG, a town in the Prussian province of Silesia, capital of a circle in the government district of Liegnitz, is situated 14 miles S. W. of that town, on the Katzbach, an affluent of the Oder. The principal buildings are an old church dating from the beginning of the 13th century, the Schwabe-Priesemuth institution, completed in 1876, for the board and education of orphans, and the gymnasium, which in the 17th century enjoyed great prosperity, and numbered Wallenstein among its pupils. The chief manufactures are woollen cloth, flannel, gloves, stockings, leather, and beer, and there is a considerable trade in corn and fruit. Goldberg owes its origin and name to a gold mine in the neighborhood, which, however, has been wholly abandoned since the time of the Hussite wars. Population (1875), 6492.

The town suffered heavily from the Tartars in 1241, from the plague in 1334, from the Hussites in 1428, and from the Saxon, imperial, and Swedish forces during the Thirty Years' War. On 27th May, 1813, a battle took place near it between the French under Macdonald and the rear guard of the Russians under Wittgenstein; and on the 23d August of the same year a skirmish, in which Macdonald suffered defeat from the Prussians under Blücher.

GOLD COAST, a British colony in western Africa, reconstituted on the 24th of July, 1876, by a royal charter which defines it as consisting of two settlements—(1.) the Gold Coast proper, comprising "all places, settlements, and territories which may at any time belong to us in Western Africa, between the fifth degree of west longitude and the second degree of east longitude; and (2.) the settlement of Lagos, similarly comprising all possessions between the second and fifth degrees of east longitude." The charter appoints a governor, establishes a legislative and an executive council, and authorizes the appointment of judges and other legal officers, etc. Both the Gold Coast colony and Lagos had previously been administered by lieutenant-governors dependent on the governor of Sierra Leone; and the two divisions are still sufficiently distinct to require separate treatment.

By Bosman, the Dutch factor at Elmina in the beginning of the 18th century, the Gold Coast is said to extend "about 60 miles, beginning with the Gold River, 3 miles west of Assini, or 12 miles above Axim, and ending with the village Ponni, 7 or 8 miles east of Acra."[1] In modern times, Cape Apollonia (2° 35′ W. long.) being accepted as the western boundary, and the mouth of the Volta river (0° 41′ 2″ E. long.) as the eastern, the whole coast measures about 225 miles, and this is divided into two sections, the windward or western and the leeward or eastern, the boundary between the two being the Secoom river (0° 3′ 2″ W. long.). Beginning at the west, the first places on the coast that deserve to be mentioned are Grand Bassam and Assini, both French settlements up to 1870. The mouth of the river Assini forms the outlet of a series of lagoons, the eastmost of which is fed by a considerable river—the Tanno or Tando. About 55 miles eastward from this point are the Four Hills or Hummocks of Apollonia, where the English formerly had a fort; and about 20 miles from Apollonia is the mouth of the Ankobne. Three miles further and we come to Axim, the site of an old Dutch fort built near the mouth of the Axim river; and other 20 miles and we reach Great Friedrichsburg, founded by the Brandenburg Company. Rounding Cape Three Points (2° 7′ W. long.), whose vicinity is marked by a line of breakers nearly 2½ miles long, the first place of importance that we find is Akodah or Aquidah, and 10 miles beyond Akodah lies the better known Dixcove or Dick's Cove. From Dixcove Pompendi is distant 10 miles, and other 12 or 13 miles brings us to Secondee, which is only 8 or 9 miles from the mouth of the Busum (or Sacred) Prah. With the exception of the Volta this is the largest river of the Gold Coast; it is on one of its sub-tributaries that Coomassee is situated. At the mouth of the Beyah, 19 or 20 miles eastward, stands Elmina, or in the native language Edenã, one of the most important posts of European settlement, with a native population of some 10,000 (see ELMINA). Eight miles east of Elmina is Cape Coast Castle, which was the capital of the British territory until 1876. Anamaboe, 10 miles distant, is a town of some 4000 or 5000 inhabitants, with a free port and a good landing-place; and about 38 miles further on we come to Winnebah, which up till 1812 was the seat of an English fort. About 11 miles eastward there is another abandoned fort at Barrocoe; and at Barrocoe we are only 23 miles from Acra or Accra (in Tshi Nkran), the present capital of the Gold Coast colony. It was selected instead of Cape Coast Castle on account of its comparatively healthy position. In the words of Dr. A. F. Elliot, it is the healthiest station on the west coast of Africa, being surrounded for miles by fresh undulating ground, and backed at the distance of a day's journey, or about 30 miles, by a range of hills where Europeans can recruit. A sanitary station has been fixed at Akropong, 1800 feet above the sea-level, where the Basel missionaries have their headquarters. About 2 miles east of Acra is the old Danish fort of Christiansborg. There is no station of much importance except Tassi, Ponce, and Great Ningo or Ningua, in the 60 miles between Acra and the Volta. The Volta, otherwise known as the Firaw, the Shilao, or the Amu, is a large river, the course of which has been only partially explored, but which may be expected to furnish a means of opening up the interior. In December, 1875, M. M. J. Bonnat, journeying partly by water and partly by land, proceeded as far as Salaha or Paraha, a commercial town of some 18,000 inhabitants. He reports that the Labelle rapids, though 25 feet high, can be ascended by steamers during the rains in September and October, because at that season the river rises 50 feet. The lower part of the course is of difficult navigation in the dry season owing to the shallows. Addah, on the right bank of the river near its mouth; Quittah, the seat of a British fort; and Jellah Coffi, a trading port, are the principal places on the coast between the Volta and Flouhow, which lies at the eastmost extremity of the Volta lagoon. According to the ordinary divisions we enter the Slave Coast when we proceed east of the Volta.

Such are the chief points of interest along the Gold Coast, but there is a considerable range of territory extending from 20 to 60 miles inland, which belongs to the colonial protectorate: and about this a few words are necessary. The western portion of the protectorate is occupied by the woody hill country of Fanti, which stretches northwards towards Ashantee. From the mouth of the Secoom a fine range varying in height from 1200 to 1500 or 1600 feet stretches N. N. E., and divides the eastern portion into two halves. Between the mountains and the sea there are large stretches of prairie land, in which the grass grows to a height of 10 or 12 feet.

The inhabitants of the Gold Coast may be divided into two great classes, the Tshi or Chee, a black type, and the Acra, a red type. The Fantis and Ashantis, both belonging to the former class, have already been described in ASHANTEE. The Akems live in a thick forest region, and maintain existence by hunting, gold-digging, and the gathering of wood snails. The capital of their country is Kyebi.[1] The Aquapems are extensively engaged in agriculture and in trade, both with the other tribes and with Europeans. The Ga or Acra, a clever race, greatly modified by contact with European culture, are to be found in all the towns of the West African coast as artisans and sailors. They are employed by the interior tribes as middle men and interpreters. On the right bank of the Volta are the Adangme[2] or Adampe, distinguished by strength and rudeness. The Crobos live in little villages in the midst of the palm tree woods which grow round about the Croboberg, an eminence about 1000 feet high,

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[1] See *Nauwkeurige Beschryving van de Guinese Goud-Tand-en Slave Kust*, Amsterdam, 1709 (frequently translated).

The Tshi or Chee language[3] belongs to the great prefix-pronominal group. It comprises many dialects, which may, however, be reduced to two classes or types.[4] Akan dialects are spoken in Assini, Amanahia (Apollonia), Awini, Ahanta, Wasaw, Tshuforo (Juffer or Tufel), and Denkyera in the west, and in Asen, Akem, and Aquapem in the east, as well as in the different parts of Ashantee. Fante dialects are spoken, not only in Fanti proper, but in Afutu or the country round Cape coast, in Abora, Agymako, Akomfi, Gomoa, and Agona. The difference between the two types is not very great; a Fanti, for example, can converse without much difficulty with a native of Aquapem or Ashantee, his language being in fact a deteriorated form of the same original. Akem is considered the finest and purest of all the Akan dialects. The Aquapem, which is based on the Akem but has imbibed Fanti influences, has been made the book-language by the Basel missionaries. About a million people in all, it is estimated, speak dialects of the Tshi. The south-eastern corner of the Gold Coast is occupied by another language known as the Ga or Acra, which comprises the Ga proper and the Adangme and Crobo dialects. Ga proper is spoken by about 40,000 people, including the inhabitants of Ga and Kinkã (*i. e.*, Dutch and British Acra, in Tshi, Nkran, and Kankan), Osu (*i. e.*, Christiansborg), La Tessi, Ningua, and numerous inland villages. It has been reduced to writing by the missionaries. The Adangme and Crobo dialects are spoken by about 80,000 people. They differ very considerably from Ga proper, but books printed in Ga can be used by both the Crobo and Adangme natives. Another language known as Guan is used in parts of Aquapem and in Anum beyond the Volta; but not much is known either about it or the Obutu tongue spoken in a few towns in Agona, Gomoa, and Akomfi. The dialects of the Ahanta country have still to be investigated.[5]

Mahometanism and Christianity are both making themselves felt to some extent among the natives of the Gold Coast. A Danish mission was started at Christiansborg about 1736 by Protten and Huckoff, the Moravian Brethren. In 1835 the Wesleyan mission began its labors among the Fanti. The Basel missionaries had made a start in 1828, but it was not till 1835 that they were fairly settled at Akropong, the capital of Aquapem. They now have stations also at Kyebi, at Kukurantimy, at Abune, at Abokoli, at Addah, and at Acra, and the leaders of the English expedition against the Ashantees speak very highly of their labors.

The climate of the Gold Coast is notoriously unhealthy. At Cape Coast Castle the thermometer ranges from 72° to 85° or 90°, and the amount of moisture in the atmosphere is very great. Not only are the coasts in many places lined with swamps and lagoons, but, according to Dr. Gordon, the very basis rock of the country—a granite in which iron ore and hornblende are present—gives off under the influence of the air and the rain large quantities of sulphuretted hydrogen gas. The native towns are populous and dirty, and to add to the evil it was, until the prohibition of the British authorities (at Elmina by Colonel Festing, and at Cape Coast by Governor Strahan), the custom to bury the dead in the floors of the houses. Intermittent fevers, remittent fevers (the so-called coast fever is of this class), and dysentery are the diseases most to be dreaded by the European. "The native inhabitants," says Marcus Allen, "appear to enjoy tolerable health and to live to an average age; but in the rainy season it is not uncommon to find them suffering from pleuritis and pneumonia, rheumatic attacks, bronchitis, and catarrh."

Though the precious dust to which the Gold Coast owes its name is no longer obtained in any considerable quantities by the rude methods of collection employed by the natives, there is abundant proof that the whole region is more or less auriferous, and it is possible that European energy and skill might make it again a real gold coast. In some parts of the country—in the neighborhood of the Volta, for example—the surface of the ground is broken by innumerable small pits dug by the native miners.[6] At present the value of the territory is mainly due to the profusion of vegetable products supplied by the rich alluvial soil. Of the timber trees which abound in the vast stretches of forest, the best known are several species of the genus *bombax* (silk cotton tree, etc.), from which canoes and wooden wares are manufactured, and the odoom used for building and cabinet-work. The cocoanut and the palm oil are common along the coast, and the bread-fruit tree has been introduced with success at Napoleon. Indian corn, yams, cassava, sweet potatoes, tiger-nuts, ground-nuts (*Arachis hypogœa*), Guinea corn (*Sorghum vulgare*), Guinea grains (*Amomum grana-paradisi*), the egg-plant (*Solanum ovigerum*), bennie seed, oranges, limes, shaddocks, pineapples, ginger, and indigo are some of the many objects of cultivation. Nor must the kola nut be forgotten (*Sterculia acuminata*), variously styled colat, khola, and in older writers gura or gouroo; for it is the favorite substitute in Western Africa for the betel nut, and forms an important article of export. Both tobacco and cotton are indigenous, but neither is cultivated by the natives. Coffee and tobacco are grown by the missionaries at Akropong.

The exports are mainly gold dust, palm oil, and palm kernels; and the imports, in exchange, dry goods from the United Kingdom, and tobacco and spirits from America. In 1875 and 1876 the exports were respectively of the value of £327,012 and £465,268; and the corresponding imports amounted to £364,672 and £446,088. The revenue of the Gold Coast, mainly derived from customs duties, was £67,368 in 1875, and £64,788 in 1876; the corresponding expenditures were £67,368 for 1875, and £93,944 for 1876. There is no public debt.

The jurisdiction of England on the Gold Coast was defined by the bond of the 6th of March, 1844, an agreement with the native chiefs by which Her Majesty receives the right of trying criminals and repressing human sacrifices, pannyaring, etc. The limits of the protectorate inland were not very rigidly defined. The purchase of the Danish forts in 1851, and of the Dutch forts and territory in 1871, led to the consolidation of the British power along the coast; and the Ashantee war of 1873–74 resulted in the extension of the area of British influence towards the interior. By the royal ordinances of December, 1874, the selling, buying, or dealing in slaves was declared unlawful, and no person can any longer be put in pawn for debt; but those who were actually slaves at that date are left in the same state, except where cruelty can be proved against the masters.

See *The Golden Coast or a Description of Guinney, together with a relation of such persons as got wonderful estates by their trade thither*, London, 1665; James Horton, *Medical Topography of the West Coast of Africa*, London, 1859, *Physical and Medical Climate*, London, 1867, and *Letters on the Political Condition of the Gold Coast*, London, 1870; Otto Finsch, "Die Goldküste und ihre Bewohner in ihrem heutigem Zustande," in *Zeitsch. für allg. Erdkunde*, Berlin, 1864; *Wanderings in West Africa, by a F. R. G. S.* (*i. e.*, Captain Burton), London, 1863; Marcus Allen, *The Gold Coast*, London, 1874; Charles A. Gordon, *Life on the Gold Coast*, London, 1874; Captain Croft, "Exploration of the River Volta," in *Proc. Roy. Geog. Soc.*, Lond., 1874; P. Wurm, "Anfänge der Basler Mission auf der Goldküste," in *Evangelisches Missions-Magazin*, 1874; E. Buhl, "Die Basler Mission auf der Goldküste." *Ibid.*, 1877. The following maps are of service:—J. Wyld, Map of *British Possessions on the Gold Coast*, London, 1873; *Die Goldküste nach den Arbeiten der Missionaire A. Riis*, etc., Basel and Stuttgart, 1873; and E. Stanford, *Map of the Gold Coast*, etc., 1873.

GOLDEN BULL (Latin, BULLA AUREA) is, in general, the designation of any charter decorated with a golden seal or *bulla*, either from the intrinsic importance of its contents, or from the rank and dignity of the bestower or the recipient. The custom of thus giving distinction to certain documents is said to be of Byzantine origin, though if this be the case it is somewhat strange that the word employed as an equivalent for golden bull in Byzantine Greek should be the hybrid *χρυσόβουλλον* (*cf.* Codinus Curopalates, *ὁ μέγας λογοθέτης διατάττει τὰ παρὰ τοῦ βασιλέως ἀποστελλόμενα προστάγματα καὶ χρυσόβουλλα πρὸς τε Ῥήγας, Σούλτανας, καὶ τοπάρχους*; and Anna Comnena, *Alexiad*, lib. iii., *διὰ χρυσο-*

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[1] See an interesting paper by Captain Hay, "On the District of Akem in West Africa," in *Journ Roy. Geogr. Soc.*, London, 1876.

[2] Adangme = Adan-gbe, *i. e.* Adah language, so called from the town of Ada or Addah on the Volta.

[3] This name appears in a great variety of forms—Kwi, Ekwi, Okwi, Oji, Odschi, Otsui, Tyi, Twi, Tshi, Tschi, Chwee, or Chee.

[4] See Rev. J. G. Christaller, *A Grammar of the Ashantee and Fante Language called Tshi*, Basel, 1875.

[5] See D. L. Carr and F. P. Brown, *Mfantsi* (*i. e.* Fanti) *Grammar*, Cape Coast, 1868; Zimmermann, *Grammatical Sketch and Vocabulary of the Akra or Ga language* Stuttgart, 1858; and *A Dictionary, English, Tshi, Akra*, by Christaller, Locher, and Zimmermann, Basel, 1874.

[6] For many interesting details on the gold of the Gold Coast, see the chapter specially devoted to the subject in Burton's *Wanderings in West Africa*.

βουλλίου λόγου; lib. viii., *χρυσόβουλλον λόγον*). In Germany a Golden Bull is mentioned under the reign of Henry I. in *Chronica Cassin.*, ii. 31, and the oldest German example, if it be genuine, dates from 983. At first the golden seal was formed after the type of a solid coin, but at a later date, while the golden surface presented to the eye was greatly increased, the seal was really composed of two thin metal plates filled in with wax. The number of golden bulls issued by the imperial chancery must have been very large; the town of Frankfort, for example, still preserves no fewer than eight. But the name has become practically restricted to a few documents of unusual political importance, the golden bull of the Empire, the golden bull of Brabant, the golden bull of Hungary, and golden bull of Milan—and of these the first is undoubtedly *the* golden bull *par excellence*.

It was drawn up under the direction of the emperor Charles IV., and it was formally ratified in 1356,—the first twenty-three chapters by the diet of Nuremberg (10th January), and the remaining seven by the diet of Metz (25th December). The actual redaction has been assigned to Bartolus de Saxoferrato, to Rudolf of Friedberg the imperial secretary, and even to the emperor himself; but there is no distinct authority for any of the three hypotheses as opposed to the others. A brief statement of the general purpose of its enactments has already been given at page 444 of the present volume. The exordium is a strangely rhetorical lamentation over the miseries of division, and more especially of a kingdom divided against itself; and the body of the document gives a survey of the duties, privileges, and relations of the various dignitaries of the empire, the emperor, the electors ecclesiastical and secular, the electoral plenipotentiaries, and the officers of the court. As might almost be expected, a large place is given to rules of ceremony and etiquette. At first the document was known simply as the Lex Carolina; but by and by the name of the Book with the Golden Bull came into use, and the present elliptical title was sufficiently established by 1417 to be officially employed in a charter by King Sigismund. The original autograph was committed to the care of the electoral prince of Mainz, as chancellor-in-chief of the empire, and it was preserved in the imperial archives at Mainz till 1789. Official transcripts were probably furnished to each of the seven electors at the time of the promulgation, and before long many of the other members of the empire secured copies for themselves. The transcript which belonged to the elector of Treves is preserved in the state archives at Stuttgart, that of the elector of Cologne in the court library at Darmstadt, and that of the elector of Bohemia in the imperial archives at Vienna. Berlin, Munich, and Dresden also boast the possession of an electoral transcript; and the town of Kitzingen has a contemporary copy in its municipal archives. There appears, however, to be good reason to doubt the genuineness of most of these so-called original transcripts. But perhaps the best known example is that of Frankfort-on-the-Main, which was procured from the imperial chancery in 1366, and is adorned with a golden seal like the original. Not only was it regularly quoted as the indubitable authority in regard to the election of the emperors in Frankfort itself, but it was from time to time officially consulted by members of the empire.

The manuscript consists of 43 leaves of parchment of medium quality, each measuring about 10⅛ inches in height by 7⅛ in breadth. The seal is of the plate and wax type. On the obverse appears a figure of the emperor seated on his throne, with the sceptre in his right hand and the globe in his left; a shield, with the crowned imperial eagle, occupies the space on the one side of the throne, and a corresponding shield with the crowned Bohemian lion with two tails, occupies the space on the other side; and round the margin runs the legend, *Karolus quartus divina favente clementia, Romanorum imperator semper Augustus et Boemiæ rex*. On the reverse is a castle, with the words *Aurea Roma* on the gate, and the circumscription reads, *Roma caput Mundi Regit orbis frena rotundi*. The original Latin text of the bull was printed at Nuremberg by Creussner in 1474, and a second edition by Kobergen appeared at the same place in 1477. Since that time it has been frequently reprinted from various manuscripts and collections. Goldastus gave the Palatine text compared with those of Bohemia and Frankfort, in his *Collectio Constitutionum Imperialium*, tom. i. Another is to be found in Onuphrius Panvinius, *De Comitiis Imperii*, and as an appendix to Cujacius, *De feudis*: and a third of unknown history, is prefixed to the *Codex Recessuum Imperii*, printed at Mainz in 1599, and again in 1615. The Frankfort text appeared in 1742—*Aurea Bulla secundum exemplar originale Frankfurtense*—from the pen of Wolfgang Ch. Multz. German translations, none of which, however, had any official authority, were published at Nuremberg, 1474 (?); at Venice, Johannus Jenson, 1476; and at Strasburg, Joh. Preussen, 1485. Among the earlier commentators of the document are Buxtorf, Dominicus Arumæus, Martinus Rumelius, H. Caninius, G. T. Dietrich, Ostermann, Speidelius, and Limnæus (*In Auream bullam*, Strasburg, 1662). The student will find a good account of the older literature of the subject in Biener, *Commentarii de origine et progressu legum Germanicarum*, 1787 (vol. ii.); and, besides the important work of Ohlenschlager, *Neue Erläuterungen der Guldener Bulla*, Frankfort and Leipsic, 1766, he may consult H. G. Thülemarius, *De bulla aurea argentea*, etc., Heidelberg, 1682 (which gives the Frankfort text of the bull of Charles IV., a golden bull of Andronicus of Constantinople, the Bulla Brabantina, and the capitulation of Maximilian II.); Pütters, *Staatsverfassung des deutschen Reichs*, Gottingen, 1788; Pfister, *Geschichte der Deutschen*, Hamburg, 1831 (vol. iii.); and Stobbe, *Gesch. der Deutschen Rechtsquellen*, Brunswick, 1860. A learned article on "Goldene Bulle," by H. Brandes, will be found in Ersch and Gruber's *Encyclopädie*, 1861.

GOLDEN-EYE, a name indiscriminately given in many parts of Britain to two very distinct species of Ducks, from the rich yellow color of their irides. The commonest of them—the *Anas fuligula* of Linnæus and *Fuligula cristata* of most modern ornithologists—is, however, usually called by English writers the Tufted Duck, while "Golden-eye" is reserved in books for the *A. clangula* and *A. glaucion* of Linnæus, who did not know that the birds he so named were but examples of the same species, differing only in age or sex; and to this day many fowlers perpetuate a like mistake, deeming the "Morillon," which is the female or young male, distinct from the "Golden-eye" or "Rattlewings" (as from its noisy flight they oftener call it), which is the adult male. This species belongs to the group known as Diving Ducks, and is the type of the very well-marked genus *Clangula* of later systematists, which, among other differences, has the posterior end of the sternum prolonged so as to extend considerably over, and, we may not unresonably suppose, protect the belly—a character possessed in a still greater degree by the Mergansers (*Merginæ*), while the males also exhibit in the extraordinarily developed bony labyrinth of their trachea and its midway enlargement another resemblance to the members of the same Subfamily. The Golden-eye, *C. glaucion* of modern writers, has its home in the northern parts of both hemispheres, whence in winter it migrates southward; but as it is one of the Ducks that constantly resorts to hollow trees for the purpose of breeding it hardly transcends the limit of the Arctic forests on either continent. So well known is this habit to the people of the northern districts of Scandinavia, that they very commonly devise artificial nest-boxes for its accommodation and their own profit. Hollow logs of wood are prepared, the top and bottom closed, and a hole cut in the side. These are affixed to the trunks of living trees in suitable places, at a convenient distance from the ground, and, being readily occupied by the birds in the breeding-season, are regularly robbed, first of the numerous eggs, and finally of the down they contain, by those who have set them up.

The adult male Golden-eye is a very beautiful bird, mostly black above, but with the head, which is slightly crested, reflecting rich green lights, a large oval white patch under each eye, and elongated white scapulars; the lower parts are wholly white and the feet bright orange, except the webs, which are dusky. In the female and young male, dark brown replaces the black, the cheek-spots are indistinct, and the elongated white scapulars wanting. The Golden-eye of North America has been by some authors deemed to differ, and has been named *C. americana*, but apparently on insufficient grounds. That country, however, has, in common with Iceland, a very distinct species, *C. islandica*, often called Barrow's Duck, which is but a rare straggler to the continent of Europe, and never, so far as known, to Britain. In Iceland and Greenland it is the only habitual representative of the genus, and it occurs from thence to the Rocky Mountains. In breeding-habits it differs from the commoner species, not placing its eggs in tree-holes; but how far this difference is voluntary may be doubted, for in the countries it frequents trees are wanting. It is a larger and stouter bird, and in the male the white cheek-patches take a more crescentic form, while the head is glossed with purple rather than green, and the white scapulars are not elongated. The New World also possesses a third and still more beautiful species of the genus in *C. albeola*, known in books as the Buffel-headed Duck, and to American fowlers as the "Spirit-Duck" and "Butter-ball"—the former name being applied from its rapidity in diving, and the latter from its exceeding fatness in autumn. This is of small size, but the lustre of the feathers in the male is most brilliant, exhibiting a deep plum-colored gloss on the head. It breeds in trees, and is supposed to have occurred more than once in Britain. (A. N.)

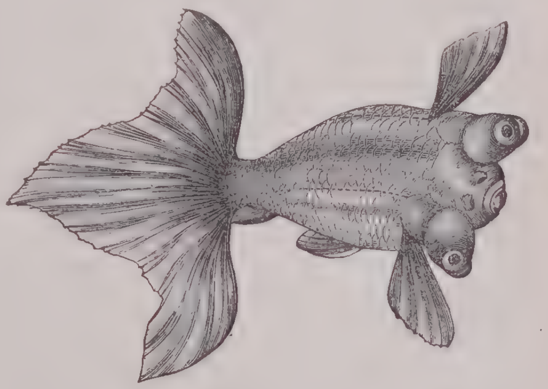
GOLDEN FLEECE. See ARGONAUTS.

GOLDEN LEGEND. See VORAGINE, JACOBUS DE.

GOLDEN ROSE (rosa aurea), an ornament, made of wrought gold and set with gems, which is blessed by the pope on the fourth (Lætare) Sunday of Lent, and usually afterwards sent as a mark of special favor to some distinguished individual, church, or civil community. The ceremonies which at present accompany the consecration of a golden rose are of a somewhat elaborate character, and are explained by liturgists as designed to make it specially emblematic of Christ and of the Christian graces. Some difficulty is experienced in tracing them to their ultimate origin; but the custom of blessing and sending some symbol of the kind seems to be as old at least as the time of Gregory the Great, with whom it was a frequent practice to send persons whom he wished to flatter a few particles filed from "Peter's chains," and set in keys or crosses of gold (Greg., *Op.* ii. 648, 711, 796, 1031, ed. 1705). This practice continued to be observed for several centuries; thus we find Gregory VII., in 1079, writing to Alphonso of Castile, "Ex more sanctorum misimus vobis claviculam auream in qua de catenis beati Petri benedictio continetur" (Mansi, *Conc. Gen.*, xii. 460). The first mention of the "golden rose," as such, is said to occur in the 11th century; and an allusion to it is certainly made in the Chronicle of William of Newburgh (1197). Pope Urban V., who sent a golden rose to Joanna of Naples in 1366, is alleged to have been the first to determine that the consecration should be annually observed. Among the very numerous recipients of this honor have been Henry VIII. of England, the famous Gonsalvo de Cordova, and, in more recent times, Napoleon III. of France and Isabella II. of Spain. The gift of the golden rose used almost invariably to accompany the coronation of the king of the Romans. If in any particular year no one is considered worthy of the rose, it is laid up in the Vatican.

GOLDFINCH (German *Goldfink*[1]), the *Fringilla carduelis* of Linnæus and the *Carduelis elegans* of later authors, an extremely well-known bird found over the greater parts of Europe and North Africa, and eastwards to Persia and Turkestan. Its gay plumage is matched by its sprightly nature; and together they make it one of the most favorite cage-birds among all classes. As a songster it is indeed surpassed by many other species, but its docility and ready attachment to its master or mistress make up for any defect in its vocal powers. In some parts of England the trade in Goldfinches is very considerable. In 1860 Mr. Hussey reported (*Zool.*, p. 7144) the average annual captures near Worthing to exceed 11,000 dozens—nearly all being cock-birds; and a witness before a Committee of the House of Commons in 1873 stated that, when a boy, he could take forty dozens in a morning near Brighton. In these districts and others the number has of late years become much reduced, owing doubtless in part to the fatal practice of catching the birds just before or during the breeding-season; but perhaps the strongest cause of their growing scarcity throughout the kingdom is the constant breaking-up of waste lands, and the extirpation of weeds (particularly of the Order *Compositæ*) essential to the improved system of agriculture; for in many parts of Scotland, East Lothian for instance, where Goldfinches were once as plentiful as Sparrows, they are now only rare stragglers, and yet there they have not been thinned by netting. Though Goldfinches may occasionally be observed in the coldest weather, incomparably the largest number leave Britain in autumn, returning in spring, and resorting to our gardens and orchards to breed, when the lively song of the cock, and the bright yellow wings of both sexes, quickly attract the notice of even the unobservant. The nest is a beautifully neat structure, often placed at no great height from the ground, but generally so well hidden by the leafy bough on which it is built as not to be easily found, until, the young being hatched, the constant visits of the parents reveal its site. When the broods leave the nest they move into the more open country, and frequenting pastures, commons, heaths, and downs, assemble in large flocks towards the end of summer. Eastward of the range of the present species its place is taken by its congener *C. caniceps*, which is easily recognized by wanting the black hood and white ear-coverts of our own bird. Its home seems to be in Central Asia, but it moves southward in winter, being common at that season in Cashmere, and is not unfrequently brought for sale to Calcutta. The position of the genus *Carduelis* in the family *Fringillidæ* is not very clear. Structurally it would seem to have some relation to the Siskins (*Chrysomitris*), though the members of the two groups have very different habits, and perhaps its nearest kinship lies with the Hawfinches (*Coccothraustes*). See FINCH, vol. ix. p. 167. (A. N.)

GOLDFISH (*Carassius auratus*). In China and the warmer parts of Japan a fish extremely similar to the Crucian carp of Europe is of very common occurrence in ponds and other still waters. In the wild state its colors do not differ from those of a Crucian carp, and like that fish it is tenacious of life and easily domesticated. Albinos seem to be rather common; and as in other fishes (for instance, the tench, carp, eel, flounder), the color of most of these albinos is a bright orange or golden yellow; occasionally even this shade of color is lost, the fish being more or less pure white or silvery. The Chinese have domesticated these albinos for a long time, and by careful selection have succeeded in propagating all those strange varieties, and even monstrosities, which appear in every domestic animal. In some individuals the dorsal fin is only half its normal length, in others entirely absent; in others the anal fin has a double spine; in others all the fins are of nearly double the usual length. The snout is frequently malformed, giving the head of the fish an appearance similar to that of a bull-dog. The variety most highly prized at present has an extremely short snout, eyes which almost wholly project beyond the orbit, no dorsal fin, and a very long three- or four-lobed caudal fin (Telescope-fish). The gold-fish is now distributed over nearly all the civilized parts of the world. It was first brought to England in the year 1691, but was very scarce till 1728, when it was imported in great numbers from Holland, where the fish had already become domesticated. It will not thrive in rivers; in large ponds it readily reverts to the coloration of the original wild stock. It flourishes best in small tanks and ponds, in which the water is constantly changing and does not freeze; in such localities, and with a full supply of food, which consists of crumbs of bread, bran, worms, small crustaceans, and insects, it attains to a length of from 6 to 12 inches, breeding readily, sometimes at different times of the same year.



Goldfish (*Carassius auratus*).

GOLD HILL, a town of Storey county, Nevada, United States, is situated at the head of a precipitous ravine of the Nevada mountains, 1 mile S. of Virginia city, and 328 E. from San Francisco by rail. The name was derived from a small hill connected with the famous Comstock lode, and containing rich golden ore. Some of the most valuable mines of this lode are within the limits of the town, the average yield being about two million dollars monthly in gold and silver. Though there are some quartz mills within the town, the greater part of the ore is conveyed to the mills on Carson river. There is a fine hall in connection with the miners' union, and another has been erected by the Oddfellows and Freemasons. The Methodists, Episcopalians, and Roman Catholics are the principal denominations of the town. Gold Hill obtains its water supply in conjunction with Virginia from the summit of the Sierra Nevada, 25 miles distant. The population in 1860 was 638, and in 1870 4311. Since then it has been rapidly increasing, and must have more than trebled its numbers.

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[1] The more common German name, however, is *Distelfink* (Thistle-Finch) or *Stieglitz*.

GOLDINGEN, in Lettish Kuldiga, a district town of the Russian province of Courland, in 56° 58′ N. lat. and 21° 58′ E. long., 85 miles W. N. W. of Mittau, on the left bank of the Windau, which forms a beautiful waterfall—the Rummel—in the neighborhood. On the Schlossberg or Castlehill are a few remains of the foundations of what in the end of the 18th century was the most magnificent ruin in Courland, and in the 17th century had been the palatial residence of the dukes. The town is beautifully built; and it possesses a Lutheran church dating from 1600, and a Catholic church five years older, a hospital and two almshouses, two benevolent societies, founded respectively in 1836 and 1839, and a society of rural economy. Brush making is the only local industry of much importance. In 1861 the population was 5475 (2764 males), of whom the greater proportion were Lutherans, 1551 being Jews, 300 Roman Catholics, and 200 members of the Greek Church; but according to the *St. Petersburg Calendar* for 1878 it has diminished to 4758. The castle of Goldingen was founded in 1240 by Dietrich of Grüningen, and in 1347 the town received its first charter of privileges from Goswin von Gerike, master of the Teutonic order. It has been a district town since 1795.

GOLD LACE. See under Gold, p. 671.

GOLDONI, Carlo (1707–1793), the most illustrious of the Italian comedy writers, and the real founder of modern Italian comedy. His life is known to us from his *Memoires*, which, though they do not reveal a great thinker, are of great value as faithfully representing the Italian society, especially the Venetian society of the 18th century. Goldoni was born at Venice in 1707, in a fine house near St. Thomas's church. His father Giulio was a native of Modena. The first playthings of the future writer were puppets which he made dance; the first books he read were plays—among others, the comedies of the Florentine Cicognini. Later he received a still stronger impression from the *Mandragora* of Macchiavelli. At eight years old he had tried to sketch a play. His father, meanwhile, had taken his degree in medicine at Rome and fixed himself at Perugia, where he made his son join him; but, having soon quarrelled with his colleagues in medicine, he departed for Chioggia, leaving his son to the care of a philosopher, Professor Caldini of Rimini. The young Goldoni soon grew tired of his life at Rimini, and ran away with a Venetian company of players. He began to study law at Venice, then went to continue the same pursuit at Pavia, but at that time he was studying the Greek and Latin comic poets much more and much better than books about law. "I have read over again," he writes in his *Mémoires*, "the Greek and Latin poets, and I have told to myself that I should like to imitate them in their style, their plots, their precision; but I would not be satisfied unless I succeeded in giving more interest to my works, happier issues to my plots, better drawn characters, and more genuine comedy." For a satire entitled *Il Colosso*, which attacked the honor of several families of Pavia, he was driven from that town, and went first to study with the jurisconsult Morelli at Udine, then to take his degree in law at Modena. After having worked some time as clerk in the chanceries of Chioggia and Feltre, his father being dead, he went to Venice, to exercise there his profession as a lawyer. But the wish to write for the stage was always strong in him, and he tried to do so; he made, however, a mistake in his choice, and began with a tragedy, *Amalasunta*, which was represented at Milan and proved a failure. In 1734 he wrote another tragedy, *Belisario*, which though not much better, chanced nevertheless to please the public. This first success encouraged him to write other tragedies, some of which were well received; but the author himself saw clearly that he had not yet found his proper sphere, and that a radical dramatic reform was absolutely necessary for the stage. He wished to create a characteristic comedy in Italy, to follow the example of Molière, and to delineate the realities of social life in as natural a manner as possible. His first essay of this kind was *Momolo Cortesan* (Momolo the Courtier), written in the Venetian dialect, and based on his own experience. Other plays followed—some interesting from their subject, others from the characters; the best of that period are—*Le trentadue Disgrazie d'Arlecchino*, *La Notte critica*, *La Bancarotta*, *La Donna di Garbo*. Having, while consul of Genoa at Venice, been cheated by a captain of Ragusa, he founded on this his play *L'Impostore*. At Leghorn he made the acquaintance of the comedian Medebac, and followed him to Venice, with his company, for which he began to write his best plays. Once he promised to write sixteen comedies in a year, and kept his word; among the sixteen are some of his very best, such as *Il Caffè*, *Il Bugiardo*, *La Pamela*. When he left the company of Medebac, he passed over to that maintained by the patrician Vendramin, continuing to write with the greatest facility. In 1761 he was called to Paris, and before leaving Venice he wrote *Una delle ultime Sere di Carnevale* (One of the Last Nights of Carnival), an allegorical comedy in which he said good-bye to his country. At the end of the representation of this play, the theatre resounded with applause, and with shouts expressive of good wishes. Goldoni, at this proof of public sympathy, wept as a child. At Paris, during two years, he wrote comedies for the Italian actors; then he taught Italian to the royal princesses; and for the wedding of Louis XVI. and of Marie Antoinette he wrote in French one of his best comedies, *Le Bourru Bienfaisant*, which was a great success. When he retired from Paris to Versailles, the king made him a gift of 6000 francs, and fixed on him an annual pension of 1200 francs. It was at Versailles he wrote his *Memoirs*, which occupied him till he reached his eightieth year. The Revolution deprived him all at once of his modest pension, and reduced him to extreme misery; he dragged on his unfortunate existence till 1793, and died on the 6th of February. The day after, on the proposal of André Chénier, the Convention agreed to give the pension back to the poet; and as he had already died, a reduced allowance was granted to his widow.

The best comedies of Goldoni are—*La Donna di Garbo*, *La Bottega di Caffè*, *Pamela nubile*, *Le Baruffe chiozzotte*, *I Rusteghi*, *Todero Brontolon*, *Gli Innamorati*, *Il Ventaglio*, *Il Bugiardo*, *La Casa Nova*, *Il Burbero benefico*, *La Locandiera*. See P. G. Molmenti, *Carlo Goldoni*, Venice, 1875.

GOLDSCHMIDT, Hermann (1802–1866), a German painter and astronomer, was the son of a Jewish merchant, and was born at Frankfort on the 17th June, 1802. He for ten years assisted his father in his business; but, his love of art having been awakened while journeying in Holland, he in 1832 began the study of painting at Munich under Cornelius and Schnorr, and in 1836 established himself at Paris, where he painted a number of pictures of more than average merit, among which may be mentioned the Cumæan Sibyl, 1844; an Offering to Venus, 1845; a View of Rome, 1849; the Death of Romeo and Juliet, 1857; and several Alpine landscapes. In 1847 he began to devote his attention to astronomy; and from 1852 to 1861 he discovered fourteen asteroids between Mars and Jupiter, on which account he received the grand astronomical prize from the Academy of Sciences. His observations of the protuberances on the sun, made during the total eclipse on the 10th July, 1860, are included in the work of Mädler on the eclipse, published in 1861. Goldschmidt died at Fontainebleau, 26th August, 1866.

GOLDSMITH, Oliver (1728–1774), one of the most pleasing English writers of the 18th century. He was of a Protestant and Saxon family which had been long settled in Ireland, and which had, like most other Protestant and Saxon families, been, in troubled times, harassed and put in fear by the native population. His father, Charles Goldsmith, studied in the reign of Queen Anne at the diocesan school of Elphin, became attached to the daughter of the schoolmaster, married her, took orders, and settled at a place called Pallas, in the county of Longford. There he with difficulty supported his wife and children on what he could earn, partly as a curate and partly as a farmer.

At Pallas Oliver Goldsmith was born in November, 1728. That spot was then, for all practical purposes, almost as remote from the busy and splendid capital in which his later years were passed as any clearing in Upper Canada or any sheep walk in Australasia now is. Even at this day those enthusiasts who venture to make a pilgrimage to the birthplace of the poet are forced to perform the latter part of their journey on foot. The hamlet lies far from any high road, on a dreary plain which, in wet weather, is often a lake. The lanes would break any jaunting car to pieces; and there are ruts and sloughs through which the most strongly built wheels cannot be dragged.

While Oliver was still a child his father was presented to a living worth about £200 a year, in the county of West Meath. The family accordingly quitted their cottage in the wilderness for a spacious house on a frequented road, near the village of Lissoy. Here the boy was taught his letters by a maid-servant, and was sent in his seventh year to a village school kept by an old quartermaster on half-pay who professed to teach nothing but reading, writing, and arithmetic, but who had an inexhaustible fund of stories about ghosts, banshees, and fairies, about the great Rapparee chiefs, Baldearg O'Donnell and galloping Hogan, and about the exploits of Peterborough and Stanhope, the surprise of Monjuich, and the glorious disaster of Brihuega. This man must have been of the Protestant religion; but he was of the aboriginal race, and not only spoke the Irish language, but could pour forth unpremeditated Irish verses. Oliver early became, and through life continued to be, a passionate admirer of the Irish music, and especially of the compositions of Carolan, some of the last notes of whose harp he heard. It ought to be added that Oliver, though by birth one of the Englishry, and though connected by numerous ties with the Established Church, never showed the least sign of that contemptuous antipathy with which, in his days, the ruling minority in Ireland too generally regarded the subject majority. So far indeed was he from sharing in the opinions and feelings of the caste to which he belonged that he conceived an aversion to the Glorious and Immortal Memory, and, even when George III. was on the throne, maintained that nothing but the restoration of the banished dynasty could save the country.

From the humble academy kept by the old soldier Goldsmith was removed in his ninth year. He went to several grammar-schools, and acquired some knowledge of the ancient languages. His life at this time seems to have been far from happy. He had, as appears from the admirable portrait of him at Knowle, features harsh even to ugliness. The small-pox had set its mark on him with more than usual severity. His stature was small, and his limbs ill put together. Among boys little tenderness is shown to personal defects; and the ridicule excited by poor Oliver's appearance was heightened by a peculiar simplicity and a disposition to blunder which he retained to the last. He became the common butt of boys and masters, was pointed at as a fright in the play-ground, and flogged as a dunce in the school-room. When he had risen to eminence, those who had once derided him ransacked their memory for the events of his early years, and recited repartees and couplets which had dropped from him, and which, though little noticed at the time, were supposed, a quarter of a century later, to indicate the powers which produced the *Vicar of Wakefield* and the *Deserted Village*.

In his seventeenth year Oliver went up to Trinity College, Dublin, as a sizar. The sizars paid nothing for food and tuition, and very little for lodging; but they had to perform some menial services from which, they have long been relieved. They swept the court, they carried up the dinner to the fellows' table, and changed the plates and poured out the ale of the rulers of the society. Goldsmith was quartered, not alone, in a garret, on the window of which his name, scrawled by himself, is still read with interest. From such garrets many men of less parts than his have made their way to the woolsack or to the episcopal bench. But Goldsmith, while he suffered all the humiliations, threw away all the advantages of his situation. He neglected the studies of the place, stood low at the examinations, was turned down to the bottom of his class for playing the buffoon in the lecture-room, was severely reprimanded for pumping on a constable, and was caned by a brutal tutor for giving a ball in the attic story of the college to some gay youths and damsels from the city.

While Oliver was leading at Dublin, a life divided between squalid distress and squalid dissipation, his father died, leaving a mere pittance. The youth obtained his bachelor's degree, and left the university. During some time the humble dwelling to which his widowed mother had retired was his home. He was now in his twenty-first year; it was necessary that he should do something; and his education seemed to have fitted him to do nothing but to dress himself in gaudy colors, of which he was as fond as a magpie, to take a hand at cards, to sing Irish airs, to play the flute, to angle in summer, and to tell ghost stories by the fire in winter. He tried five or six professions in turn without success. He applied for ordination; but, as he applied in scarlet clothes, he was speedily turned out of the episcopal palace. He then became tutor in an opulent family, but soon quitted his situation in consequence of a dispute about play. Then he determined to emigrate to America. His relations, with much satisfaction, saw him set out for Cork on a good horse, with £30 in his pocket. But in six weeks he came back on a miserable hack, without a penny, and informed his mother that the ship in which he had taken his passage, having got a fair wind while he was at a party of pleasure, had sailed without him. Then he resolved to study the law. A generous kinsman advanced £50. With this sum Goldsmith went to Dublin, was enticed into a gaming house, and lost every shilling. He then thought of medicine. A small purse was made up; and in his twenty-fourth year he was sent to Edinburgh. At Edinburgh he passed eighteen months in nominal attendance on lectures, and picked up some superficial information about chemistry and natural history. Thence he went to Leyden, still pretending to study physic. He left that celebrated university, the third university at which he had resided, in his twenty-seventh year, without a degree, with the merest smattering of medical knowledge, and with no property but his clothes and his flute. His flute, however, proved a useful friend. He rambled on foot through Flanders, France, and Switzerland, playing tunes which everywhere set the peasantry dancing, and which often procured for him a supper and a bed. He wandered as far as Italy. His musical performances, indeed, were not to the taste of the Italians; but he contrived to live on the alms which he obtained at the gates of convents. It should, however, be observed that the stories which he told about this part of his life ought to be received with great caution; for strict veracity was never one of his virtues; and a man who is ordinarily inaccurate in narration is likely to be more than ordinarily inaccurate when he talks about his own travels. Goldsmith indeed was so regardless of truth as to assert in print that he was present at a most interesting conversation between Voltaire and Fontenelle, and that this conversation took place at Paris. Now it is certain that Voltaire never was within a hundred leagues of Paris during the whole time which Goldsmith passed on the Continent.

In 1756 the wanderer landed at Dover, without a shilling, without a friend, and without a calling. He had indeed, if his own unsupported evidence may be trusted, obtained from the university of Padua a doctor's degree; but this dignity proved utterly useless to him. In England his flute was not in request; there were no convents; and he was forced to have recourse to a series of desperate expedients. He turned strolling player; but his face and figure were ill suited to the boards even of the humblest theatre. He pounded drugs and ran about London with phials for charitable chemists. He joined a swarm of beggars, which made its nest in Axe Yard. He was for a time usher of a school, and felt the miseries and humiliations of this situation so keenly that he thought it a promotion to be permitted to earn his bread as a bookseller's hack; but he soon found the new yoke more galling than the old one, and was glad to become an usher again. He obtained a medical appointment in the service of the East India Company; but the appointment was speedily revoked. Why it was revoked we are not told. The subject was one on which he never liked to talk. It is probable that he was incompetent to perform the duties of the place. Then he presented himself at Surgeons' Hall for examination, as mate to a naval hospital. Even to so humble a post he was found unequal. By this time the schoolmaster whom he had served for a morsel of food and the third part of a bed was no more. Nothing remained but to return to the lowest drudgery of literature. Goldsmith took a garret in a miserable court, to which he had to climb from the brink of Fleet Ditch by a dizzy ladder of flagstones called Breakneck Steps. The court and the ascent have long disappeared, but old Londoners well remember both. Here, at thirty, the unlucky adventurer sat down to toil like a galley slave.

In the succeeding six years he sent to the press some things which have survived, and many which have perished. He produced articles for reviews, magazines, and newspapers; children's books, which, bound in gilt paper and adorned with hideous woodcuts, appeared in the window of the once far-famed shop at the corner of Saint Paul's Churchyard; *An Inquiry into the State of Polite Learning in Europe*, which, though of little or no value, is still reprinted among his works; a *Life of Beau Nash*, which is not reprinted, though it well deserves to be so; a superficial and incorrect, but very readable, *History of England*, in a series of letters purporting to be addressed by a nobleman to his son; and some very lively and amusing *Sketches of London Society*, in a series of letters purporting to be addressed by a Chinese traveller to his friends. All these works were anonymous; but some of them were well known to be Goldsmith's; and he gradually rose in the estimation of the booksellers for whom he drudged. He was, indeed, emphatically a popular writer. For accurate research or grave disquisition he was not well qualified by nature or by education. He knew nothing accurately; his reading had been desultory; nor had he meditated deeply on what he had read. He had seen much of the world; but he had noticed and retained little more of what he had seen than some grotesque incidents and characters which had happened to strike his fancy. But, though his mind was very scantily stored with materials, he used what materials he had in such a way as to produce a wonderful effect. There have been many greater writers; but perhaps no writer was ever more uniformly agreeable. His style was always pure and easy, and, on proper occasions, pointed and energetic. His narratives were always amusing, his descriptions always picturesque, his humor rich and joyous, yet not without an occasional tinge of amiable sadness. About everything that he wrote, serious or sportive, there was a certain natural grace and decorum, hardly to be expected from a man a great part of whose life had been passed among thieves and beggars, street-walkers and merryandrews, in those squalid dens which are the reproach of great capitals.

As his name gradually became known, the circle of his acquaintance widened. He was introduced to Johnson, who was then considered as the first of living English writers; to Reynolds, the first of English painters; and to Burke, who had not yet entered parliament, but had distinguished himself greatly by his writings and by the eloquence of his conversation. With these eminent men Goldsmith became intimate. In 1763 he was one of the nine original members of that celebrated fraternity which has sometimes been called the Literary Club, but which has always disclaimed that epithet, and still glories in the simple name of the Club.

By this time Goldsmith had quitted his miserable dwelling at the top of Breakneck Steps, and had taken chambers in the more civilized region of the Inns of Court. But he was still often reduced to pitiable shifts. Towards the close of 1764 his rent was so long in arrear that his landlady one morning called in the help of a sheriff's officer. The debtor, in great perplexity, despatched a messenger to Johnson; and Johnson, always friendly, though often surly, sent back the messenger with a guinea, and promised to follow speedily. He came, and found that Goldsmith had changed the guinea, and was railing at the landlady over a bottle of Madeira. Johnson put the cork into the bottle, and entreated his friend to consider calmly how money was to be procured. Goldsmith said that he had a novel ready for the press. Johnson glanced at the manuscript, saw that there were good things in it, took it to a bookseller, sold it for £60, and soon returned with the money. The rent was paid; and the sheriff's officer withdrew. According to one story, Goldsmith gave his landlady a sharp reprimand for her treatment of him; according to another, he insisted on her joining him in a bowl of punch. Both stories are probably true. The novel which was thus ushered into the world was the *Vicar of Wakefield*.

But before the *Vicar of Wakefield* appeared in print, came the great crisis of Goldsmith's literary life. In Christmas week 1764 he published a poem, entitled the *Traveller*. It was the first work to which he had put his name, and it at once raised him to the rank of a legitimate English classic, The opinion of the most skilful critics was that nothing finer had appeared in verse since the fourth book of the *Dunciad*. In one respect the *Traveller* differs from all Goldsmith's other writings. In general his designs were bad, and his execution good. In the *Traveller*, the execution, though deserving of much praise, is far inferior to the design. No philosophical poem, ancient or modern, has a plan so noble, and at the same time so simple. An English wanderer, seated on a crag among the Alps, near the point where three great countries meet, looks down on the boundless prospect, reviews his long pilgrimage, recalls the varieties of scenery, of climate, of government, of religion, of national character, which he has observed, and comes to the conclusion, just or unjust, that our happiness depends little on political institutions, and much on the temper and regulation of our own minds.

While the fourth edition of the *Traveller* was on the counters of the booksellers, the *Vicar of Wakefield* appeared, and rapidly obtained a popularity which has lasted down to our own time, and which is likely to last as long as our language. The fable is indeed one of the worst that ever was constructed. It wants, not merely that probability which ought to be found in a tale of common English life, but that consistency which ought to be found even in the wildest fiction about witches, giants, and fairies. But the earlier chapters have all the sweetness of pastoral poetry, together with all the vivacity of comedy. Moses and his spectacles, the vicar and his monogamy, the sharper and his cosmogony, the squire proving from Aristotle that relatives are related, Olivia preparing herself for the arduous task of converting a rakish lover by studying the controversy between Robinson Crusoe and Friday, the great ladies with their scandal about Sir Tomkyn's amours and Dr. Burdock's verses, and Mr. Burchell with his "Fudge," have caused as much harmless mirth as has ever been caused by matter packed into so small a number of pages. The latter part of the tale is unworthy of the beginning. As we approach the catastrophe, the absurdities lie thicker and thicker, and the gleams of pleasantry become rarer and rarer.

The success which had attended Goldsmith as a novelist emboldened him to try his fortune as a dramatist. He wrote the *Goodnatured Man*, a piece which had a worse fate than it deserved. Garrick refused to produce it at Drury Lane. It was acted at Covent Garden in 1768, but was coldly received. The author, however, cleared by his benefit nights, and by the sale of the copyright, no less than £500, five times as much as he had made by the *Traveller* and the *Vicar of Wakefield* together. The plot of the *Goodnatured Man* is, like almost all Goldsmith's plots, very ill constructed. But some passages are exquisitely ludicrous,—much more ludicrous indeed than suited the taste of the town at that time. A canting, mawkish play, entitled *False Delicacy*, had just had an immense run. Sentimentality was all the mode. During some years, more tears were shed at comedies than at tragedies; and a pleasantry which moved the audience to anything more than a grave smile was reprobated as low. It is not strange, therefore, that the very best scene in the *Goodnatured Man*, that in which Miss Richland finds her lover attended by the bailiff and the bailiff's follower in full court dresses, should have been mercilessly hissed, and should have been omitted after the first night.

In 1770 appeared the *Deserted Village*. In mere diction and versification this celebrated poem is fully equal, perhaps superior, to the *Traveller;* and it is generally preferred to the *Traveller* by that large class of readers who think, with Bayes in the *Rehearsal*, that the only use of a plan is to bring in fine things. More discerning judges, however, while they admire the beauty of the details, are shocked by one unpardonable fault, which pervades the whole. The fault which we mean is not that theory about wealth and luxury which has so often been censured by political economists. The theory is indeed false; but the poem, considered merely as a poem, is not necessarily the worse on that account. The finest poem in the Latin language,—indeed, the finest didactic poem in any language,—was written in defence of the silliest and meanest of all systems of natural and moral philosophy. A poet may easily be pardoned for reasoning ill; but he cannot be pardoned for describing ill, for observing the world in which he lives so carelessly that his portraits bear no resemblance to the originals, for exhibiting as copies from real life monstrous combinations of things which never were and never could be found together. What would be thought of a painter who should mix August and January in one landscape, who should introduce a frozen river into a harvest scene? Would it be a sufficient defence of such a picture to say that every part was exquisitely colored, that the green hedges, the apple-trees loaded with fruit, the wagons reeling under the yellow sheaves, and the sunburned reapers wiping their foreheads were very fine, and that the ice and the boys sliding were also very fine? To such a picture the *Deserted Village* bears a great resemblance. It is made up of incongruous parts. The village in its happy days is a true English village. The village in its decay is an Irish village. The felicity and the misery which Goldsmith has brought close together belong to two different countries, and to two different stages in the progress of society. He had assuredly never seen in his native island such a rural paradise, such a seat of plenty, content, and tranquillity, as his Auburn. He had assuredly never seen in England all the inhabitants of such a paradise turned out of their homes in one day, and forced to emigrate in a body to America. The hamlet he had probably seen in Kent; the ejectment he had probably seen in Munster; but by joining the two, he has produced something which never was and never will be seen in any part of the world.

In 1773 Goldsmith tried his chance at Covent Garden with a second play, *She Stoops to Conquer*. The manager was, not without great difficulty, induced to bring this piece out. The sentimental comedy still reigned, and Goldsmith's comedies were not sentimental. The *Goodnatured Man* had been too funny to succeed; yet the mirth of the *Goodnatured Man* was sober when compared with the rich drollery of *She Stoops to Conquer*, which is, in truth, an incomparable farce in five acts. On this occasion, however, genius triumphed. Pit, boxes, and galleries were in a constant roar of laughter. If any bigoted admirer of Kelly and Cumberland ventured to hiss or groan, he was speedily silenced by a general cry of "turn him out," or "throw him over." Two generations have since confirmed the verdict which was pronounced on that night.

While Goldsmith was writing the *Deserted Village* and *She Stoops to Conquer*, he was employed on works of a very different kind,—works from which he derived little reputation but much profit. He compiled for the use of schools a *History of Rome*, by which he made £300; a *History of England*, by which he made £600; a *History of Greece*, for which he received £250; a *Natural History*, for which the booksellers covenanted to pay him 800 guineas. These works he produced without any elaborate research, by merely selecting, abridging, and translating into his own clear, pure, and flowing language, what he found in books well known to the world, but too bulky or too dry for boys and girls. He committed some strange blunders, for he knew nothing with accuracy. Thus, in his *History of England*, he tells us that Naseby is in Yorkshire; nor did he correct this mistake when the book was reprinted. He was very nearly hoaxed into putting into the *History of Greece* an account of a battle between Alexander the Great and Montezuma. In his *Animated Nature* he relates, with faith and with perfect gravity, all the most absurd lies which he could find in books of travels about gigantic Patagonians, monkeys that preach sermons, nightingales that repeat long conversations. "If he can tell a horse from a cow," said Johnson, "that is the extent of his knowledge of zoology." How little Goldsmith was qualified to write about the physical sciences is sufficiently proved by two anecdotes. He on one occasion denied that the sun is longer in the northern than in the southern signs. It was vain to cite the authority of Maupertuis. "Maupertuis!" he cried, "I understand those matters better than Maupertuis." On another occasion he, in defiance of the evidence of his own senses, maintained obstinately, and even angrily, that he chewed his dinner by moving his upper jaw.

Yet, ignorant as Goldsmith was, few writers have done more to make the first steps in the laborious road to knowledge easy and pleasant. His compilations are widely distinguished from the compilations of ordinary bookmakers. He was a great, perhaps an unequalled, master of the arts of selection and condensation. In these respects his histories of Rome and of England, and still more his own abridgments of these histories, well deserved to be studied. In general nothing is less attractive than an epitome; but the epitomes of Goldsmith, even when most concise, are always amusing; and to read them is considered by intelligent children not as a task but as a pleasure.

Goldsmith might now be considered as a prosperous man. He had the means of living in comfort, and even in what to one who had so often slept in barns and on bulks must have been luxury. His fame was great and was constantly rising. He lived in what was intellectually far the best society of the kingdom, in a society in which no talent or accomplishment was wanting, and in which the art of conversation was cultivated with splendid success. There probably were never four talkers more admirable in four different ways than Johnson, Burke, Beauclerk, and Garrick; and Goldsmith was on terms of intimacy with all the four. He aspired to share in their colloquial renown, but never was ambition more unfortunate. It may seem strange that a man who wrote with so much perspicuity, vivacity, and grace should have been, whenever he took a part in conversation, an empty, noisy, blundering rattle. But on this point the evidence is overwhelming. So extraordinary was the contrast between Goldsmith's published works and the silly things which he said, that Horace Walpole described him as an inspired idiot. "Noll," said Garrick, "wrote like an angel, and talked like poor Poll." Chamier declared that it was a hard exercise of faith to believe that so foolish a chatterer could have really written the *Traveller*. Even Boswell could say, with contemptuous compassion, that he liked very well to hear honest Goldsmith run on. "Yes, sir," said Johnson, "but he should not like to hear himself." Minds differ as rivers differ. There are transparent and sparkling rivers from which it is delightful to drink as they flow; to such rivers the minds of such men as Burke and Johnson may be compared. But there are rivers of which the water when first drawn is turbid and noisome, but becomes pellucid as crystal and delicious to the taste, if it be suffered to stand till it has deposited a sediment; and such a river is a type of the mind of Goldsmith. His first thoughts on every subject were confused even to absurdity, but they required only a little time to work themselves clear. When he wrote they had that time, and therefore his readers pronounced him a man of genius; but when he talked he talked nonsense, and made himself the laughing-stock of his hearers. He was painfully sensible of his inferiority in conversation; he felt every failure keenly; yet he had not sufficient judgment and self-command to hold his tongue. His animal spirits and vanity were always impelling him to try to do the one thing which he could not do. After every attempt he felt that he had exposed himself, and writhed with shame and vexation; yet the next moment he began again.

His associates seem to have regarded him with kindness, which, in spite of their admiration of his writings, was not unmixed with contempt. In truth, there was in his character much to love, but very little to respect. His heart was soft even to weakness; he was so generous that he quite forgot to be just; he forgave injuries so readily that he might be said to invite them, and was so liberal to beggars that he had nothing left for his tailor and his butcher. He was vain, sensual, frivolous, profuse, improvident. One vice of a darker shade was imputed to him, envy. But there is not the least reason to believe that this bad passion, though it sometimes made him wince and utter fretful exclamations, ever impelled him to injure by wicked arts the reputation of any of his rivals. The truth probably is that he was not more envious, but merely less prudent than his neighbors. His heart was on his lips. All those small jealousies, which are but too common among men of letters, but which a man of letters who is also a man of the world does his best to conceal, Goldsmith avowed with the simplicity of a child. When he was envious, instead of affecting indifference, instead of damning with faint praise, instead of doing injuries slily and in the dark, he told everybody that he was envious. "Do not, pray, do not, talk of Johnson in such terms," he said to Boswell; "you harrow up my very soul." George Steevens and Cumberland were men far too cunning to say such a thing. They would have echoed the praises of the man whom they envied, and then have sent to the newspapers anonymous libels upon him. Both what was good and what was bad in Goldsmith's character was to his associates a perfect security that he would never commit such villainy. He was neither ill-natured enough, nor long-headed enough, to be guilty of any malicious act which required contrivance and disguise.

Goldsmith has sometimes been represented as a man of genius, cruelly treated by the world, and doomed to struggle with difficulties, which at last broke his heart. But no representation can be more remote from the truth. He did, indeed, go through much sharp misery before he had done anything considerable in literature. But after his name had appeared on the title-page of the *Traveller*, he had none but himself to blame for his distresses. His average income, during the last seven years of his life, certainly exceeded £400 a year, and £400 a year ranked, among the incomes of that day, at least as high as £800 a year would rank at present. A single man living in the Temple, with £400 a year, might then be called opulent. Not one in ten of the young gentlemen of good families who were studying the law there had so much. But all the wealth which Lord Clive had brought from Bengal, and Sir Lawrence Dundas from Germany, joined together, would not have sufficed for Goldsmith. He spent twice as much as he had. He wore fine clothes, gave dinners of several courses, paid court to venal beauties. He had also, it should be remembered, to the honor of his heart, though not of his head, a guinea, or five, or ten, according to the state of his purse, ready for any tale of distress, true or false. But it was not in dress or feasting, in promiscuous amours or promiscuous charities, that his chief expense lay. He had been from boyhood a gambler, and at once the most sanguine and the most unskilful of gamblers. For a time he put off the day of inevitable ruin by temporary expedients. He obtained advances from booksellers, by promising to execute works which he never began. But at length this source of supply failed. He owed more than £2000; and he saw no hope of extrication from his embarrassments. His spirits and health gave way. He was attacked by a nervous fever, which he thought himself competent to treat. It would have been happy for him if his medical skill had been appreciated as justly by himself as by others. Notwithstanding the degree which he pretended to have received at Padua, he could procure no patients. "I do not practise," he once said; "I make it a rule to prescribe only for my friends." "Pray, dear Doctor," said Beauclerk, "alter your rule; and prescribe only for your enemies." Goldsmith now, in spite of this excellent advice, prescribed for himself. The remedy aggravated the malady. The sick man was induced to call in real physicians; and they at one time imagined that they had cured the disease. Still his weakness and restlessness continued. He could get no sleep. He could take no food. "You are worse," said one of his medical attendants, "than you should be from the degree of fever which you have. Is your mind at ease?" "No; it is not," were the last recorded words of Oliver Goldsmith. He died on the 3d of April, 1774, in his forty-sixth year. He was laid in the churchyard of the Temple; but the spot was not marked by any inscription, and is now forgotten. The coffin was followed by Burke and Reynolds. Both these great men were sincere mourners. Burke, when he heard of Goldsmith's death, had burst into a flood of tears. Reynolds had been so much moved by the news that he had flung aside his brush and palette for the day.

A short time after Goldsmith's death, a little poem appeared, which will, as long as our language lasts, associate the names of his two illustrious friends with his own. It has already been mentioned that he sometimes felt keenly the sarcasm which his wild blundering talk brought upon him. He was, not long before his last illness, provoked into retaliating. He wisely betook himself to his pen; and at that weapon he proved himself a match for all his assailants together. Within a small compass he drew with a singularly easy and vigorous pencil the characters of nine or ten of his intimate associates. Though this little work did not receive his last touches, it must always be regarded as a masterpiece. It is impossible, however, not to wish that four or five likenesses which have no interest for posterity were wanting to that noble gallery, and that their places were supplied by sketches of Johnson and Gibbon, as happy and vivid as the sketches of Burke and Garrick.

Some of Goldsmith's friends and admirers honored him with a cenotaph in Westminster Abbey. Nollekens was the sculptor, and Johnson wrote the inscription. It is much to be lamented that Johnson did not leave to posterity a more durable and a more valuable memorial of his friend. A life of Goldsmith would have been an inestimable addition to the Lives of the Poets. No man appreciated Goldsmith's writings more justly than Johnson; no man was better acquainted with Goldsmith's character and habits; and no man was more competent to delineate with truth and spirit the peculiarities of a mind in which great powers were found in company with great weaknesses. But the list of poets to whose works Johnson was requested by the booksellers to furnish prefaces ended with Lyttleton, who died in 1773. The line seems to have been drawn expressly for the purpose of excluding the person whose portrait would have most fitly closed the series. Goldsmith, however, has been fortunate in his biographers. Within a few years his life was written by Mr. Prior (1836), by Mr. Washington Irving (1849), and by Mr. Forster (1848; 2d ed., 1854). The diligence of Mr. Prior deserves great praise; the style of Mr. Washington Irving is always pleasing; but the highest place must, in justice, be assigned to the eminently interesting work of Mr. Forster. (M.)

GOLDSTÜCKER, THEODOR (1821–1872), an eminent Sanskrit scholar was born of Jewish parents at Königsberg on the 18th of January, 1821, and, after passing through a prolonged course of study at the gymnasium, entered the university in 1836, where he attended the lectures of Lobeck, Rosenkranz, and Von Bohlen, under the last of whom he began the study of Sanskrit. In 1838 he removed to Bonn, where he heard W. von Schlegel, Lassen, and Freytag; and after graduating at Königsberg in 1840, he proceeded to Paris, where he heard the lectures and enjoyed the friendship of Burnouf, and where in 1842 he edited a German translation of the *Prabodha Chandrodaya*. From 1846 to 1850 he resided at Berlin, where his talents and scholarship were recognized by A. von Humboldt; in the latter year he was induced, for the further prosecution of his Sanskrit researches, to remove to London, where in 1851 he was appointed professor of Sanskrit in University College. He now began to devote himself to the execution of a new Sanskrit dictionary, of which the first instalment appeared in 1856. In 1861 he published an important monograph, entitled *Panini: his Place in Literature;* and from 1866 he was one of the chief promoters of the Sanskrit Text Society, which had been founded in that year; he was also an active member of the Philological Society, and of other learned bodies. His literary productiveness was not, however, proportionate to the extent and accuracy of his reading; he had "allowed his learning to stifle his creative faculty," and a morbid dread of the risk of making inaccurate or defective statements made him unduly reluctant to communicate to the world the results of his laborious collecting and collating. The dictionary—so copious as almost to deserve the name of a cyclopædia of Indian archæology—was never advanced further than to about the middle of the first letter (1864); and whatever else he may have written was published anonymously in various periodicals and works of reference. He died on the 6th of March, 1872.

GOLF (in its older forms GOFF, GOUFF, or GOWFF, the last of which gives the genuine old pronunciation) is an amusement so peculiar to Scotland and so prevalent there that—unless curling may be held to dispute the place with it—it may be called, *par excellence*, the national game. There seems little doubt the word is derived from the German *kolbe*, a club—in Dutch, *kolf*—which last is nearly in sound identical, and might give inference for the game of a Dutch origin.[1]

Golf may be practised on any good stretch of meadowland, where the grass is not too rank; but the ground best suited for the purpose is a reach of undulating down-country, such as is common on the seaboard—sandy in soil, and as such covered with a short crisp turf, occasionally broken up by sandholes or "bunkers," and provided, in addition, with a fair supply of gorse or whin. These "bunkers" and whins constitute the main "hazards" of the game, in the avoidance of which skill in it is specially shown; and without a fair provision of them, no golfing "links" or "green" can be held to approach the ideal standard. Small holes, of about 4 inches diameter, are punched in the turf at distances indefinitely variable, but ranging from about 100 to 400 or 500 yards; and from one of these holes into the next in order, a ball of gutta percha of about $1\frac{3}{4}$ oz. weight has to be driven with implements

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[1] From an enactment of James VI. (then James I. of England), bearing date 1618, we find that a considerable importation of golf balls at that time took place from Holland, and as thereby "na small quantitie of gold and silver is transported zierly out of his Hienes' kingdome of Scoteland" (see letter of his Majesty from Salisbury, 5th Aug., 1618), he issues a royal prohibition, at once as a wise economy of the national monies, and a protection to native industry in the article. From this it might almost seem that the game was at that date still known and practised in Holland, though it has long since entirely disappeared there.

(clubs) of some variety, devised for the purpose. Their variety is determined by this, that while, in starting from the hole, the ball may be *teed* (*i.e.*, placed where the player chooses, with a little pinch of sand under it called a *tee*), it must in every other case be played strictly from its place as it chances to lie—in sand, whin, or elsewhere—a different club being necessary in each particular difficulty. These clubs may generally be defined as shafts of wood, with so called *heads* of wood or iron attached.[1] Starting from the one hole, it is the immediate aim of the player to drive his ball as far towards the next as he can. Having got within some moderate distance of it, he proceeds to make his "approach shot," carefully selecting the appropriate implement. When he has reached the "putting green,"—a smooth space carefully chosen for the purpose - he essays to put (or putt) his ball into the hole; and generally, if he does it in two strokes, he may be held skilful or fortunate. The player who holes his ball in the smallest number of strokes is, as matter of course, winner of the hole. The "approach" and the "putting" are by far the most difficult, critical, and important parts of the game; though no one who is not fairly competent in his driving also is ever in the least likely to take rank as a first-class player. The maximum length of a good driving stroke for a first-class player, not favored by any exceptional circumstances, may perhaps fairly be stated as something over 180 yards, and under 200. For further details as to the mode and order of playing, the reader is referred to the set of "rules" appended to this article.

The game, in description as above, may not seem very lively or entertaining; and it is to be admitted that, seen for the first time, more especially if played by bungling or indifferent performers, it does not look of much promise. No game, however, stirs a keener enthusiasm in its votaries; and very few people who have ever fairly committed themselves to serious practice of it will be found to deny its extreme fascination. It is a manly and eminently healthful recreation, pursued as it is mostly amid the fresh sea-breezes; while, as exercise, it has this peculiar merit, that, according to pace, it may be made easy or smart at pleasure, and thus equally adapts itself to the overflowing exuberance of youth, the matured and tempered strength of manhood, and the gentler decays of age.

It is uncertain at what date golf was introduced into Scotland, but in 1457 the popularity of the game had already become so great as seriously to interfere with the more important pursuit of archery, and cause the rulers of the realm to sound a note of alarm. In March of that year, it is recorded that the Scottish parliament "decreted and ordained that wapinshawingis be halden be the lordis and baronis spirituale and temporale, four times in the zeir; and that the fute-ball and *golf be utterly cryit doun, and nocht usit;* and that the bowe-merkis be maid at ilk paroche kirk a pair of buttis, and *schuttin be usit ilk Sunday.*" It does not appear, however, that to this patriotic decree of their parliament the people paid much attention; and fourteen years afterwards, in May, 1471, it was judged necessary to pass another Act "anent wapenshawings," and for opposing "our auld enimies of England." But it seems to have been pretty much as before; *schuttin* was no more *usit*, nor golf the less steadily played because of these decrees of parliament; and accordingly, in 1491, a final and evidently angry fulmination is issued on the general subject, with pains and penalties annexed. It runs thus—"Futeball and Golfe forbidden. Item, it it statut and ordainit that in na place of the realme there be usit futeball, *golfe, or uther sik unprofitabill sportis*, but for the commoun gude of the realme, and defence thereof, *that bowis and schuttin be hanted*, and bow-markis maid therefor, ordainit in ilk parochin under the pain of fourtie shillinges, to be raisit be the schireffe and baillies foresaid," etc. This, be it noted, is an edict of James IV.; and it is not a little curious presently to find the monarch himself breaking his own behest, and setting an ill example to his commons, by practice of this "unprofitabill sport," as is shown by various entries in the accounts of the Lord High Treasurer of Scotland (1503–6).

About a century later, the game again appears on the surface of history, and it is quite as popular as before. In the year 1592, the Town Council of Edinburgh "ordanis proclamation to be maid threw this burgh that, seeing the Sabboth day being the Lordis day, it becumis every Christiane to delicat himselff to the service of God, thairfore commanding in our soverane lord's name, and in name of the provost and baillies, that na inhabitants of the samyn be seen at ony pastymes within or without the toun, *upoun the Sabboth day, sic as golfe, etc.*"[2] The following year the edict was reannounced, but with the modification that the prohibition was "in tyme of sermons."

Golf has from old times been known in Scotland as "The *Royal and Ancient* Game of Goff." Though no doubt Scottish monarchs handled the club before him, James IV. is the first who figures formally in the golfing record. James V. was also very partial to the game distinctively known as "royal;" and there is some scrap of evidence to show that his daughter, the unhappy Mary Stuart, was, in some sort of feminine way, a *golfer*. It was alleged by her enemies that, as showing her shameless indifference to the fate of her husband, a very few days after his murder, she "was seen playing *golf* and pallmall in the fields beside Seton."[3] That her son, James VI. (afterwards James I. of England), was a golfer tradition confidently asserts, though the evidence which connects him with the personal practice of the game is slight. Of the interest he took in it we have evidence in his Act—already alluded to—"anent *golfe ballis*," prohibiting their importation, except under certain restrictions. Charles I. (as his brother Prince Henry had been[4]) was devotedly attached to the game. Whilst engaged in it on the links of Leith, in 1642, the news reached him of the Irish rebellion of that year. He had not the equanimity to finish his match, but returned precipitately and in much agitation to Holyrood.[5] Long afterwards, while prisoner to the Scots army at Newcastle, before being given up to the tender mercies of the English Parliament, he found his favorite diversion in "the royal game." "The King was nowhere treated with more honor than at Newcastle, as he himself confessed, both he and his train having liberty to go abroad and play at golf in the Shield Field, without the walls."[6] Of his son, Charles II., as a golfer, nothing whatever is ascertained, but his brother, James II., was a known devotee.[7] After the Restoration, James, then duke of York, was sent to Edinburgh in 1681–2 as commissioner of the king to parliament, and an historical monument of his prowess as a golfer remains there to this day in the "Golfer's Land," as it is still called, 77 Canongate. The duke having been challenged by two English noblemen of his suite, or *entourage*, to play a match against them, for a very large stake, along with any Scotch ally he might select, judiciously chose as his partner one "Johne Patersone," a shoemaker—a local *crack* of the day, it is to be presumed. The duke and the said Johne won easily, and half of the large stake the duke made over to his humble coadjutor, who therewith built himself the house mentioned above. With the Revolution royal patronage entirely ceased, to be renewed only in comparatively recent times. In 1834 William IV. became patron of the St. Andrews Golf Club (St. Andrews, the ancient ecclesiastical metropolis of Scotland, being now, as of old, the most famous seat of the game), and to approve of its being styled in time coming "The *Royal and Ancient* Golf Club of St. Andrews." In 1837, as further proof of royal favor, he presented to it a magnificent gold medal, which "should be challenged and played for annually;" and in 1838 the queen dowager, duchess of St. Andrews, became patroness of the club, and presented to it a handsome gold medal —"The Royal Adelaide,"—as a mark of her approbation, with a request that it should be worn by the captain, as president, on all public occasions. In June, 1863, the prince of Wales signified his desire to become patron of the club, and in the following September was elected captain by acclamation. The engagements of the prince did not admit of his coming in person to undertake the duties of the office, but his brother Prince Leopold, having in 1876 done the club the honor to become its captain, twice visited the ancient city in that capacity. Prince Leopold is himself a keen player, and under his superintendence a green has been laid out in Windsor-park. The ancient game of golf has thus fairly now again become as "royal" as ever it was in its old historic periods.

The later fortunes of the game have been uneventful. While always keeping its hold on the affections of the people, it might readily be shown, that over Scotland generally its tide, till nearly within our own time, was rather an ebbing than a flowing one. While it remained a favorite pastime with some of the aristocracy and gentry who always had a sufficient following where—as instance, in Edinburgh—the due facilities admitted, the general enthusiasm for the sport which lives for us in the old records had certainly disappeared, and over various isolated greens, where playing was at one time constant, it had virtually and sometimes absolutely died out. Its increased popularity within recent years has no doubt been largely due to those general causes which have led to a keener interest in almost every form of out-door amusement, but it is also in some measure to be attributed to greatly extended railway facilities, and to the introduction some thirty years ago of the cheap and durable gutta percha ball to replace the old missile.[1]

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[1] A complete set of them may number about a dozen:—a driving club, a long, a middle, and a short "spoon" (so called from the face of the club being spooned, or bevelled, to lift a bad-lying ball), and a "putter" (the use of which is explained below) are the clubs formed wholly of wood, while of iron there are—a heavy and a light "iron," a driving and a lifting "cleek," possibly also a "putting" cleek, finally a "niblick," constructed to pick a ball out of some such hole as no other iron can reach.

[2] *Records of the City of Edinburgh.*

[3] *Inventories of Mary Queen of Scots*, preface, p. lxx., 1863.

[4] Anonymous author of MS. in the Harleian Library.

[5] See *History of Leith*, by A. Campbell, 1827.

[6] *Local Records of Northumberland*, by John Sykes, Newcastle, 1833.

[7] Robertson's *Historical Notices of Leith.*

It remains to give some little account of the more noted golf clubs and golfing grounds. The most famous of golf clubs, to which primacy is by common consent accorded, is that of the city of St. Andrews, instituted in 1754. For various reasons this club has always been of much more than merely local celebrity. Its membership is far more numerous than that of any other; nearly all golfers of note belong to it; and to its spring and autumn meetings they flock from every part of the kingdom. To be winner of a medal at St. Andrews is thus the highest honor to which the ambition of the golfer can aspire. A "round," as it is termed, of the links is very nearly four miles; and, extent and quality considered, the green is on the whole unrivalled by any other in Scotland. Of greens in Fife of minor importance, those of Elie and Leven may be noted. Next in importance to "The Royal and Ancient Golf Club of St. Andrews" ranks "The Honorable the Edinburgh Company of Golfers," who play over Musselburgh green, one of fair but scarcely supreme quality. The first of its regular series of minutes bears date 1744, and is signed by Lord President Duncan Forbes of Culloden, but the club itself is beyond question very much older. Of other Edinburgh golf clubs may be noted "The Bruntsfield," founded in the year 1760, and the "Edinburgh Burgess," the minute books of which are preserved since the year 1773, though it claims to have date of origin 1735. In East Lothian, besides the good old green of North Berwick, there are of late years two others,—Gullane and Luffness,—and on all three excellent golfing sport is to be had. At the ancient city of Perth, though the ground is but indifferently adapted for it, the old Scottish game has continuously been maintained, and still flourishes. So also in Forfarshire, at the historic green of Montrose, to which in our own time have been added those of Monifeith and Carnoustie, which, from their proximity to Dundee, naturally attract many players; and all three may be ranked as greens of fair quality. At Aberdeen, till very lately, the game had quite died out, but it has now been with more or less of vigor resumed. At Stirling likewise it was extinct, but is now again fairly alive, though under conditions of ground, as at Perth, not quite satisfactory. At Glasgow also, where on the old "Glasgow Green" the game was habitually played, it had lapsed into disuse and even oblivion: but within the last ten years the general resuscitation has reached it, and a spirited club now exists there. If the ground is by no means what might be wished, the Glasgow golfer, by a very easy railway run, can reach the green of Prestwick, near Ayr. The "Prestwick Club" is, by comparison, of recent origin, having been organized mainly by the last earl of Eglintoun, and one or two gentlemen in the neighborhood, interested like himself in the game. Except for limitation in extent, making it impossible that a large "field" should be accommodated without confusion and even danger, such is the excellence of the ground that, as a "sporting" green, to test play, that of Prestwick is held by competent judges perhaps to surpass all others. A second links has recently been opened at Prestwick, and another at Troon, on the same coast.

The oldest golf club in the kingdom is not improbably that of Blackheath, near London. The old records of the club were unfortunately destroyed by fire at Greenwich, where they were kept, and 1766 is thus the earliest date for which there is documentary evidence. Tradition places the origin of this club so far back as 1608, when King James, with his Scotch following, brought the game south into England. Recently another London club has been started, whose ground of play is at Wimbledon. Neither green is of great merit, but both are much prized and frequented by golfers in and near London. In 1864, at Bideford, in Devonshire, a golfing green was laid out by the well-known Tom Morris of St. Andrews, and a club was duly instituted, which has since continued to flourish. This links is one of the finest and most extensive anywhere to be found, and despite the disadvantage of remoteness and difficulty of access, the meetings of the club attract players from all quarters, and are commonly most successful. More lately an excellent green was opened at Hoylake, near Liverpool, and the club here has also prospered greatly. At Crookham in Berkshire, and Alnwick in Northumberland, the game is regularly played; and at the universities of Oxford and Cambridge rival golf clubs have within the last few years been formed. In brief, the game has now thoroughly taken root in England; from year to year it is rapidly spreading, and many fine English players have already passed into the front rank.

In nearly all the British colonies the game has naturalized itself. Golf clubs of old standing exist at Calcutta and Bombay, and more casually over India a good deal of play is to be met with. Wherever Scots congregate in any numbers a golf club is pretty sure to spring up. In Canada and the United States, as in Australia and New Zealand, many clubs may be found flourishing; and oddly enough, at Pau in the Pyrenees, a golf club has long existed. An export of clubs and balls to all these golfing dependencies has long formed, and still forms, an important item of the manufacture.

We must not quit the subject without making note of one pleasing innovation. Some six or eight years ago, the ladies took to the game, and since have diligently prosecuted it in large numbers, some attaining no mean proficiency. They have hitherto confined themselves to the "short game," as it is termed, or putting; and where a separate piece of ground has been assigned them, as at St. Andrews, North Berwick, and elsewhere, the "Ladies' Links" form a pretty and charming adjunct to the main green.

We append the more important rules of the game, as played by "The Royal and Ancient Golf Club of St. Andrews," which, though it has no claim to give law to other clubs, may be accepted as, on the whole, the best authority on the subject:—

I. *Mode and Order of Playing the Game.*—The game of golf is played by two persons, or by four (two of a side), playing alternately. It may also be played by three or more persons, each playing his own ball. The game commences by each party playing off a ball from a place called the *tee*, near the first hole. In a match of four, those who are opposed to each other, and to play off, shall be named at starting, and shall continue so during the match. The person entitled to play off first shall be named by the parties themselves; and although the courtesy of starting is generally granted to old captains of the club, or members, it may be settled by lot or toss of a coin. The hole is won by the party holing at fewest strokes, and the reckoning of the game is made by the terms *odds* and *like, one more, two more*, etc. The party gaining the hole is to lead, unless his opponent has won the previous match, in which case the latter leads off, and is entitled to claim his privilege, and to recall his opponent's stroke should he play out of order. One round of the links, or 18 holes, is reckoned a match, unless otherwise stipulated. If, in a double match, one person shall play twice in succession, he loses the hole.

II. *Place of Teeing.*—The ball must be teed not nearer the hole than eight, nor further than twelve club lengths, except where special ground has been marked by the conservator of the links, which shall be considered the "teeing ground," and the balls shall be teed within and not in advance of such marks. After the balls are struck off, the ball farthest from the hole to which the parties are playing must be played first. When two parties meet on the putting green, the party first there may claim the privilege of holing out, and any party coming up must wait till the other party has played out the hole, and on no account play their balls up lest they should annoy the parties who are putting. No player may play his teed ball till the party in front have played their second strokes.

III. *Changing the Balls.*—The balls struck off from the tee must not be changed, touched, or moved before the hole is played out (except in striking, and the cases provided for by Rules VIII., XVIII., and XIX.); and if the parties are at a loss to know the one ball from the other, neither shall be lifted till both parties agree.

IV. *Lifting of Break-Clubs*, etc.—All loose impediments within a club length of the ball may be removed on or off the course, when the ball lies on grass (see Rules VI. and XII.). When a ball lies in a bunker, sand, or any other hazard, there shall be no impression made, nor sand or other obstacle removed by the club, or otherwise, either on or off the green, before striking at the ball. When a ball lies within a club length of a washing-tub, the tub may be removed, and when on clothes the ball may be lifted and dropped behind them.

V. *Entitled to see the Ball.*—When a ball is completely covered with fog, bent, whins, etc., so much thereof shall be set aside as that the player shall merely have a view of his ball before he plays, whether in a line with the hole or otherwise. A ball stuck fast in wet ground or sand may be taken out and replaced loosely in the hole it has made.

VI. *Clearing the Putting Green.*—All loose impediments of whatever kind, may be lifted on the putting green or table-land on which the hole is placed (excepting as declared in Rule IV.), which is considered not to exceed twenty yards from the hole. Nothing can be lifted either on the course or putting green, if it is to move the ball out of its position.

VII. *Lifting Balls.*—When, on any part of the course, or off it, or in a bunker, the balls lie within six inches of each other, the ball nearest the hole must be lifted till the other is played, and then placed as nearly as possible in its original position—the six inches to be measured from the surface of the balls. In a three-ball match, the ball in any degree interposing between the player and the hole on the putting green, must be played out.

VIII. *Ball in Water, or in the Burn, and Place of Re-teeing.*—If the ball is in water, the player may take it out, change the ball if he pleases, tee it, and play from behind the hazard, losing a stroke. If the ball lies in any position in the burn across the first hole, the player may take it out, tee it on the line where it entered the burn, on the opposite side from the hole to which he is playing, and lose a stroke; or he may play it where it lies, without a penalty. However, should a ball be driven into the Eden at the high hole, or the sea at the first hole, the ball must be placed a club-length in front of either sea or river, the player or party losing a stroke. In playing for a medal, a ball driven into the Eden may be treated as a lost ball.

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[1] The old ball was, roughly, a circlet of leather, stitched together in sections, and stuffed as hard as a stone with feathers. It was about twice the price of the present ball, and almost incomparably less durable.

IX. *Rubs of the Green.*—Whatever happens to a ball by accident, such as striking any person, or being touched with the foot by a third party, or by the fore cady, must be reckoned a rub of the green and submitted to. If, however, the player's ball strike his opponent, or his opponent's cady or clubs, the opponent loses the hole; or if he strikes himself or his partner, or their cadies or clubs, or if he strikes the ball a second time while in the act of playing, the player loses the hole. If the player touch the ball with his foot, or any part of his body, or with anything except his club, or if he with his club displace the ball in preparing to strike, he loses a stroke; and if one party strikes his opponent's ball with his club, foot, or otherwise, that party loses the hole. But if he plays it inadvertently, thinking it his own, and the opponent also plays the wrong ball, it is then too late to claim the penalty, and the hole must be played out with the balls thus changed. If, however, the mistake occurs from wrong information given by one party to the other, the penalty cannot be claimed; and the mistake, if discovered before the other party has played, must be rectified by replacing the ball as nearly as possible where it lay. If the player's ball be played away by mistake, or lifted by a third party, then the player must drop a ball as near the spot as possible, without any penalty. Whatever happens to a ball on a medal day, such as a player striking his cady, or himself, or his clubs, or moving the ball with his foot or club, or his cady doing so, or the player striking it twice before it stops motion, the player in such cases shall lose one stroke only as the penalty.

X. *Ball Lost.*—If a ball is lost, the player (or his partner, in a double match) returns to the spot, as near as possible, where the ball was struck, tees another ball, and loses both the distance and a stroke. If the original ball is found before the party has struck the other ball, the first shall continue the one to be played.

XI. *Club Breaking.*—If, in striking, the club breaks, it is nevertheless counted to be a stroke, if the part of the club remaining in the player's hand either strike the ground or pass the ball.

XII. *Holing out the Ball.*—In holing, no mark shall be placed, or line drawn, to direct the ball to the hole; the ball must be played fairly and honestly for the hole, and not on your opponent's ball not being in the way to the hole; nor, although lying in the way to the hole, is the player entitled to play with any strength upon it that might injure his opponent's position, or greater than is necessary honestly to send your own ball the distance of the hole. Either party may smooth sand lying around the hole, but this must be done lightly and without pressure, or beating down with the feet, club, or otherwise. If, in holing out, the ball rests upon the flag-stick in the hole, the player shall be entitled to have the stick removed, and if the ball falls in, it shall be considered as holed out; but either party is entitled to have the flag-stick removed when approaching the hole.

XIII. *Unplaying Balls.*—In *Match* playing every ball must be played, wherever it lies, or the hole be given up, excepting when it lies on clothes, in water, or in the bed of the burn (see Rules IV. and VIII.), or in any of the holes, or short holes, made for golfing, in which latter case it may be lifted, dropped behind the hazard, and played without losing a stroke. In *Medal* playing a ball may, under a penalty of two strokes, be lifted out of a difficulty of any description, and teed behind the hazard, and if in any of the golfing holes, it may be lifted, dropped, and played, without a penalty. In all cases where a ball is to be dropped, the party doing so shall front the hole to which he is playing, standing close on the hazard, and drop the ball behind him from his head.

XV. *Asking Advice.*—A player must not ask advice about the game, by word, look, or gesture, from any one except his own cady, his partner's cady, or his partner.

XVIII. *Balls Splitting.*—If a ball shall split into two or more pieces, a fresh ball shall be put down where the largest portion of the ball lies; and if a ball is cracked the player may change it on intimating his intention of doing so to his opponent.

XIX. *Breach of Rules.*—Where no penalty for the infringement of a rule is specially mentioned, the loss of the hole shall be understood to be the penalty.

Golf which, as we have seen, has a history of some interest, has also a literature (copious in verse and prose), and a somewhat amusing anecdotage. In *Golf, a Royal and Ancient Game*, a work issued in 1875 by Mr. Robert Clark of Edinburgh, a well-known and accomplished adept, a very careful collection will be found of everything connected with the game which in this form deserves preservation. Through the ready kindness of the author this admirable compendium has been available, and free use has been made of it, in the preparation of this article.

(P. P. A.)

GOLGOTHA. See JERUSALEM.

GOLIUS, JACOBUS (1596–1667), Orientalist, was born at the Hague in 1596, and studied at Leyden, where in Oriental languages he was the most distinguished pupil of Erpenius. In 1622 he accompanied the Dutch embassy to Morocco, and on his return he was chosen to succeed Erpenius (1624). In the following year he set out on a Syrian and Arabian tour from which he did not return until 1629. The remainder of his life was spent at Leyden, where from that date he held the chair of mathematics as well as that of Arabic until his death, which occurred on September 28th, 1667.

His most important work is the *Lexicon Arabico-Latinum*, fol., Leyden, 1653, which, based on the *Sihah* of Al-Jauhari, has only recently been superseded by the corresponding work of Freytag. Among his earlier publications may be mentioned editions of various Arabic texts (*Proverbia quædam Alis, imperatoris Muslemici, et Carmen Tograi, poetæ doctissimi, necnon dissertatio quædam Aben Synæ*, 1629; and *Ahmedis Arabsiadæ vitæ et rerum gestarum Timuri, qui vulgo Tamerlanes dicitur, historia*, 1636). In 1656 he published a new edition, with considerable additions, of the *Grammatica Arabica* of Erpenius. After his death, there was found among his paper a *Dictionarium Persico-Latinum* which was published, with additions, by Edmund Castell in his *Lexicon Heptaglotton* (1669). Golius also edited, translated, and annotated the astronomical treatise of Alfragan (*Muhammedis, filii Ketiri Ferganensis, qui vulgo Alfraganus dicitur, Elementa Astronomica Arabice et Latine* (1669).

GOLLNOW, a town in the Prussian province of Pomerania, government district of Stettin, is situated on the right bank of the Ilna, 14 miles N. N. E. of Stettin, with which it has communication by steamer. It possesses two suburbs, and has manufactures of linen and woollen goods, copper wares, ribbons, paper, and tobacco. Gollnow was founded in 1190, was raised to the rank of a town by Barnim I. in 1268, and in 1314 received Lübeck rights. It was formerly a Hanse town, and came into the possession of Prussia in 1720. The population in 1876 was 7913.

GÖLNITZ, or **GÖLLNITZ** (GOLNICZBÁNYA), a mining town of Hungary, on a river of the same name, in the county of Szepes (Zips), about 18 miles south-west of Eperies, 48° 51′ N. lat., 20° 59′ E. long. In the vicinity are iron and copper mines, which with the forges, and the nail and wire factories, etc., afford employment to most of the inhabitants. It is the seat of a mining council and tribunal, has Roman Catholic and Protestant churches, post and telegraph offices, and a high school. In 1870 the population amounted to 5205, composed of Magyars, Slavs, and Germans. Gölnitz was formerly a royal free town; its chief importance now is as a mining centre.

GOLOVNIN, VASILY MIKHAILOVICH (1776–1831), a Russian vice-admiral, was born April 20, 1776, in the village of Gulynki, in the province of Ryazan, and received his education at the Cronstadt naval school. From 1801 to 1806 he served as a volunteer in the English navy. In 1807 he was commissioned by the Russian Government to survey the coast of Kamchatka and of Russian America, including also the Kurile Islands. Golovnin sailed round the Cape of Good Hope, and on October 5, 1809, arrived in Kamchatka. In 1810, whilst attempting to survey the coast of the island of Kunashir, he was seized by the Japanese, and was retained by them as a prisoner until October 13, 1813, when he was liberated, and in the following year he returned to St. Petersburg. Soon after this the Government planned another expedition, which had for its object the circumnavigation of the globe by a Russian ship, and Golovnin was appointed to the command. He started from St. Petersburg on the 7th September, 1817, sailed round Cape Horn, and arrived in Kamchatka in the following May. He returned to Europe by way of the Cape of Good Hope, and landed at St. Petersburg, September 17, 1819. He died July 12, 1831.

Golovnin published several works of which the following are the most important:—*Journey to Kamchatka*, 2 vols., 1819; *Journey round the World*, 2 vols., 1822; and *Narrative of my Captivity in Japan*, 2 vols. 1816. The last has been translated into French, German, and English. A complete edition of his works was published at St. Petersburg, 1864, in five volumes, with maps and charts, and a biography of the author by N. Grech.

GOLTZ, Bogumil (1801–1870), humorist and satirist, was born of a German family settled at Warsaw, March 20, 1801. At the age of seven he was taken by some friends to Königsberg, and after studying at the gymnasium was placed under the care of a country clergyman near Marienwerder. He next went to the gymnasium of Marienwerder, and finally returned to Königsberg. In 1817 he began to learn practical farming on an estate near Thorn, but the strong desire which he felt for scientific culture led him, five years later, to the university of Breslau. There he at first entered upon the study of theology, but he did not pursue it, selecting instead philosophy and philology. The next year he bought an estate near Thorn, married the daughter of a Prussian officer, and applied himself to the duties of a farmer. He did not succeed; and after other equally unsuccessful experiments in the same line in Poland and Prussia, he retired in 1830 to the small town of Gollub, and devoted himself to literary studies. Sixteen years of meditative seclusion passed away; and then, having taken up his abode at Thorn, he gave to the world the first fruits of his studies and reflections in the charming poetic *Buch der Kindheit* (1847), in which he delineates the incidents and impressions of his own childhood with a tender feeling like that of Jean Paul. The dates which he gives in this narrative are inconsistent with those which he furnished for the memoir in Brockhaus's *Conversations-Lexikon*; and a chronological difficulty is thus created which perhaps it may not be possible to solve.

The *Buch der Kindheit* was speedily followed by a satirical and polemical epistle against Ronge and the friends of enlightenment, which he entitled *Deutsche Entartung in der lichtfreundlichen und modernen Lebensart.* For the purpose of enlarging his experience of men, and amassing stores of material for his art as humorist and reformer of human life and society, he undertook a course of extensive travels, visiting Germany, France, England, Italy, and Egypt. In 1850 he published *Das Menschendaseyn in seinen weltewigen Zügen und Zeichen.* This was followed by another poetically conceived work on his own early life, entitled *Ein Jugendleben; Biographisches Idyll aus Westpreussen* (1852), and by *Ein Kleinstädter in Aegypten* (1853). In his next work, *Der Mensch und die Leute* (1858), he especially displays his peculiar powers in profound and acute sketches of various races of men. It is a book of enduring value. His *Die Deutschen,* consisting of a series of studies on the history and peculiarities of the genius of the Germans, appeared in 1860. His other works are *Zur charakteristik und Naturgeschichte der Frauen* (1859), *Typen der Gesellschaft* (1860), *Die Bildung und die Gebildeten* (1864), *Vorlesungen* (1869), and *Die Weltklugheit und die Lebensweisheit mit ihren correspondirenden Studien* (1869). Goltz is a follower of Jean Paul, and has many of the characteristics of his master; but he takes a lower place as literary artist, wanting Jean Paul's creative imagination. He died at Thorn, November, 11, 1870.

An interesting essay on Goltz was contributed by the poet, Rudolf Gottschall, to *Unsere Zeit,* new series, 1871.

GOLTZIUS, Hendrik (1558–1617), a Dutch painter and engraver, was born in 1558 at Mülebrecht, in the duchy of Juliers. After studying painting on glass for some years under his father, he was taught the use of the burin by Dirk Volkertsz Coornlert, a Dutch engraver of mediocre attainment, whom he soon surpassed, but who retained his services for his own advantage. He was also employed by Philip Galle to engrave a set of prints of the history of Lucretia. At the age of twenty-one he married a widow somewhat advanced in years, whose money enabled him to establish at Haarlem an independent business; but his unpleasant relations with her so affected his health that he found it advisable in 1590 to make a tour through Germany to Italy, where he acquired an intense admiration for the works of Michelangelo, which led him to surpass that master in the grotesqueness and extravagance of his designs. He returned to Haarlem considerably improved in health, and labored there at his art till his death, January 1, 1617. Goltzius ought not to be judged chiefly by the works he valued most, his eccentric imitations of Michelangelo. His portraits, though mostly miniatures, are master-pieces of their kind, both on account of their exquisite finish, and as fine studies of individual character. Of his larger heads, the life-size portrait of himself is probably the most striking example. His "master-pieces," so called from their being attempts to imitate the style of the old masters, have perhaps been overpraised. In his command of the burin Goltzius is not surpassed even by Dürer; but his technical skill is often unequally aided by higher artistic qualities. Even, however, his eccentricities and extravagances are greatly counterbalanced by the beauty and freedom of his execution. He began painting at the age of forty-two, but none of his works in this branch of art—some of which are in the imperial collection at Vienna—display any special excellences. He also executed a few pieces in chiaroscuro. His prints amount to more than 300 plates, and are fully described in Bartsch's *Peintre-graveur*, and Weigel's supplement to the same work.

GOMARUS, Francis (1563–1641), professor of theology at Leyden, was born at Bruges on the 30th January, 1563. His parents, having embraced the principles of the Reformation, emigrated to the Palatinate in 1578, in order to enjoy freedom to profess their new faith, and they sent their son to be educated at Strasburg under John Sturmius. He remained there three years and then went to Neustadt, whither the professors of Heidelberg had been driven by the elector-palatine because they were not Lutherans. He did not stay long at Neustadt, but crossed to England towards the end of the year 1582, and entered first the university of Oxford, where he attended the lectures of John Raynold, and then the university of Cambridge, where he attended those of William Whitaker. At Cambridge he received his bachelor's degree in June, 1584, and thence proceeded to Heidelberg, where the faculty had been by this time reestablished, and continued his studies there for two years more. He was called to be minister of a Reformed church in Frankfort in 1587, and labored there till the congregation was dispersed by the persecution of the year 1593. In 1594 he was appointed professor of theology at Leyden, and before going thither received from the university of Heidelberg the degree of doctor. He taught quietly at Leyden till 1603, when Arminius came to be one of his colleagues in the theological faculty, and began to teach Pelagian doctrines and to create a new party in the university. Gomarus immediately set himself earnestly to oppose these views, in his classes at college, and wherever he found opportunity. He became the leader of the opponents of Arminius, who from that circumstance came to be known as Gomarists. He engaged twice in personal disputation with Arminius in the assembly of the estates of Holland in 1608, and was one of five Gomarists who met five Arminians or Remonstrants in the same assembly in the following year. On the death of Arminius shortly after this time, Vorstius, who sympathized with his views, was appointed to succeed him, in spite of the keen opposition of Gomarus and his friends; and Gomarus took his defeat so ill that, rather than have such a man for his colleague, he resigned his post, and went to Middleburg in 1611, where he became minister of a congregation and gave public lectures. From this place he was called to a chair of theology at Saumur, where he remained four years, and then accepted a call as professor of theology and Hebrew to Gröningen, where he stayed till his death on 11th January, 1641. He took a leading part in the synod of Dort, assembled in 1618 to judge of the doctrines of Arminius. He was a man of ability, enthusiasm, and learning, a considerable Oriental scholar, and also a keen controversialist. He took part in the translation of the Old Testament into Dutch in 1633, and after his death a book by him called the *Lyra Davidis* was published, which sought to explain the principles of Hebrew metre, and which created some controversy at the time, having been opposed by Louis Capel. His works were collected and published in one volume folio, in Amsterdam in 1645.

GOMBROON, another name for Bender-Abbasi (*q. v.*).

GOMER, the eldest son of Japhet (Gen. x. 2), and an ally of Gog (Ezek. xxxviii. 6), has usually, since Calmet's time, been identified with those Cimmerii who, originally inhabiting the districts to the N. E. and N. of the Black Sea and Sea of Azoff, at an early period began to penetrate as far as to Asia Minor, and in the 7th century B. C. overran Lydia, though without leaving permanent traces of their presence. This identification, however, is to be met with in none of the older writers. Josephus understands the Galatians of northern Phrygia to be intended; and Gimmeri or Gamir was, in the language of the ancient Armenians, a usual designation for their neighbors the Cappadocians (see Dillmann on Gen. x. 2; whose authority is Kephalion, in the Armenian version of the *Chronica* of Eusebius, ed. Aucher). It is not impossible that an intimate ethnological connection between the Cappadocians of Kephalion and the Cimmerians of Homer may ultimately be established; but meanwhile it is important to observe that the three sons of Gomer, as named in Gen. x. 2, admit of a tolerably definite localization. Ashkenaz, who has sometimes been identified with the Germans, is almost certainly the same as the Ascanians, a very ancient tribe of northern Phrygia (*cf.* Strabo, xii. 4, 5, *sqq.*, and note the juxtaposition in Jer. li. 27). Riphath has nothing to do with the Rhipæan mountains, with the Carpathians, or with Niphates, but, as Josephus has pointed out, is to be identified with Paphlagonia; as Bochart has shown, the name probably survives in Ῥῆβας, the designation of a river in Bithynia, and in Ῥηβαντία, a district situated on the Thracian Bosphorus. Although Togarmah is by Josephus interpreted as equivalent to Phrygia, there is a considerable amount of ancient testimony in favor of its identification with Armenia. It is possible that the same root is actually at the basis of the two words; at all events the connection is assumed in the account which the Armenians themselves give of their legendary history.

GONDA, a district of Oudh, lying between 26° 46′ and 27° 50′ N. lat., and between 81° 35′ and 82° 48′ E. long., bounded on the N. by the lower range of the Himálayas, on the E. by Basti district, on the S. by Fyzabad and Bara Banki, and on the W. by Bharaich, and having an area of 2824 square miles.

Gonda presents the aspect of a vast plain with very slight undulations, studded with groves of mango trees. The surface consists of a rich alluvial deposit which is naturally divided into three great belts known as the *tarái* or swampy tract, the *uparhár* or uplands, and the *tarhár* or wet lowlands, all three being marvellously fertile. Several rivers flow through the district, but only two, the Gogra and Rápti, are of any commercial importance, the first being navigable throughout the year, and the latter during the rainy season. The country is dotted over with small lakes, the water of which is largely used for irrigation. The *feræ naturæ* consist of tigers, leopards, bears, wolves, and deer. Large game birds are plentiful.

This district has no particular history of its own; what ancient history it has is included in that of Oudh. On the outbreak of the mutiny, the rájá of Gonda, after honorably escorting the Government treasures to Fyzabad, joined the rebels. His estates, along with those of the rání of Tulsipur, were confiscated and conferred as rewards upon the mahárájás of Balrámpur and Sháhganj, who had remained loyal. The census of 1869 disclosed a population of 1,166,515 (602,862 males, and 563,653 females)—Hindus, 1,049,397; Mahometans, 117,070; Christians—European, Eurasian, and native—48. Five towns contain a population exceeding 5000, namely, Gonda, Balrámpur, Colonelganz, Nawabganj, and Utraula. Rice, wheat, and barley are the chief products of the district. The area under cultivation is 993,858 acres. The exports are rice and food grains; the imports, cotton, European piece goods, and salt. The administration is under a deputy commissioner, aided by two European assistants. The total revenue (1875–76) amounted to £135,509; the expenditure to £15,810. The police force (1873) consisted of 484 officers and men, maintained at a cost of £6655. Education is still in its infancy. In 1875–76 there were 116 schools under Government inspection, attended by 5879 pupils. Fever is prevalent throughout the district. The other principal diseases are scurvy, cholera, diarrhœa, and goitre. The average rainfall during the eleven years 1865–75 was 42·0 inches. The average yearly temperature is 77·5° Fahr., the highest recorded being 106°, the lowest 48°.

GONDA, the chief town and administrative headquarters of Gonda district, in 27° 8′ N. lat. and 82° 1′ E. long. The site on which the town now stands was originally a jungle, in the centre of which was a cattle fold (Gontha or Gothán), in which the cattle were enclosed at night as a protection against wild beasts, and from this the town derived its name. The place was formerly celebrated for the manufacture of shields; now it is neither of commercial nor of religious importance. The town contains a civil station, dispensary, school, literary institute, court-house, and jail. Population, 13,722.

GONDAR, properly GUENDAR, a town of Abyssinia, formerly the capital of the Amharic kingdom, is situated on a basaltic ridge in the country of Dembea, about 21 miles N. E. of Lake Tsana or Tana, a splendid view of which is obtained from the castle. According to Rüppell, its latitude is 12° 35′ N. and its longitude 37° 31′ 57″ E., and it lies 7460 feet above the level of the sea. Two streams, the Angreb on the east side and the Gaha or Kaha, on the west, flow down from the ridge, and meeting below the town pass onwards to the lake. In the Gaha the Christian inhabitants of Gondar are accustomed to bathe in vast disorderly crowds on the feast of St. John the Baptist (10th September), and again in a more decent manner on the anniversary of the Saviour's birth. The town is divided into several districts separated from each other by wood and field,—one being the Abun-Bed or bishop's quarter, another the Etchege-Bed or quarter of the prior or chief of the monks, while a third takes its name from the Debra Birhan or Church of the Light, and a fourth from the Gemp or castle. This was at one time a splendid pile, designed on the plan of a mediæval stronghold; and the solidity of its masonry, the beauty of its ornamentations, and the general effect of its arrangement stand in striking contrast to the mean and monotonous houses of the town, which are all erected after the cylindro-conical type. It was built in the 16th century for King Socinius by the Portuguese adventurers, who employed Indian workmen in its erection. At some distance there is another palace built at a later date for Ras Michael, which affords no bad imitation of the Portuguese style. Upwards of forty churches, all in the circular Abyssinian style, are said to exist in the town and immediate vicinity; of these the most important is the Quisquam or Flight into Egypt, erected by Mintwab Muntwar, the empress mother of Yasu the Great and Yasu the Little. The painting of the interior was probably executed by the Venetian artists mentioned by Bruce. The city was founded in the 15th century by emperor Fasilidas or A'lem-Seged; it has been frequently sacked, and in 1868 it was laid in ruins by Theodorus, who did not spare either the castle or the churches. The population, estimated by Bruce at 10,000 families, has been brought to a very low ebb by the political distractions of the country. In 1853 Heuglin thought the inhabitants might number from 5000 to 6000, and in 1861–62 he raised the figure to from 6000 to 7000. About 2000 of the number are Mahometans, and there is a considerable settlement of Jews (Falasha). Cotton cloth, gold and silver ornaments, copper wares, fancy articles in bone and ivory, excellent saddles, and shoes are among the products of the local industry. The shoes are made almost exclusively for the clergy, as the ordinary Abyssinians either go barefoot or wear sandals. See especially Rüppell, *Reise in Abyssinien*, Frankfort-on-the-Main, 1838–40; Heuglin, *Reise nach Abessinien*, Jena, 1868; Lejean, *Voyage en Abyssinie*, Paris, 1872; and Raffray, *Afrique Occidentale*, Paris, 1876. Views of the castle are given by Heuglin and Raffray.

GONDOKORO. See ISMAILIA.

GONDWÁNA, a tract of country in Central India, extending from the 19th to the 25th degree of N. lat., deriving its name from the aboriginal tribe of *Gonds*, who form the predominant element in the population. The tract may be considered as comprising part of the British territory of Ságor and Nerbudda, with the districts of Singraulí, Chotá Nágpur, and Sirguja, the petty native states on the S. W. frontier of Bengal, the Cuttack Mahals, and the northern portion of Nágpur. It is estimated to be 400 miles in length by 280 in average breadth. Gondwána, in its most extensive sense, includes all that part of India within the above-mentioned boundaries which remained unconquered by the Mahometans up to the reign of Aurungzebe. But Gondwána proper is limited to four districts, named Mándla, Chhatísgarh, Nágpur, and Chándal, and it stretches south along the east side of the Wardha and Godávari, to within 100 miles of the mouth of the latter. The greater part of this province is a mountainous, unhealthy, and ill-watered country, covered with jungle, and thinly inhabited; and to its poverty and other bad qualities its independence may be ascribed. A continued chain of moderately elevated hills extends from the southern frontier of Bengal almost to the Godávari, and by these the eastern was formerly separated from the western portion of the Nágpur dominions. This province contains the sources of the Nerbudda and the Son, and is bounded by the Wardha and Godávari; but a want of water is still the general defect, the streams by which it is intersected, namely, the Mahánadi, Kárun, Hatus, and Siláir, being inconsiderable, and not navigable within its limits. The

Gonds, or the hill tribes who took refuge in the mountains and fastnesses from the invaders of the country, are the original inhabitants of the country, and, till recently, retained all their primeval habits of barbarism. They have now adopted a form of Hinduism, but they retain many of their ancient customs, and abstain from no flesh except that of the ox, cow, and bull. According to the census of 1872 they numbered 2,041,276, or nearly 25 per cent. of the entire population of the Central Provinces. The more fertile tracts of Gondwána were subdued at an early period by the Marhattás, who claimed as paramount over the whole. The inhabitants were rendered nominally tributary; but it was found impossible to collect any revenue from them without military force, so that, in fact, the collection of the revenue was like a plundering expedition, the cost of which always exceeded the profit.

During the war against the Pindáris in 1818 when the British troops invaded the territories of Appa Sáhib, the rájá of Nágpur, their operations were greatly facilitated by the insurrection of the hill tribes, who occupied the passes into the Nágpur territories. For a long series of years it was the policy of the rájá of this territory, a descendant of Sivají, to interfere as little as possible with the neighboring powers. At length, in 1803, Raghoji Bhonslá was induced, in an evil hour for himself, to depart from this system of neutrality, and to join Sindhia in a confederacy against the British. He was soon reduced, however, by the defeats which the confederates sustained at Assaye and Argaum, to sue for peace, as the price of which he ceded a large portion of his dominions to the conquerors, namely the province of Orissa. After the death of this rájá, the throne, contested by various competitors, was at last secured by Appa Sáhib, his nephew, who, in the war against the Pindáris, joined the coalition against the British power, and was involved in ruin along with his other allies. A treaty of peace was concluded with him, which he violated; and he was finally deposed in 1818, and the grandson of the late rájá put in his stead. The latter prince, after a reign of 35 years, died without issue in 1853; the dynasty thus became extinct, and the kingdom of Nágpur was incorporated with the British empire, and now forms the chief commissionership of the Central Provinces.

GONG (Chinese, *gong-gong* or *tam-tam*), a sonorous or musical instrument of Chinese origin and manufacture, made in the form of a broad thin disc with a deep rim. Gongs vary in diameter from about 20 to 40 inches, and they are made of bronze containing a maximum of 22 parts of tin to 78 of copper; but in many cases the proportion of tin is considerably less. Such an alloy, when cast and allowed to cool slowly, is excessively brittle, but it can be tempered and annealed in a peculiar manner. If suddenly cooled from a cherry-red heat, the alloy becomes so soft that it can be hammered and worked on the lathe, and afterwards it may be hardened by re-heating and cooling it slowly. In these properties, it will be observed, the alloy behaves in a manner exactly opposite to steel, and the Chinese avail themselves of the known peculiarities for preparing the thin sheets of which gongs are made. They cool their castings of bronze in water, and after hammering out the alloy in the soft state, the finished gongs are hardened by heating them to a cherry-red, and allowing them to cool slowly. The gong is beaten with a round, hard, leather-covered pad, fitted on a short stick or handle. It emits a peculiarly sonorous sound, its complex vibrations bursting into a wave-like succession of tones, sometimes shrill, sometimes deep. In China and Japan it is used in religious ceremonies, state processions, marriages, and other festivals; and it is said that the Chinese can modify its tone variously by particular ways of striking the disc. Among Western communities it is only employed as a substitute for a dinner bell or a general household signal.

GÓNGORA Y ARGOTE, Luis de (1561–1627), Spanish lyric poet, was born at Cordova, on the 11th of July, 1561. His father, Don Francisco de Argote, was corregidor of that city; and his mother, Doña Leonora de Góngora, was descended from an ancient and noble family of Navarre. Having been sent, at the age of fifteen, as a student of civil and canon law to the university of Salamanca, he soon took a prominent place among his fellow-students; but the great talent which he exhibited did not point in the direction either of legal or of diplomatic employments. Leaving the university some years afterwards (the exact date is unknown) without a degree, but already with a considerable literary reputation, he returned to Cordova, where he had succeeded to a moderate property, and where he was able to associate on terms of intimacy and equality with the best society of the city and province. Lope de Vega, writing about 1593, speaks of him as surrounded there by a literary society, and acknowledged as its chief. In 1604, when past his fortieth year, he took the tonsure, and accepted a prebendal stall in the cathedral of Cordova,—steps which have usually been attributed to worldly or sordid motives, but which really cannot be regarded as unnatural or unbecoming in a man circumstanced as he was. From this time he began to spend a portion of each year at the seat of the court, first at Valladolid and afterwards at Madrid, where as Pellicer, his contemporary, remarks, he "noted everything and pecked at everything with his satirical pen." His circle of literary and other distinguished admirers was now greatly enlarged; but the acknowledgment which the court accorded to his singular genius was both slight and tardy. Ultimately indeed, through the influence of the duke of Lerma and the marquis of Siete Iglesias, he obtained an appointment as honorary chaplain to Philip III., but even this slight honor he was not permitted long to wear. A severe illness, which had seriously impaired his memory, compelled his retirement to Cordova, where, after a period of deep seclusion, he peacefully breathed his last on the 23d of May, 1627. An edition of his poems was published almost immediately after his death by Juan Lopez de Vicuña; but the frequently reprinted edition by Hozes did not appear till 1633. The collection consists of numerous sonnets, heroical, amorous, satirical, humorous, elegiac, and "miscellaneous," of various odes, ballads, songs for the guitar, of a few uncompleted comedies, and of certain larger poems, such as the *Soledades* ("Solitary Musings") and the *Polifemo*, which hardly admit of classification. They all exhibit that learned and polished elaboration of style (estilo culto) with which the name of Góngora is inseparably associated; but if, since the days of Lope de Vega, they have been justly censured for their affected Latinisms, unnatural transpositions, strained metaphors, and frequent obscurity, it must never be forgotten that their author was a man of genius,—a fact cordially acknowledged by those of his contemporaries who were most capable of judging, and indeed a fact capable of direct verification by any one who chooses to take the trouble of reading him even in an imperfect translation. It was only in the hands of those who served themselves heirs to Góngora's style, without inheriting his genius, that, "cultismo" became really laughable; but it is manifestly unjust to charge the memory of the master with the follies of his weaker disciples.

A series of *Leciones Solemnes*, or expository lectures on the *Polifemo*, *Soledades*, *Panegirico*, and *Piramo y Tisbe* was published by Pellicer in 1630; an *Illustracion y Defensa de la Fábula de Piramo y Tisbe*, by Salazar Mardones, followed in 1636; there is also a commentary on the entire works by Salcedo Coronel (1636–48). A good edition of the works of the "Andalucian Pindar" (as Góngora is designated by Pellicer) is that of Brussels (1659). The admirable labors of Churton (*Gongora, an Historical and Critical Essay on the Times of Philip III. and IV. of Spain, with Translations*, 1862) have made this obscure author easily accessible to the English reader.

GONIOMETER. Strictly speaking this name is applicable to any instrument, such as a mural circle, a theodolite, and so on, used for measuring an angle; it is in reality, however, applied exclusively to instruments used for measuring the angles between the faces of crystals. The oldest instrument of the kind was invented by Carangeot, and consisted simply of a pair of rulers jointed together and fitted with a graduated circle for measuring the angle between their edges. A carpenter uses a somewhat similar instrument, not, it is true, for measuring, but for transferring angles. The application of the principle of reflexion by Wollaston in 1809 converted the goniometer into an instrument of precision. His form, with a vertical divided circle, is still much used. The principle of reflexion is briefly this. The crystal is mounted so that it can be rotated about an axis parallel to the edge in which its two faces meet. It is first placed so that a ray of light coming in some fixed direction (say, along the axis of a collimator), when reflected from one face, passes in another fixed direction (say, along the axis of a telescope). The crystal is then turned till the ray reflected from the other face passes in the same direction as before. The angle through which the crystal has been turned is either $180^\circ + 2A$ or $180^\circ - 2A$, where A is the angle between the faces. The introduction of the fixed mirror by Degen and Lang, and of the horizontal circle with collimators, brought the instrument into its most modern form. Babinet, Malus, Mitscherlich, Haidinger, Von Lang, and others have contributed towards perfecting the instrument. Recently Professor W. H. Miller (*Phil. Mag.*, 1876) has described a new form of goniometer. In the paper quoted some useful details concerning the use of the instrument will be found. For further instructions how to use the goniometer the reader may refer to Phillips's *Mineralogy*, or Groth's *Physikalische Krystallographie*, Abth. iii. The modern goniometer has so much in common with the spectrometer that it is unnecessary to describe it in detail here. See Spectroscope.

GONSALVO. See Gonzalo.

GONZAGA, or Gonzugue, an old princely family of Italy, which traces its origin to the emperor Lothair, but first came into notice in the 11th century, after the overthrow of the imperial power in Italy, where they for some time disputed the sovereignty of Mantua with the Bonacosse. The long dispute was ended by the murder of Passerino de Bonacossi in 1328, after which the Gonzaga retained possession of Mantua for four centuries. Their claims were in 1354 confirmed to Ludovico I. (1267–1360) by Louis the Bavarian, who nominated him imperial vicar, and gave him also the sovereignty of Reggio and other towns. Petrino, youngest son of Ludovico, founded the countship of Novellara, which became extinct in 1728. The elder branch of the family was continued by Guido and his son Ludovico II., who, on his death in 1382, was succeeded by his brother Francesco. He was followed in 1407 by his son Giovanni Francesco (1394–1444), on whom, for his services in the Italian wars, the emperor Sigismund in 1433 bestowed the title of marquis. Ludovico III. (1414–1478), son of the preceding, surnamed, for what reason is not quite certain, the Turk, retained a body of troops which he granted on hire to neighboring princes. The younger sons of this Ludovico, Giovanni Francesco and Rudolpho, founded the dukedoms of Gabioneta and Castiglione respectively, which were confiscated in 1692. The elder branch of the family was continued by Frederick I. (1439–1484), whose son, Giovanni Francesco II. (1466–1519), was in 1494 appointed to the supreme command of the united Italian army against Charles VIII. of France, and on the 6th of July of the following year gained the victory of Fornovo, and took prisoner the bastard of Bourbon. His son, Frederick II. (1500-1540), received in 1530 the title of duke from Charles V., and in 1536 the principality of Montferrat. A younger son, Ferdinand, was the founder of the Guastella branch of the family, which became extinct in 1746. Of the succeeding members of the elder branch, the only notable one was Vincenzo I. (1562–1612), to whom the Admirable Crichton was tutor, and by whom he was murdered from jealousy in 1582. This branch became extinct in 1627 through the death of Vincenzo II., sixth successor of Frederick II. The nearest heir was Carlo I., duke of Nevers, who was recognized by the Mantuans, but his claims were contested by Ferdinand II. of Guastella, who had the support of the emperor Ferdinand II. In the war which followed, the duke of Nevers obtained the assistance of Louis XIII. of France, but in 1630 Mantua was captured and pillaged by the imperial troops, and the duke was forced to retire to the States of the Church. In 1631 a treaty was, however, concluded between France and the emperor, by which the duke, on making submission, was reinvested with the duchies of Mantua and Montferrat. Anna, a daughter of Carlo I., became wife of Edward, elector-palatine of the Rhine, and after playing a distinguished part at the French court, died at Paris in 1684, leaving behind her a volume of interesting *Memoirs* (London and Paris, 1686). Carlo died in 1639, and was succeeded by his grandson Carlo III., who, on his death in 1665, was succeeded by his son Carlo IV. This duke married in 1670 Anna Isabella, eldest daughter of Ferdinand duke of Guastella; and on the death of Ferdinand in 1679, he endeavored to obtain possession of that duchy, but was compelled to relinquish his claims to Vincenzo, a cousin-german of the deceased duke. He took part on the side of France in the Spanish succession war, and received a French garrison into Mantua. After the defeat of the French he was placed under the ban by the emperor Joseph I., whereupon Victor Amadeus of Savoy conquered Montferrat, and Austria, in agreement with France whom Carlo had offended, took possession of Mantua. On his death without issue in 1708, the dynasty of the Gonzagas of Mantua became extinct.

GONZAGA, Thomaz Antonio (1744–1809), "the Portuguese Petrarch," perhaps better known as Dirceu, was born at Oporto in 1744, and received his early education there and at Bahia, where his father, after having held various judicial appointments, became a member of the supreme court in 1759. Having completed his law studies at the university of Coimbra, which he attended from 1763 to 1768, Gonzaga in the latter year returned to Brazil, and after having acted for some years as juiz de fora or local magistrate at Beja and elsewhere he ultimately was appointed a judge (ouvidor) at Villa-Rica in the province of Minas, where he highly distinguished himself it is said both by his administrative ability and by the many excellences of his private character. He appears before this time to have developed some talent for versification, and his literary tastes soon brought him into intimate association with Claudio Manoel, Alvarenga Peixoto, and other writers of the so-called Minas school; but the love which makes the poet did not, in his own opinion at least, come upon him until he had made the acquaintance (about 1788) of D. Maria Joaquina Dorothea de Seixas, the "Marilia de Dirceu" to whom all his extant poems relate. He had just been nominated a member of the supreme court of Bahia, and was on the eve of his marriage, when discovery was made of the treasonable plot of Minas, and he was arrested on suspicion of having been implicated in it. On merely circumstantial evidence, and that of a very inconclusive kind, he was condemned, 18th April, 1792, to banishment for life to Pedras de Angoche, a sentence which was afterwards commuted to one of ten years' exile at Mozambique. Here he made some effort to practise as an advocate, but he never recovered from the wearing-out depression into which he had been thrown by his cruel lot; an attack of nervous fever undermined his health, and after years of an ever-deepening melancholy, which occasionally alternated with fits of acute mania, he died in 1809.

His collection of poems, entitled *Marilia de Dirceu*, consists of two parts. In the first of these, the charms of Marilia and his own happiness in the love he bears to her are his endlessly varied theme. The second, written during his imprisonment, is full of laments over his terrible fate, protestations of his innocence, and many fine expressions of the support and comfort he still finds in the remembrance of his love. Almost everywhere these "lyras" plainly enough betray a conscious imitation of Petrarch or other models; but they also exhibit an imaginative charm, a naturalness and delicacy of feeling, a harmoniousness of diction, and a gracefulness of versification which, in the unanimous opinion of competent critics, entitle them to rank among the best love lyrics in the language. In Brazil their popularity, perhaps aided by feelings of sympathy for their unfortunate author, has from the first been very great.

The editions are very numerous, the best probably being that of J. M. P. da Sylva which is accompanied with an historical and biographical introduction (1845). A critical notice, along with selections from the poems of Gonzaga, will be found in Wolf's *Brésil Littéraire* (1863). They have been translated into French by Monglave and Chalas (1825), into Spanish by Vedia, and into Italian by Ruscalla.

GONZALO DE BERCEO, mystic and didactic poet and one of the earliest names in Castilian literature, was parish priest at Berceo, near San Domingo de la Calzada, in the province of Burgos, and lived, it is believed, during the first sixty years of the 13th century. His works, which are reprinted in the *Poesias Castellanas Anteriores al Siglo XV.* of Sanchez, amount to upwards of 13,000 lines of verse, chiefly in rhymed quatrains. The subjects chosen for treatment are the Lives of San Domingo de Silos, Santa Oria, and San Millan; the Sacrifice of the Mass; the Miracles, Glories, and Pains of the Blessed Virgin; the Signs of the Day of Judgment; and the Martyrdom of San Lorenzo. Apart from the interest which attaches to them in the eyes of the literary and ecclesiastical archæologist, they have little to attract the modern reader. The monotony of their "sermo pedestris" is but seldom relieved by any touches of poetical genius; in some places, however, as Ticknor remarks, there is a simple-hearted piety that is very attractive, and in others a power in story-telling that is very striking. The poem on the Miracles of the Virgin, which is the largest, is also the most curious; but that upon the Signs of the Last Day is often very solemn, while the Mourning of Mary at the Cross breathes such a childlike spirit of gentle, faithful, credulous devotion as enables one to realize with some vividness many of the best characteristics of the religious life of the time.

See Ticknor, *History of Spanish Literature;* and Carus, *Darstellung der Spanischen Literatur* (1846); also Dunham's *History of Spain and Portugal,* vol. iv. (1832.)

GONZALO FERNANDEZ Y AGUILAR (1453–1515), commonly known as Gonsalvo de Cordova, El Gran Capitan ("The Great Captain"), was born at Montilla on the 16th of March, 1453, and in his fifteenth year was presented to Queen Isabella at Segovia, where his manly beauty, his graceful manners, and his soldierly accomplishments speedily made him conspicuous in the court. He first saw active military service in Portugal under Alonzo de Cardenas, and gained special praise for his conduct on the battlefield of Albuera in 1479. In the protracted Moorish war begun in 1481, he served with distinction in various capacities, and was finally employed to conduct the peace negotiations with Abdallah. For his efficient services in this business he was rewarded with a pension and a grant out of the conquered territory (1492). When, in consequence of the advance of Charles VIII. into Italy, a Spanish expedition was decided upon in 1495, Gonzalo was selected for the chief command; and although at Seminara, near Reggio, through the interference of the friendly Ferdinand of Naples, he lost the battle (it was the only occasion on which he ever was defeated), he gained in reputation both for prudence and for bravery. In spite of his subsequent successes in Lower Calabria, the campaign of this year closed with indecisive results; but in the opening of the following season, he still further increased his fame by his brilliant surprise and capture of Laino, and by his junction with the Neapolitan forces before Atella, after an arduous march through hostile territory. It is most commonly, and with most probability, said to have been on this occasion that he received the honorable title of El Gran Capitan, by which the Spaniards still delight to designate him. The conquest of Calabria having been thus rapidly achieved, he, at the pope's invitation, proceeded to clear Ostia of the French garrison by which it had been held, and shortly afterwards entered Rome itself, where he was greeted by the populace as "deliverer of the city." The object of his expedition, the total expulsion of the French from Neapolitan territory, having been fully attained, he, in August, 1498, returned to Spain, where he was received with the utmost enthusiasm by all classes, the king publicly declaring that the reduction of Naples, and the humiliation inflicted on the French, reflected more lustre on his crown than the conquest of Granada. After having, early in 1500, efficiently co-operated with Tendilla in putting down the Moorish insurrection in the Alpujarras, Gonzalo, in May of the same year, took command of an armada designed to operate on the coast of Sicily and in the Levant, and generally to uphold the influence of Spain. In conjunction with the Venetian admiral he stormed St. George in Cephalonia, in January, 1501; and soon afterwards returning to Sicily, commenced operations against Frederick in accordance with the treaty concluded between France and Spain for the partition of Naples. The whole of Calabria was occupied in less than a month, with the exception of Tarento, which did not surrender until March, 1502. On the outbreak of hostilities between France and Spain in July of the same year, Gonzalo was compelled to fall back upon Barletta, whence, after having sustained a memorable siege of nearly ten months, he sallied in April, 1503, and coming upon the French troops at Cerignola, inflicted on them a disastrous defeat, which at once made him master of the city of Naples and of the greater part of the kingdom. A subsequent victory at the bridge of Garigliano (29th December, 1503) gave him Gaeta and terminated the war. For more than three years he continued to act with popularity and efficiency at Naples as Ferdinand's viceroy; but the jealousy and distrust of that somewhat narrow-minded monarch led to his recall in 1507, and to his subsequent retirement from court shortly afterwards. The remainder of his days were passed on his estate at Loja, where, in the midst of preparations for a voyage to Flanders, he was seized with a fever, of which he died, 2d December, 1515.

The life of "the great captain" has been rather a favorite subject with literary men, having been treated by Giovio in his *Vitæ Illustrium Virorum,* and by Quintana in his *Españoles Célebres,* as well as by Florian (*Gonsalve de Cordoue, ou Grenade Reconquise,* 1791), Duponcet (*Histoire de Gonsalve de Cordoue,* 1714), and an anonymous author, sometimes supposed to be Pulgar (*Crónica del Gran Capitan,* 1584). A skilful and judicious use of all these sources has been made by Prescott in his *History of the Reign of Ferdinand and Isabella,* where the purity, generosity, and loyalty of the private character of Gonzalo, as well as the coolness, sobriety, and energy of his military genius, are very fully and vividly illustrated.

GOOD, John Mason (1764–1827), a writer on medical, religious, and classical subjects, was born May 25, 1764, at Epping, Essex, where his father, the Rev. Peter Good, was Independent minister. After receiving his education in the seminary conducted by his father, he was, at about the age of fifteen, apprenticed to a surgeon-apothecary at Gosport. In 1783 he went to London to prosecute his medical studies, and in the autumn of 1784 he commenced practice as a surgeon at Sudbury in Suffolk. Through an obligation rendered to a friend he, in 1792, got into pecuniary embarrassment, and, with a view to surmount his difficulties, he removed in 1793 to London, where he entered into partnership with a surgeon and apothecary who enjoyed an extensive practice. In November of the same year he was admitted a member of the college of surgeons. On account of disagreements with his colleague, the partnership was soon afterwards dissolved, and to increase his income he now devoted more of his attention to literary pursuits. Besides contributing both in prose and poetry to the *Analytical* and *Critical Reviews,* and the *British* and *Monthly Magazines,* and other periodicals, he is the author of a large number of works, relating chiefly to medical and religious subjects. In 1794 he became a member of the British Pharmaceutical Society, and in that connection, and especially by the publication of his work, *A History of Medicine,* he did much to effect a greatly needed reform in the profession of the apothecary. In 1820 he took the diploma of M. D. at Marischal College, Aberdeen. He died January 2, 1827. Dr. Good was not only well versed in classical literature, but was acquainted with the principal European languages, and also with Persian, Arabic, and Hebrew. His prose works display wide erudition and considerable intellectual vigor, and contain much interesting and curious information; but their style is dull and tedious, and they are now very generally forgotten. His poetry never rises above pleasant and well-versified commonplace.

The following are his principal writings:— *Maria,* an elegiac ode, 1786; *Diseases of Prisons and Poorhouses,* 1795; *History of Medicine,* 1795; *Parish Workhouses,* 1798; *Song of Songs, translated from the Hebrew, with notes critical and explanatory,* 1803; *Triumph of Britain, an Ode,* 1803; *Memoirs of the Life and Writings of Alex. Geddes, LL.D.,* 1803; *The Nature of Things: a Didactic Poem, translated from the Latin of Titus Lucretius Carus, with the original text and notes philological and explanatory,* 1805–7, 2 vols. 4to, which is still of considerable value for its parallel passages and quotations both from European and Asiatic languages; *Oration on the Structure and Physiology of Plants,* 1808; *Essay on Medical Technology,* 1810; *The Book of Job literally translated,* etc., 1812; *The Study of Medicine,* 1822, 4 vols. 8vo, 3d ed. in 1832, edited by Dr. Samuel Cooper; and *The Book of Nature,* 1826, 3 vols. See *Memoirs* by Olinthus Gregory, LL.D., 1828, and a biographical sketch in the *Gentleman's Magazine* for March, 1827. His *Thoughts for all Seasons, in Prose and Verse,* was published, with a short biographical sketch, in 1860.

GOOD FRIDAY, the usual English name for the day observed throughout a great part of Christendom as the anniversary of the passion and death of Christ. In the Greek Church it has been or is known as *πάσχα* [*σταυρώσιμον*], *παρασκευή, παρασκευή μεγάλη* or *ἁγία, σωτηρία* or *τὰ σωτήρια, ἡμέρα τοῦ σταυροῦ,* while among the Latins the names of most frequent occurrence are Pascha Crucis, Dies Dominicæ Passionis, Parasceve, Feria Sexta Paschæ, Feria Sexta Major in Hierusalem, Dies Absolutionis. It was called Long Friday by the Anglo-Saxons[1] and Danes; in Germany it is sometimes designated Stiller Freitag (compare Greek, *ἑβδομὰς ἄπρακτος*; Latin, hebdomas inofficiosa, non laboriosa), but more commonly Charfreitag. The etymology of this last name has been much disputed, but there seems now to be little doubt that it is derived from the Old High German *chara,* meaning suffering or mourning.

The origin of the custom of a yearly commemoration of the crucifixion is involved in some obscurity. It may be regarded as certain, indeed, that among Jewish Christians it almost imperceptibly grew out of the old habit of annually celebrating the Passover on the 14th of Nisan, and of observing the "days of unleavened bread," from the 15th to the 21st of that month. In the Gentile churches, on the other hand, it seems to be well established that originally no yearly cycle of festivals was known at all. The weekly observance of the dies dominica, however, became universal at a very early date; and the practice of giving special prominence to Easter Sunday (the first Sunday after the 14th of Nisan), as well as that of keeping a previous fast of considerable rigor, though of indeterminate duration, had established itself in Egypt and in the Western churches at least by the middle of the 2d century. The accounts which have been transmitted by Eusebius, Socrates, and Epiphanius of the paschal controversies, which began to be agitated about 160 A. D., are obscure on many points—so obscure, indeed, as to suggest doubts whether these historians had altogether comprehended the questions under discussion. So much, however, is clear, that Occidental feeling had even then begun to take great offence at the prevailing Eastern practice. In Asia Minor, Syria, and Mesopotamia, the 14th and 16th of Nisan were specially observed, altogether irrespective of the day of the week, and for this apostolic sanction was urged by Polycarp; but Anicetus of Rome, with great earnestness, though still with deference, pleaded immemorial usage for the custom of observing a Friday and Saturday fast followed by an Easter Sunday feast. As the Western churches gained in influence, the practice of tolerance became increasingly difficult; already in 190 A. D. we find Victor of Rome insisting on the conformity of Polycrates of Ephesus, and proclaiming the contumacious Asiatics to be out of communion (*ἀκοινωνήτους*). To secure uniformity in this matter was one of the objects for which the council of Nice was convened in 325; no canon, however, was framed by the fathers there assembled, but it was recommended in a circular letter that Easter (*πάσχα*) should invariably be observed on a Sunday, and that the passion should with equal regularity, be commemorated on Friday. Considerable progress towards the compulsory establishment of a uniform paschal usage was made in the years immediately following; thus, by a canon of the council of Antioch (341), the followers of the Oriental use were laid under severe ecclesiastical censures; in the decrees of that of Laodicea (361) the ominous word *αἵρεσις* is heard (*αἵρεσις τῶν τεσσαρες καιδεκατιτῶν*); while in the Theodosian Code (xvi. 5, 9; 6, 6; 10, 24), the Quartodecimans are formally ranked among the other heretics whose error is to be visited with civil pains and penalties.

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[1] See Johnson's *Collection of Ecclesiastical Laws* (vol. i., anno 957): "Housel ought not to be hallowed on Long Friday, because Christ suffered for us on that day."

From the earliest period of its observance, the day was marked by a specially rigorous fast, and also, on the whole, by a tendency to greater simplicity in the public services of the church. Prior to the 4th century there is no evidence of non-celebration of the eucharist on Good Friday; but after that date the prohibition of communion became common. In Spain, indeed, it became customary to close the churches altogether as a sign of mourning; but this practice was condemned by the council of Toledo (633). In the Romish Church the Good Friday ritual at present observed is marked by many special features, most of which can be traced back to a date at least prior to the close of the 8th century (see the Ordo Romanus in Muratori's *Liturg. Rom. Vet.*). The altar and officiating clergy are draped in black, this being the only day on which that color is permitted. Instead of the epistle, sundry passages from Hosea, Habakkuk, Exodus, and the Psalms are read. The gospel for the day consists of the history of the passion as recorded by St. John. The reading of this is followed by bidding prayers for the peace and unity of the church, for the pope, the clergy, all ranks and conditions of men, the sovereign, for catechumens, the sick and afflicted, heretics and schismatics, Jews and heathen. Then follows the "adoration of the cross" (a ceremony said to date back to near the time of Helena's "invention of the cross"); the hymns *Pange Lingua* and *Vexilla Regis* are sung, and the reserved host brought out and partaken of by the priest. In many Roman Catholic countries, as, for example, in Spain, it is usual with the faithful to spend much time in the churches in meditation on the "seven last words" of the Saviour; no carriages are driven through the streets; the bells and organs are silent; and in every possible way it is sought to deepen the impression of a profound and universal grief. In the Greek Church also the Good Friday fast is excessively strict; as in the Roman Church, the passion history is read and the cross adored; towards evening a dramatic representation of the entombment takes place, amid open demonstrations of contempt for Judas and the Jews. In Lutheran churches the organ is silent on this day; and altar, font, and pulpit are draped in black, as indeed throughout Holy Week. In the Church of England the history of the passion from the gospel according to John is also read; the collects for the day are based upon the bidding prayers which are found in the Ordo Romanus.

GOODRICH, Samuel Griswold (1793–1860), an American author better known under the pseudonym of Peter Parley, was the son of a Congregational minister, and was born at Ridgefield, Connecticut, August 19, 1793. In 1814 he commenced business as a publisher in Hartford. He visited Europe in 1823–4, and on his return to America removed to Boston, where from 1828 to 1842 he published an illustrated journal, the *Token*, to which he was a frequent contributor both in prose and verse. A selection from these contributions was published in 1841 under the title *Sketches from a Student's Window.* In the same year he established *Merry's Museum*, which he continued to edit till 1854. In 1827 he commenced, under the name of "Peter Parley," his series of books for the young, which, embracing geography, biography, history, science, and miscellaneous tales, numbered in 1857 as many as 170 volumes, of which about 7,000,000 had been sold, and 300,000 were being sold annually. In 1858 he published *Recollections of a Lifetime*, which contains a list both of the works of which he was the author and of the spurious works published under his name. By his writings and publications he amassed a large fortune. In 1838 he was chosen a member of the senate of Massachusetts, and in 1851 he was appointed consul to Paris, where he remained till 1855, taking advantage of his stay to have several of his works translated into French. After his return to America he published, in 1859, *History of the Animal Kingdom.* He died at New York, May 9, 1860.

GOODSIR, John (1814–1867), anatomist, born at Anstruther, Fife, March 20, 1814, was the son of Dr. John Goodsir, and grandson of Dr. John Goodsir of Largo. He was educated at the burgh and grammar schools of his native place, and at the university of St. Andrews. He served an apprenticeship for a short time to Mr. Nasmyth, the eminent dentist, but the higher studies of medicine and surgery were more to his liking, and, under the fascinating impulsion of the lectures of Dr. Knox, anatomy, descriptive, surgical, and pathological, became his hobby,—the work of Carus giving the first impetus to his investigations in developmental anatomy. From his mother he had imbibed a love of art, and his sketches and casts and methodical demonstrations were the admiration of his fellow students. In Dr. Knox's rooms he made the acquaintance of Edward Forbes, the naturalist. Goodsir also worked under Mr. Syme, Professor Christison, Dr. John Macintosh, Professor Robert Jameson, Dr. Thomas Hope, and Dr. Graham. His earliest scientific paper was on the snail,—a novel, elaborate, and highly illustrated treatise. In 1835 he became a licentiate of the Royal College of Surgeons, Edinburgh. After aiding Mr. Nasmyth, he joined his father in practice at Anstruther. Three years later he communicated to the British Association a paper on the pulps and sacs of the human teeth, his researches on the whole process of dentition being at this time distinguished by their completeness. He had already commenced the formation of a natural history museum, which attracted many visitors,—the habits of animals, from the polype to the ape, possessing an irresistible charm for him. The results of his studies in natural history were laid before the Society of St. Andrews, at the request of whose president, Sir D. Brewster, he furnished an account of *cilia*, reading to the society in 1840 his views on the cephalic termination of the sympathetic nerve. The ichthyolites of the Concerres quarry had not escaped him; and we find him now foreshowing his diversified knowledge in essays on the eye of the cephalopodous mollusks, in descriptions of his dredging expeditions with Edward Forbes, and in his lectures at Cupar on the conditions of health. On the nomination of Forbes, he was in 1838 elected to the famous coterie called the "Universal Brotherhood of the Friends of Truth," which comprised artists, scholars, naturalists, and others whose relationship became a potent influence in science. Goodsir was a noble example of the brotherhood, which sought to bind man to man in ties of home and friendship, love and good will. Goodsir and Forbes worked together at marine zoology, but human anatomy, pathology, and morphology formed Goodsir's chief study. The connection of these two men was illustrated in a paper read at the British Association in 1840 on *Pelonaia*, and further researches on the British *Ciliograda*. In that year Goodsir became a member of the Wernerian Society, contributing several papers, some jointly with Forbes. Professor Jameson was the president, which may account for the greater part of Goodsir's studies in comparative anatomy from 1840 to 1847 being imparted to its members. In 1841 he joined the Edinburgh Botanical Society, holding the office of secretary from 1842–48, when he was chosen vice-president. In 1840–42 ulcers and abcesses and continued fever, in cases of which he advocated the depletive system, occupied his attention. He had associated himself with the Royal Medical Society in 1833, and was in 1841–42 elected the senior president, at the same time becoming president of the Anatomical and Physiological Societies, to which he submitted his studies on the structure of the liver and kidneys. A member of the Royal Physical Society in 1841, he read his papers on the development of the skeleton in the series of invertebrate animals; in 1849 he was elected president, remaining in office till 1852. His own estimate of his work at this period was represented to the Royal College of Surgeons of Edinburgh on his candidature for the post of conservator of the museum. He stated that he had practised every department of preparation and conservation, that he had considerable experience in modelling in clay, plaster, and wax, and in the use of microscope and pencil, and that his own collection of preparations in human, comparative, and morbid anatomy exceeded 400 examples. He succeeded Macgillivray in April, 1841, giving lectures on the subjects illustrated by the museum. Goodsir rested no small part of his reputation on his knowledge of the anatomy of tissues. In his lectures in the theatre of the college in 1842–43 he evidenced the largeness of his observation of cell-life, both physiologically and pathologically, advocating the importance of the cell as a centre of nutrition, and pointing out that the organism is subdivided into a number of departments. Virchow recognized his indebtedness to these discoveries by dedicating his *Cellular Pathologie* to Goodsir, as "one of the earliest and most acute observers of cell-life." In 1843 Goodsir obtained the post of curator in the university of Edinburgh; the following year he was appointed demonstrator of anatomy to Professor Monro, and in 1845 curator of the entire museum. He elucidated about this time much that had been obscure in digestion, in parasitic formation, and in the secreting structures. He fully confirmed the supposition that cells are the structures which perform the process of secretion, and that the functions of nutrition and secretion are essentially alike in their nature. His views on the nucleated cell as the great agent in absorption, nutrition, and secretion are established data in the science of physiology. In 1846 Goodsir was elected to the anatomical chair in the university of Edinburgh, his highest ambition being thus satisfied. The same year the Royal Society of London enrolled him as a fellow. All his energies were now devoted to the perfection of the science of anatomy; and his system of teaching was regarded as the best that ever regulated the anatomical department of any British university or medical school.

Human myology was his strong point; no one had labored harder at the dissecting-table; and he strongly emphasized the necessity of practice as a means of research. He believed that anatomy, physiology, and pathology could never be properly advanced without daily consideration and treatment of disease. In 1848 he became a fellow of the Royal College of Surgeons, and in the same year he joined the Highland and Agricultural Society, acting as chairman of the veterinary department, and advising on strictly agricultural matters. In 1847 he delivered a series of systematic lectures on the comparative anatomy of the invertebrata; and, about this period, as member of an æsthetic club, he wrote papers on the natural principles of beauty, the æsthetics of the ugly, of smell, the approbation or disapprobation of sounds, and other refinements. Owing to the failing health of Professor Jameson, Goodsir was induced to deliver the course of lectures on natural history during the summer of 1853. It was mainly zoological, and included the psychological conditions of man as compared with the brute, and the highest exercise of the human faculties—perception, logic, and science. These lectures are among the *memorabilia* of the university; but the infinite amount of thought and exertion which they cost broke the health of the lecturer. Goodsir, nevertheless, persisted in work till 1853, when the necessity for rest urged itself with painful force. A sojourn on the Continent, though it refreshed, could not rid him of incipient paralysis, the common penalty for overtaxing powers. The death of Forbes in 1854 was a sore trial to Goodsir, and though other friends were numerous, the firm attachment of this man could not be replaced. Goodsir persevered in his labors, writing in 1855 on organic electricity, in 1856 on morphological subjects, and afterwards on the structure of organized forms,—his speculations in the latter domain giving birth to his theory of a triangle as the mathematical figure upon which nature had built up both the organic and inorganic worlds. The fundamental principle of form he conceived to exist within the province of crystallography, and to be discernible by a close study of the laws of that science. As he believed that every cell had a parent cell, or "a mother," so he argued there was an umbilicus or centre in everything. He regarded man as simply a conglomerate of cells, rising up, maturing, and decaying. He saw in the growth and form and finished structure of man a tetrahedron,—man, a physical being and a form divine, but a crystal in his structural entity and arrangement. Goodsir hoped to complete the triangle theory of formation and law as the greatest of his works. In his lectures on the skull and brain he held the doctrine that symmetry of brain had more to do with the higher faculties than bulk or form. Goodsir was still working out these higher studies when death ended his labors. He expired at Wardie, near Edinburgh, on the 6th of March, 1867, in the same cottage in which his friend Edward Forbes died. Goodsir's anatomical lectures are remarkable for their solid basis of fact; and no one in Britain took so wide a field for survey, or marshalled so many facts for anatomical tabulation and synthesis.

See *Anatomical Memoirs of John Goodsir, F. R. S., edited by W. Turner, M. B., with Memoir by H. Lonsdale, M. D.*, Edinb. 1868, 2 vols., in which Goodsir's lectures, addresses, and writings are epitomized; *Proceedings of the Roy. Soc. of Lond.*, vol. iv., 1868; *Transactions of the Botanical Soc. Edin.*, 1868, vol. ix.

(T. N.)

GOODWIN, THOMAS (1600–1679), a prominent English divine of the later Puritan period, was born at Rollesby, Norfolk, on the 5th of October, 1600, and a little before the completion of his thirteenth year was enrolled a student of Christ's College, Cambridge, where in 1616 he proceeded to the degree of B. A. In 1619 he removed to St. Catherine's Hall, and there in 1620 he was chosen fellow. In 1625 he was licensed a preacher of the university; and three years afterwards he became lecturer of Trinity Church, to the vicarage of which he was presented by the king in 1632. Harassed by the interferences of his bishop, who was a zealous adherent of Laud, he resigned all his preferments and left the university in 1634. He then seems to have lived for some time in London, where in 1638 he married the daughter of an alderman; but, in the following year, he found it expedient to withdraw to Holland, and for some time was pastor of a small congregation of English merchants and refugees at Arnheim. Returning to London soon after Laud's impeachment by the Long Parliament, he ministered for some years to an independent congregation in the parish of St. Dunstan's-in-the-East, and rapidly rose to considerable eminence as a preacher; in 1643 he was chosen a member of the Westminster Assembly, and at once identified himself with the Congregational party, generally referred to in contemporary documents as "the dissenting brethren." He frequently preached by appointment before the Commons, and in January, 1650, his talents and learning were rewarded by the House with the presidentship of Magdalen College, Oxford, a post which he held until the period of the Restoration. He rose into high favor with the Protector, and ultimately became somewhat prominent among his more intimate advisers. From 1660 until his death, which occurred on the 23d of February, 1679, he lived in London, and devoted himself exclusively to theological study and to the pastoral charge of a small congregation which his piety and intellectual abilities had attached to him.

The works published by Goodwin during his lifetime consist chiefly of sermons printed by order of the House of Commons; but he was also associated with Nye and others in the preparation of the *Apologeticall Narration* (1643). His collected writings, which include expositions of considerable portions of the Epistle to the Ephesians and of the Apocalypse, were published in five folio volumes between 1681 and 1704, and have recently been reprinted in twelve 8vo volumes (Edin. 1861–66). Characterized by great yet one-sided reading, remarkable at once for the depth and for the narrowness of their observation and spiritual experience, often admirably thorough in their workmanship, yet in style prolix to a degree that, by modern readers at least, is sometimes found to be almost intolerable,—they fairly exemplify both the merits and the defects of the special school of religious thought to which they belong. Calamy's estimate of Goodwin's qualities may be quoted as both friendly and just. "He was a considerable scholar and an eminent divine, and had a very happy faculty in descanting upon Scripture so as to bring forth surprising remarks, which yet generally tended to illustration." A memoir derived from his own papers, by his son, is prefixed to the fifth volume of his collected works; as a "patriarch and Atlas of Independency" he is also noticed by Wood in the *Athenæ Oxonienses*. A somewhat amusing sketch, from Addison's point of view, of the Puritan president of Magdalen's is to be met with in No. 494 of the *Spectator*.

GOOJERAT. See GUJARAT.

GOOLE, a market town and river-port of England, West Riding of Yorkshire, is situated on the right bank of the Ouse, 25 miles W. of Hull, on the Hull and Doncaster Railway, and at the eastern terminus of the Wakefield, Pontefract, and Goole branch of the Lancashire and Yorkshire Railway. About a mile north of Goole the Ouse is crossed by a railway swing bridge, worked by hydraulic power. Until it was made a bonding port in 1829, Goole was an obscure hamlet; but since the erection shortly afterwards of commodious docks, it has steadily advanced in prosperity. The harbor, 250 feet long and 200 wide, communicates by gates with the wet docks, which consist of the ship dock 700 feet by 200, with a depth of 18 feet, the railway dock 600 feet by 200, and the steamship dock 900 feet by 150. The town is well built, and possesses a fine modern parish church in the Perpendicular style, a Roman Catholic chapel in the Early English style, a neat custom-house, a market hall, a handsome courthouse, a union poorhouse, public, free, and national schools, and extensive warehouses for grain and other goods. The number of British ships that entered the port in 1877 was 1686, with a tonnage of 298,150; of foreign ships 62, with a tonnage of 16,399. The number of British ships that cleared was 2642, with a tonnage of 342,727; of foreign ships 64, with a tonnage of 17,038. There is regular steam communication with London and the principal Continental ports. The chief exports are coal, woollen goods, and machinery; and the chief imports, butter, fruit, indigo, logwood, timber, and wool. The industries include the manufacture of alum, sugar, ropes, and agricultural instruments, and iron-founding. Shipbuilding is also carried on, and there is a large dry dock, and a patent slip for repairing vessels. The population in 1871 was 7680.

GOOSANDER. See MERGANSER.

GOOSE (Anglo-Saxon, *Gós*), the general English name for a considerable number of birds, belonging to the Family *Anatidæ* of modern ornithologists, which are mostly larger than Ducks and less than Swans. Technically the word Goose is reserved for the female, the male being called Gander (Anglo-Saxon, *Gandra*).

The most important species of Goose, and the type of the genus *Anser*, is undoubtedly that which is the origin of our well-known domestic race, the *Anser ferus* or *A. cinereus* of most naturalists, commonly called in English the Grey or Grey Lag[1] Goose, a bird of exceedingly wide range in the Old World, apparently breeding where suitable localities are to be found in most European countries from Lapland to Spain and Bulgaria. Eastwards it extend to China, but does not seem to be known in Japan. It is the only species indigenous to the British Islands, and in former days bred abundantly in the English Fen-country, where the young were caught in large numbers and kept in a more or less reclaimed condition with the vast flocks of tame-bred Geese that at one time formed so valuable a property to the dwellers in and around the Fens. It is impossible to determine when the wild Grey Lag Goose ceased from breeding in England, but it certainly did so towards the end of the last century, for Daniell mentions (*Rural Sports*, iii. p. 242) his having obtained two broods in one season. In Scotland this Goose continues to breed sparingly in several parts of the Highlands and in certain of the Hebrides, the nests being generally placed in long heather, and the eggs seldom exceeding five or six in number. It is most likely the birds reared here that are from time to time obtained in England, for at the present day the Grey Lag Goose, though once so numerous, is, and for many years has been, the rarest species of those that habitually resort to the British Islands. The domestication of this species, as Mr. Darwin remarks (*Animals and Plants under Domestication*, i. p. 287), is doubtless of very ancient date, and yet scarcely any other animal that has been tamed for so long a period, and bred so largely in captivity, has varied so little. It has increased greatly in size and fecundity, but almost the only change in plumage is that tame Geese lose the browner and darker tints of the wild bird, and are invariably more or less marked with white—being often indeed wholly of that color.[2] The most generally recognized breeds of domestic Geese are those to which the distinctive names of Emden and Toulouse are applied; but a singular breed, said to have come from Sebastopol, was introduced into Western Europe about the year 1856. In this the scapulars are elongated, curled, and spirally twisted, having their shaft transparent, and so thin that it often splits into fine filaments, which, remaining free for an inch or more, often coalesce again.[3]

The other British species of typical Geese are the Bean-Goose (*A. segetum*), the Pink-footed (*A. brachyrhynchus*), and the White-fronted (*A. albifrons*). On the continent of Europe, but not yet recognized as occurring in Britain, is a small form of the last (*A. erythropus*) which is known to breed in Lapland. All these, for the sake of discrimination, may be divided into *two* groups—(1) those having the "nail" at the tip of the bill white, or of a very pale flesh color, and (2) those in which this "nail" is black. To the former belong the Grey Lag Goose, as well as *A. albifrons* and *A. erythropus*, and to the latter the other two. *A. albifrons* and *erythropus*, which hardly differ but in size,—the last being not much bigger than a Mallard (*Anas boschas*),—may be readily distinguished from the Grey Lag Goose by their bright orange bill and legs, and their mouse-colored upper wing-coverts, to say nothing of their very conspicuous white face and the broad black bars which cross the belly, though the two last characters are occasionally observable to some extent in the Grey Lag Goose, which has the bill and legs flesh-colored, and the upper wing-coverts of a bluish-grey. Of the second group, with the black "nail," *A. segetum* has the bill long, black at the base and orange in the middle; the feet are also orange, and the upper wing-coverts mouse-colored, as in *A. albifrons* and *A. erythropus*, while *A. brachyrhynchus* has the bill short, bright pink in the middle, and the feet also pink, the upper wing-coverts being nearly of the same bluish-grey as in the Grey Lag Goose. Eastern Asia possesses in *A. grandis* a third species of this group, which chiefly differs from *A. segetum* in its larger size. In North America there is only one species of typical Goose, and that belongs to the white-"nailed" group. It very nearly resembles *A. albifrons*, but is larger, and has been described as distinct under the name of *A. gambeli*. Central Asia and India possess in the Bar-headed Goose

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[1] The meaning and derivation of this word *Lag* had long been a puzzle until Prof. Skeat suggested (*Ibis*, 1870, p. 301) that it signified late, last, or slow, as in *laggard*, a loiterer, *lagman*, the last man, *lag-teeth*, the posterior molar or "wisdom" teeth (as the last to appear), and *lagclock*, a clock that is behind time. Thus the Grey Lag Goose is the Grey Goose which in England when the name was given was not migratory, but *lagged* behind the other wild species at the season when they betook themselves to their northern breeding-quarters. In connection with this word, however, must be noticed the curious fact mentioned by the late Mr. Rowley (*Orn. Miscell.*, iii. p. 213), that to this day the flocks of tame Geese in Lincolnshire are urged on by their drivers with the cry of "Lag'em, Lag'em."

[2] From the times of the Romans white Geese have been held in great estimation, and hence, doubtless, they have been preferred as breeding stock, but the practice of plucking Geese alive, continued for so many centuries, has not improbably also helped to perpetuate this variation, for it is well known to many bird-keepers that a white feather is often produced in place of one of the natural color that has been pulled out.

[3] Want of space forbids our entering on the breeding of tame Geese, which was formerly so largely practised in some English counties, especially Norfolk and Lincoln. It was no uncommon thing for a man to keep a stock of a thousand, each of which might be reckoned to rear on an average seven Goslings. The flocks were regularly taken to pasture and water, just as sheep are, and the man who tended them was called the Gooseherd, corrupted into Gozzerd. The birds were plucked five times in the year, and in autumn the flocks were driven to London or other large markets. They travelled at the rate of about a mile an hour, and would get over nearly ten miles in the day. For further particulars the reader may be referred to Pennant's *British Zoology*; Montagu's *Ornithological Dictionary*; Latham's *General History of Birds*; and Rowley's *Ornithological Miscellany* (iii. pp. 206–215), where some account also may be found of the Goose-fatting at Strasburg, which, since the reconquest of Alsace, has been transferred to the south of France.

(*A. indicus*) a bird easily distinguished from any of the foregoing by the character implied by its English name: but it is certainly somewhat abnormal, and, indeed, under the name of *Eulabia*, has been separated from the genus *Anser*, which has no other member indigenous to the Indian Region, nor any at all to the Ethiopian, Australian, or Neotropical Regions.

But the New World possesses by far the greatest wealth of Anserine forms. Besides others, presently to be mentioned, its northern portions are the home of all the species of Snow-Geese belonging to the genus *Chen*. It is true that two of these are reported as having appeared, and that not unfrequently, in Europe and Asia; but they possibly have been but stragglers from America. The first of these is *C. hyperboreus*, the Snow-Goose proper, a bird of large size, and when adult of a pure white, except the primaries, which are black. This has long been deemed a visitor to the Old World, and sometimes in considerable numbers, but the later discovery of a smaller form, *C. albatus*, scarcely differing except in size, throws some doubt on the older records, especially since examples which have recently been obtained in the British Islands undoubtedly belong to this lesser bird, and it would be satisfactory to have the occurrence in the Old World of the true *C. hyperboreus* placed on a surer footing. So nearly allied to the species last named as to have been often confounded with it, is the Blue-winged Goose, *C. cœrulescens*, which is said never to attain a snowy plumage. Then we have a very small species, long ago described as distinct by Hearne, the Arctic traveller, but until 1861 discredited by ornithologists. Its distinctness has now been fully recognized, and it has received, somewhat unjustly, the name of *C. rossi*. Its face is adorned with numerous papillæ, whence it has been removed by Mr. Elliot to a separate genus, *Exanthemops*, and for the same reason it has, for more than a century, been known to the European residents in the fur countries as the "Horned Wavey"—the last word being a rendering of a native name, *Wawa*, which signifies Goose. Finally, there appears to belong to this section, though it has been frequently referred to another (*Chloephaga*), and has also been made the type of a distinct genus (*Philacte*), the beautiful Painted Goose, *C. canagica*, which is almost peculiar to the Aleutian Islands, though straying to the continent in winter, and may be recognized by the white edging of its remiges.

The southern portions of the New World are inhabited by about half a dozen species of Geese, akin to the foregoing, but separated as the genus *Chloephaga*. The most noticeable of them are the Rock or Kelp Goose, *C. antarctica*, and the Upland Goose, *C. magellanica*. In both of these the sexes are totally unlike in color, the male being nearly white, while the female is of a mottled brown, but in others a greater similarity obtains.[1] Very nearly allied to the birds of this group, if indeed that can be justifiably separated, comes one which belongs to the northern hemisphere, and is common to the Old World as well as the New. It contains the Geese which have received the common names of Bernacles or Brents,[2] and the scientific appellations of *Bernicla* and *Branta*—for the use of either of which much may be said by nomenclaturists. All the species of this section are distinguished by their general dark sooty color, relieved in some by white of greater or less purity, and by way of distinction from the members of the genus *Anser*, which are known as Grey Geese, are frequently called by fowlers Black Geese. Of these, the best known both in Europe and North America is the Brent-Goose—the *Anas bernicla* of Linnæus, and the *B. torquata* of many modern writers—a truly marine bird, seldom (in Europe at least) quitting salt water, and coming southward in vast flocks towards autumn, frequenting bays and estuaries on our coasts, where it lives chiefly on sea-grass (*Zostera maritima*). It is known to breed in Spitzbergen and in Greenland. A form which is by some ornithologists deemed a good species, and called by them *B. nigricans*, occurs chiefly on the Pacific coast of North America. In it the black of the neck, which in the common Brent terminates just above the breast, extends over most of the lower parts. The true Bernacle-Goose,[3] the *B. leucopsis* of most authors, is but a casual visitor to North America, but is said to breed in Iceland, and occasionally in Norway. Its usual *incunabula*, however, still form one of the puzzles of the ornithologist, and the difficulty is not lessened by the fact that it will breed freely in semi-captivity, while the Brent-Goose will not. From the latter the Bernacle-Goose is easily distinguished by its larger size and white cheeks. Hutchins's Goose (*B. Hutchinsi*) seems to be its true representative in the New World. In this the face is dark, but a white crescentic or triangular patch extends from the throat on either side upwards behind the eye. Almost exactly similar in coloration to the last, but greatly superior in size, and possessing 18 rectrices, while all the foregoing have but 16, is the common wild Goose of America, *B. canadensis*, which, for some two centuries or more, has been introduced into Europe, where it propagates so freely that it has been included by nearly all the ornithologists of this quarter of the globe as a member of its fauna. An allied form, by some deemed a species, is *B. leucopareia*, which ranges over the western part of North America, and, though having 18 rectrices, is distinguished by a white collar round the lower part of the neck. The most diverse species of this group of Geese are the beautiful *B. ruficollis*, a native of North-eastern Asia, which occasionally strays to Western Europe, and has been obtained more than once in Britain, and that which is peculiar to the Hawaian archipelago, *B. sandvicensis*.

The largest living Goose is that called the Chinese, Guinea, or Swan-Goose, *Cygnopsis cygnoides*, and it seems to be the stock whence the domestic Geese of several Eastern countries have sprung. It may not unfrequently be seen in English farmyards, and it is found to cross readily with our common tame Goose, the offspring being fertile, and Blyth has said that these crosses are very abundant in India. The true home of the species is in Eastern Siberia or Mongolia. It is distinguished by its upright bearing, which has been well rendered by Bewick's excellent figure. The ganders of the reclaimed form are distinguished by the knob at the base of the bill, but the evidence of many observers shows that this is not found in the wild race. Of this bird there is a perfectly white breed.

We have next to mention a very curious form, *Cereopsis novæ-hollandiæ*, which is peculiar to Australia, and appears to be a more terrestrial type of Goose than any other now existing. Its short, decurved bill and green cere give it a very peculiar expression, and its almost uniform grey plumage, bearing rounded black spots, is also remarkable. It bears captivity well, breeding in confinement, and may be seen in many parks and gardens. It appears to have been formerly very abundant in many parts of Australia. from which it has of late been exterminated. Some of its peculiarities seem to have been still more exaggerated in a bird that is wholly extinct, the *Cnemiornis calcitrans* of New Zealand, the remains of which were described in full by Professor Owen in 1873 (*Trans. Zool. Society*, ix. p. 253). Among the first portions of this singular bird that were found were the *tibiæ*, presenting an extraordinary development of the *patella*, which, united with the shank-bone, gave rise to the generic name applied. For some time the affinity of the owner of this wonderful structure was in doubt, but all hesitation was dispelled by the discovery of a nearly perfect skeleton, now in the British Museum, which proved the bird to be a Goose, of great size, and unable, from the shortness of its wings, to fly. In correlation with this loss of power may also be noted the dwindling of the keel of the sternum. Generally, however, its osteological characters point to an affinity to *Cereopsis*, as was noticed by Dr. Hector (*Trans. New Zeal. Institute*, vi. pp. 76–84), who first determined its Anserine character.

Birds of the genera *Chenalopex* (the Egyptian and Orinoco Geese), *Plectropterus*, *Sarcidiornis*, *Chlamydochen*, and some others, are commonly called Geese. To the writer it seems uncertain whether they should be grouped with the *Anserinæ*. The males of all appear to have that curious enlargement at the junction of the bronchial tubes and the trachea which is so characteristic of the Ducks or *Anatinæ*. As much may be said for the genus *Nettapus*, but want of space precludes further consideration of the subject here. (A. N.)

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[1] See Sclater and Salvin, *Proc. Zool. Society*, 1876, pp. 361–369.

[2] The etymology of these two words is exceedingly obscure, and no useful purpose could be attained by discussing it here, especially as any disquisition upon it must needs be long. Suffice it to say that the ordinary spelling Bernicle seems to be wrong, if we may judge from the analogy of the French *Bernache*. In both words the *e* should be sounded as *a*.

[3] The old fable, perhaps still believed by the uneducated in some parts of the world, of Bernacle-Geese being produced from the Bernacles (*Lepadidæ*) that grow on timber exposed to salt-water, is not more absurd than many that in darker ages had a great hold of the popular mind, and far less contemptible than the conceited spirit in which many modern zoologists and botanists often treat it. They should remember that the doctrine of spontaneous generation has still many adherents, and that seems to be hardly less extravagant than the notion of birds growing from "worms," as they were then called. The mistake of our forefathers is of course evident, but that is no reason for deriding their innocent ignorance as some of our contemporaries are fond of doing.

GOOSEBERRY, *Ribes grossularia*, a well-known fruit-bush of northern and central Europe, usually placed in the same genus of the natural order to which it gives name as the closely allied currants, but by some made the type of a small sub-genus, *Grossularia*, the members of which differ from the true currants chiefly in their spinous stems, and in their flowers growing on short footstalks, solitary, or two or three together, instead of in racemes.

The wild gooseberry is a small, straggling bush, nearly resembling the cultivated plant—the branches being thickly set with sharp spines, standing out singly or in diverging tufts of two or three from the bases of the short spurs or lateral leaf shoots, on which the bell-shaped flowers are produced, singly or in pairs, from the groups of rounded, deeply-crenated 3 or 5-lobed leaves. The fruit is smaller than in the garden kinds, but is often of good flavor; it is generally hairy, but in one variety smooth, constituting the *R. uva-crispa* of writers; the color is usually green, but plants are occasionally met with having deep purple berries. The gooseberry is indigenous to the central parts of Europe and western Asia, growing naturally in alpine thickets and rocky woods in the lower country, from France eastward, perhaps as far as the Himalaya. In Britain it is often found in copses and hedgerows and about old ruins, but has been so long a plant of cultivation that it is difficult to decide upon its claim to a place in the native flora of the island. Common as it is now on some of the lower slopes of the Alps of Piedmont and Savoy, it is uncertain whether the Romans were acquainted with the gooseberry, though it may possibly be alluded to in a vague passage of Pliny: the hot summers of Italy, in ancient times as at present, would be unfavorable to its cultivation. Abundant in Germany and France, it does not appear to have been much grown there in the Middle Ages, though the wild fruit was held in some esteem medicinally for the cooling properties of its acid juice in fevers; while the old English name, *Fea-berry*, still surviving in some provincial dialects, indicates that it was similarly valued in Britain, where it was planted in gardens at a comparatively early period. Turner describes the gooseberry in his *Herball*, written about the middle of the 16th century, and a few years later it is mentioned in one of Tusser's quaint rhymes as an ordinary object of garden culture. Improved varieties were probably first raised by the skilful gardeners of Holland, whose name for the fruit, *Kruisbezie*, may have been easily corrupted into the present English vernacular word.[1] Towards the end of the last century the gooseberry became a favorite object of cottage-horticulture, especially in Lancashire, where the working cotton-spinners have raised numerous varieties from seed, their efforts having been chiefly directed to increasing the size of the fruit. Of the many hundred sorts enumerated in recent horticultural works, few perhaps equal in flavor some of the older denizens of the fruit-garden, such as the "old rough red" and "hairy amber." The climate of the British Islands seems peculiarly adapted to bring the gooseberry to perfection, and it may be grown successfully even in the most northern parts of Scotland; indeed, the flavor of the fruit is said to improve with increasing latitude. In Norway even, the bush flourishes, in gardens on the west coast, nearly up to the Arctic circle, and it is found wild as far north as 63°. The dry summers of the French and German plains are less suited to it, though it is grown in some hilly districts with tolerable success. The gooseberry in the south of England will grow well in cool situations, and may be sometimes seen in gardens near London flourishing under the partial shade of apple trees; but in the north it needs full exposure to the sun to bring the fruit to perfection. It will succeed in almost any soil, but prefers a rich loam or black alluvium, and, though naturally a plant of rather dry places, will do well in moist land, if drained.

The varieties are most easily propagated by cuttings planted in the autumn, which root rapidly, and in a few years form good fruit-bearing bushes. Much difference of opinion prevails regarding the mode of pruning this valuable shrub; it is probable that in different situations it may require varying treatment. The fruit being borne on the lateral spurs, and on the shoots of the last year, it is the usual practice to shorten the side branches in the winter, before the buds begin to expand; some reduce the longer leading shoots at the same time, while others prefer to nip off the ends of these in the summer while they are still succulent. When large fruit is desired, plenty of manure should be supplied to the roots, and the greater portion of the berries picked off while still small. Burbidge states that the gooseberry may be with advantage grafted or budded on stocks of some other species of *Ribes*, *R. aureum*, the ornamental golden currant of the flower garden, answering well for the purpose. The giant gooseberries of the Lancashire "fanciers" are obtained by the careful culture of varieties specially raised with this object, the growth being encouraged by abundant manuring, and the removal of all but a very few berries from each plant. Single gooseberries of nearly 2 ounces in weight have been occasionally exhibited; but the produce of such fanciful horticulture is generally insipid. The bushes at times suffer much from the ravages of the caterpillar of the gooseberry or magpie moth, *Abraxas grossulariata*, which often strip the branches of leaves in the early summer, if not destroyed before the mischief is accomplished. The most effectual way of getting rid of this pretty but destructive insect is to look over each bush carefully, and pick off the larvæ by hand; when larger they may be shaken off by striking the branches, but by that time the harm is generally done—the eggs are laid on the leaves of the previous season. Equally annoying in some years is the smaller larva of the V-moth, *Halias vanaria*, which often appears in great numbers, and is not so readily removed. The gooseberry is sometimes attacked by the grub of a fly, *Nematus ribesii*, of which several broods appear in the course of the spring and summer, and are very destructive. The grubs bury themselves in the ground to pass into the pupal state; the first brood of flies, hatched just as the bushes are coming into leaf in the spring, lay their eggs on the lower side of the leaves, where the small greenish larvæ soon after emerge. For the destruction of the first broods it has been recommended to syringe the bushes with tar-water; perhaps a very weak solution of carbolic acid might prove more effective. The powdered root of white hellebore is said to destroy both this grub and the caterpillars of the gooseberry and V-moth; infusion of foxglove, and tobacco-water, are likewise tried by some growers. If the fallen leaves are carefully removed from the ground in the autumn and burnt, and the surface of the soil turned over with the fork or spade, most eggs and chrysalids will be destroyed.

The gooseberry was introduced into the United States by the early settlers, and in some parts of New England large quantities of the green fruit are produced and sold for culinary use in the towns; but the excessive heat of the American summer is not adapted for the healthy maturation of the berries, especially of the English varieties. Perhaps if some of these, or those raised in the country, could be crossed with one of the indigenous species, kinds might be obtained better fitted for American conditions of culture, although the gooseberry does not readily hybridize. The bushes are apt to be infested by a minute fly, known as the gooseberry midge, *Cecidomyia grossulariæ*, which lays its eggs in the green fruit, in which the larvæ are hatched, causing the berries to turn purple and fall prematurely. According to Mr. Fitch, the midge attacks the wild native species as well as the cultivated gooseberry.

The gooseberry, when ripe, yields a fine wine by the fermentation of the juice with water and sugar, the resulting sparkling liquor retaining much of the flavor of the fruit. By similarly treating the juice of the green fruit, picked just before it ripens, an effervescing wine is produced, nearly resembling some kinds of champagne, and, when skilfully prepared, far superior to much of the liquor sold under that name. Brandy has been made from ripe gooseberries by distillation; by exposing the juice with sugar to the acetous fermentation a good vinegar may be obtained. The gooseberry, when perfectly ripe, contains a large quantity of sugar, most abundant in the red and amber varieties; in the former it amounts to from 6 to upwards of 8 per cent. The acidity of the fruit is chiefly due to malic acid.

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[1] The Scotch *grossart*, originally *grosel*, evidently from the French *groseille*, may have the same ultimate origin; the usual derivation from *grossus*, a green fig, seems far-fetched. The rough wild fruit is called by the Germans *krausbeere*.

Several other species of the sub-genus produce edible fruit, though none have as yet been brought under economic culture. Among them may be noticed *R. oxyacanthoides* and *R. cynosbati*, abundant in Canada and the northern parts of the United States, and *R. gracile*, common along the Alleghany range. The group is a widely distributed one, species occurring to the west of the Rocky Mountains, and in Siberia and Japan, while one is said to have been found by recent explorers on the lofty Kilimanjaro, near the lake-sources of the Nile. (C. P. J.)

GOPHER (*Testudo gopher*, Bartr.), the only living representative on the North American continent of the *Testudinidæ* or family of land tortoises, where it occurs in the south-eastern parts of the United States, from Florida in the south to the river Savannah in the north. Its carapace, which is oblong and remarkably compressed, measures from 13 to 14 inches in extreme length, the shields which cover it being grooved, and of a yellow-brown color. The gopher abounds chiefly in the forests, but occasionally visits the open plains, where it does great damage, especially to the potato crops, on which it feeds. It is a nocturnal animal, remaining concealed by day in its deep burrow, and coming forth at night to feed. Its strength in proportion to its size is said to be enormous, it being able, according to Dumeril and Bibron, to move along comfortably bearing a man on its back. The flesh of the gopher or mungofa, as it is also called, is considered excellent eating.

GÖPPINGEN, a town of Würtemberg, circle of the Danube, on the right bank of the Fils, 22 miles E. S. E. of Stuttgart. It possesses an old castle erected by Duke Christopher in the 16th century, two evangelical churches, a Roman Catholic chapel, a synagogue, a real school, a classical school, and an advanced school. The manufactures include linen and woollen cloth, leather, glue, paper, machines, and toys. Three miles north of the town are the ruins of the old castle of Hohenstaufen, with the Barbarossa chapel, containing, besides other adornments, an old fresco of Frederick Barbarossa, dating probably from the 16th century. Göppingen originally belonged to the house of Hohenstaufen, and at a later period came into the possession of the counts of Würtemberg. It was surrounded by walls in 1129. The population in 1875 was 9532.

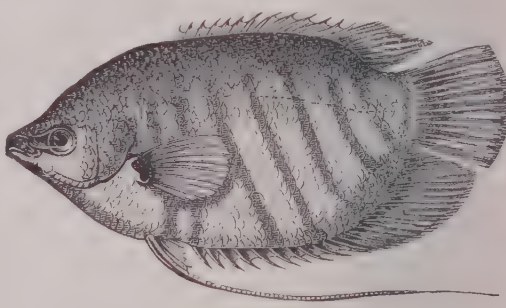
GORAKHPUR, a district of the North-Western Provinces, India, between 26° 50′ 15″ and 27° 28′ 48″ N. lat., and between 83° 7′ and 84° 29′ E. long., bounded on the N. by the territory of Nepál, on the E. by Champáran and Sáran, on the S. by the Gogra river, and on the W. by Basti and Fyzabad, with an area of 4578 square miles. The district lies immediately south of the lower Himálayan slopes, but forms itself a portion of the great alluvial plain. Only a few sandhills break the monotony of its level surface, which is, however, intersected by numerous rivers studded with lakes and marshes. In the north and centre dense forests abound, and the whole country has a verdant appearance. The principal rivers are the Rápti, the Gogra, the great and little Gandak, the Kuána, the Rolim, the Ámi, and the Gunghi. The tiger is found in the north, and many other wild animals abound throughout the district. The lakes are well stocked with fish.

The population, which in 1853 numbered 1,816,390, had risen to 2,019,361 in 1872, a great increase in so short a period; of these, 1,819,445 or 90·1 per cent. are Hindus, 199,372 Mussulmans, and 533 Christians. The district contains a total cultivated area of 2621 square miles, with 897 square miles available for cultivation, most of which is now under forest. The chief products are cotton, rice, *bájra, joár, moth* and other food-stuffs. The commerce of Gorakhpur is confined to the above products. The means of communication are still imperfect. Two good metalled roads run through the district, one from Gorakhpur to Benares *via* Barhalganj, the other to Basti and Fyzabad. The total revenue in 1876 was £227,738. The police force in 1875 numbered 755 officers and men. In 1875 there were 435 schools, with 13,525 pupils. The district is not subject to very intense heat, from which it is secured by its vicinity to the hills and the moisture of its soil. Dust-storms are rare, and cool breezes from the south, rushing down the gorges of the Himálayas, succeed each short interval of warm weather. The climate is, however, relaxing. The southern and eastern portions are as healthy as most parts of the province, but the *tárai* and forest-tracts are still subject to malaria. The average rainfall from 1860 to 1871 was 45·8 inches; the maximum was 60 inches in 1861, and the minimum 25 inches in 1868. The mean monthly temperature in the shade was 77° in 1870, and 76° in 1871. The death rate in 1875 was 40·092, or 19·85 per thousand of the population.

Gautama Buddha, the founder of the religion bearing his name, died within the district of Gorakhpur. It thus became the headquarters of the new creed, and was one of the first tracts to receive it. The country from the beginning of the 6th century was the scene of a continuous struggle between the Bhars and their Aryan antagonists, the Rahtors. About 900 the Domhatárs or military Bráhmans appeared, and expelled the Rahtors from the town of Gorakhpur, but they also were soon driven back by other invaders. During the 15th and 16th centuries, after the district had been desolated by incessant war, the descendants of the various conquerors held parts of the territory, and each seems to have lived quite isolated, as no bridges or roads attest any intercourse with each other. Towards the end of the 16th century, Mussulmans occupied Gorakhpur town, but they interfered very little with the district, and allowed it to be controlled by the native rájás. In the middle of the 18th century a formidable foe, the Banjáras from the west, kept the district in a state of terror, and so weakened the power of the rájás that they could not resist the fiscal exactions of the Oudh officials, who plundered and ravaged the country to a great extent. The district formed part of the territory ceded by Oudh to the British under the treaty of 1801. During the mutiny it was lost for a short time, but under the friendly Gurkhás the rebels were driven out, and the whole district once more passed under British rule.

GORAKHPUR, a municipal city, and the administrative headquarters of Gorakhpur district, North-Western Provinces, in 26° 44′ 8″ N. lat., and 83° 23′ 44″ E. long., on the river Rápti, near the centre of the district. It was founded about 1400, on the site of a more ancient city. It is the headquarters of a civil and sessions judge, with the usual administrative offices, and has a considerable trade in grain and timber sent down the Rápti to the Gogra and the Ganges. The municipal revenue in 1875–76 was £4771. Population (1872), 51,117.

GORAMY, or GOURAMY (*Osphronemus olfax*), is reputed to be one of the best-flavored freshwater fishes in the East Indian Archipelago. Its original home is Java, Sumatra, Borneo, and several other East Indian islands, but thence it has been transported to and acclimatized in Penang, Malacca, Mauritius, and even Cayenne. Being an almost omnivorous fish and tenacious of life, it seems to recommend itself particularly for acclimatization in other tropical countries; and specimens kept in captivity become as tame as carps. It attains the size of a large turbot. Its shape is flat and short, the body covered with large scales; the dorsal and anal fins are provided with numerous spines, and the ventral fins produced into long filaments.



Goramy.

GORCUM, or GORKUM (Dutch, *Gorinchem*), a town of the Netherlands, chief town of a circle in the province of South Holland, 22 miles E. S. E. of Rotterdam, on the right bank of the Merve or Merwede, at the influx of the Linge, by which it is intersected. It is surrounded by walls, and has an old town-house adorned with fine old paintings, a prison, a custom-house, barracks, an arsenal, and a military hospital. The old church of St. Vincent contains the monuments of the lords of Arkel. The charitable and benevolent institutions are numerous, and there are also a library and several learned associations. Gorcum possesses a good harbor, and carries on a considerable trade in grain, hemp, cheese, potatoes, and fish, although it is still destitute of railway communication. The population in 1876 was 9301.

The earliest notice of Gorcum is in a document of John I., duke of Brabant (in the close of the 13th century), granting the town's folk free trade throughout his duchy. The history in the 15th century is closely connected with that of the countship of Arkel. It was within its walls that William, the last lord of Arkel, perished in 1417, on the capture of the town by the Kabeljaus; and it was the burghers of Gorcum who in 1573 laid the castle of Arkel in ruins. In 1572, when the town was taken by William de la Marck, he put to death 19 priests and friars, who have a place in the Romish calendar as the Martyrs of Gorcum. The place defended itself successfully against the French in 1672, but was taken by the Prussians in 1785, by the French in 1795, and by the allies in 1814.

GORDIANUS, or **Gordian**, the name of three Roman emperors. The first, Marcus Antonius Africanus Gordianus, the wealthiest of the Romans, was descended on the father's side from the Gracchi, on the mother's from Trajan, while his wife was the granddaughter of Antoninus Pius. While he gained unbounded popularity by his magnificent games and shows, his prudent and retired life did not alarm the tyranny of Caracalla. Alexander Severus called him to the dangerous honors of government in Africa, and during his proconsulship there occurred the usurpation of Maximin. The universal discontent roused by the oppressive rule of Maximin culminated in a revolt in Africa in 238, and Gordian reluctantly yielded to the popular clamor and assumed the purple. His son was associated with him in the dignity. The senate confirmed the choice of the Africans, and most of the provinces gladly sided with the new emperors; but, even while their cause was so successful abroad, they had fallen before the sudden inroad of Capellianus, who commanded Mauretania in the interest of Maximin. They had reigned only 36 days. Both the Gordians had deserved by their amiable character their high reputation; they were men of great accomplishments, fond of literature, and voluminous authors; but they were rather intellectual voluptuaries than able statesmen or powerful rulers. Having embraced the cause of Gordian, the senate was obliged to continue the revolt against Maximin, and appointed Maximus and Balbinus, two of its noblest and most esteemed members, as joint emperors. At their inauguration a sedition arose, and the popular outcry for a Gordian was appeased by the association of M. Antonius Gordianus Pius, nephew of the younger and grandson of the elder Gordian, a boy of thirteen. Maximin forthwith invaded Italy, but was murdered by his own troops while besieging Aquileia; and a revolt of the prætorian guards, to which Maximus and Balbinus fell victims, left Gordian sole emperor. For some years he was under the control of his mother's eunuchs, till happily Misitheus, his teacher of rhetoric, whose daughter he married, roused him to free himself from the ignoble tyranny. Misitheus was appointed prefect of the prætorian guards, and wielded ably the supreme power that now belonged to him. When the Persians invaded Mesopotamia, the young emperor at his persuasion opened, for the last time recorded in history, the temple of Janus, and marched in person to the East. Misitheus proved a skilful and prudent general; but his sudden death under strong suspicions of poisoning was the end of Gordian's prosperity. Discontent and seditions, fostered by Philip, who had succeeded Misitheus, arose in the camp, and Gordian was slain by the mutinous soldiers (244). A monument near the confluence of the Euphrates and Aboras marked the scene.

GORDIUM, an ancient town of Bithynia, was situated not far from the river Sangarius, but the site has not been exactly ascertained, though M. Lejean believes that it may be identified with ruins which he observed in the vicinity of the village Emret. It was undoubtedly a place of high antiquity, and though Strabo describes it as a village, it afterwards increased in size, and, under the name of Juliopolis, which it received in the reign of Augustus, it continued to flourish to the time of Justinian at least. According to the legend, Gordium was founded by a certain Gordius, who had been called to the throne by the Phrygians in obedience to an oracle of Zeus commanding them to select the first person that rode into the agora in a car. The king afterwards dedicated his car to the god, and another oracle declared that whoever succeeded in untying the strangely entwined knot of the yoke should reign over all Asia. Alexander the Great, according to the well-known story, overcame the difficulty of the Gordian knot by a stroke of his sword.

See Kiepert, *Beiträge zur inschriftlichen Topographie Klein-Asiens*, 1863; Lejean, in *Bull. de la Soc. de Géogr.*, Paris, 1869.

GORDON, Alexander, the "Sandy Gordon" of Scott's *Antiquary*, is believed to have been a native of Aberdeen, and a graduate of either King's or Marischal College, but of his parentage and early history nothing is known. When still a young man he is said to have travelled abroad, probably in the capacity of tutor. He must, however, have returned to Scotland previous to 1726, when, betaking himself to antiquarian pursuits, he made the acquaintance of, among others, Roger Gale, the first vice-president of the Society of Antiquaries. In the year just mentioned appeared the *Itinerarium Septentrionale*, his greatest and best known work. He was already the friend of Sir John Clerk, of Penicuick, better known as Baron Clerk, from his having been appointed one of the Barons of the Exchequer; and the Baron and Roger Gale are the "two gentlemen, the honor of their age and country," whose letters were published, without their consent it appears, as an appendix to the *Itinerarium*. Subsequently Gordon was appointed secretary to the Society for the Encouragement of Learning, with an annual salary of £50. Resigning this post he succeeded Dr. Stukely as secretary to the Society of Antiquaries, and also acted for a short time as secretary to the Egyptian Club, an association composed of gentlemen who had visited Egypt. In 1741 he accompanied Governor Glen to South Carolina. No explanation has yet been given of the reasons which led to this step, or of the relations between the old "Roman" antiquary and his new patron. A hint, but nothing more, is afforded by the fact that in the list of subscribers to the *Itinerarium* we find the name of "James Glen of Longcroft, Esq." Through the influence probably of his friend, Gordon, besides receiving a grant of land in Carolina, was appointed registrar of the province, and justice of the peace, and filled several other offices. From his will, still in existence, dated 22d August, 1754, we learn that he had a son Alexander and a daughter Frances, to whom he bequeathed most of his property, among which were portraits of himself and of friends painted by his own hand.

Some additional particulars regarding Gordon and his works may be got from a communication to the Society of Antiquaries of Scotland by Professor Daniel Wilson, LL.D., Toronto, printed in the *Proceedings*, with Additional Notes and an Appendix of Original Letters by the late Dr. David Laing (*Proc. Soc. of Antiq. of Scot.*, vol. x. pp. 363–382).

GORDON, Lord George (1751–1793), third and youngest son of Cosmo George, duke of Gordon, was born in London, 26th December, 1751. After completing his education at Eton, he entered the navy, where he rose to the rank of lieutenant; but on account of a disagreement regarding promotion with Lord Sandwith, then at the head of the admiralty, he resigned his commission shortly before the commencement of the American war. In 1774 he entered parliament as member for the small borough of Luggershall, and possessing some wit, great ease of address, and the confidence arising from sincere conviction, he advocated his individual notions on any subject with great volubility and with something of the eagerness of monomania. After supporting the ministry for some time, he began to attack both ministry and opposition with such ceaseless pertinacity that it became a common saying that "there were three parties in parliament, the ministry, the opposition, and Lord George Gordon." He vehemently opposed the passing of the Acts for the removal of the Roman Catholic disabilities, and took a leading part in organizing the Protestant associations of Scotland and England. Of both associations he was chosen president, and on June 2d 1780, he headed the mob which marched in procession from St. George's Fields to the houses of Parliament in order to present the monster petition against the Acts. After the mob reached Westminster a terrific riot ensued, which continued several days, during which the city was virtually at their mercy. At first indeed they dispersed after threatening to make a forcible entry into the House of Commons, but reassembled soon afterwards and destroyed several Roman Catholic chapels, pillaged the private dwellings of many Roman Catholics, set fire to Newgate and broke open all the other prisons, attacked the Bank of England and several other public buildings, and continued the work of violence and conflagration until the interference of the military, by whom no fewer than 450 persons were killed and wounded before the riots were quelled. For his share in instigating the riots Lord

Gordon was apprehended on a charge of high treason; but, mainly through the skilful and eloquent defence of Erskine, he was acquitted on the ground that he had no treasonable intentions. In 1786 he was excommunicated by the archbishop of Canterbury for refusing to bear witness in an ecclesiastical suit; and in 1787 he was convicted of libelling the queen of France, the French ambassador, and the administration of justice in England. He was, however, permitted to withdraw from the court without bail, and made his escape to Holland; but on account of representations from the court of Versailles he was commanded to quit that country, and, returning to England, was apprehended, and in January, 1788, was sentenced to five years' imprisonment in Newgate, where, after refusing to grant the guarantees required as a condition of his obtaining his liberty at the conclusion of his original term of imprisonment, he died of delirious fever November 1, 1793. Some time before his apprehension he had become a convert to Judaism, and had undergone the initiatory rite. A serious defence of most of his eccentricities is undertaken in *The Life of Lord George Gordon, with a Philosophical Review of his Political Conduct*, by Robert Watson, M. D., London, 1795.

GORDON, Sir John Watson (1788–1864), Scottish painter, was the eldest son of Captain Watson, R. N., a cadet of the family of Watson of Overmains, in the county of Berwick. He was born in Edinburgh in 1788, and, it being his father's desire that he should enter the army, was educated specially with a view to his joining the Royal Engineers. As drawing was even at that period considered a not inappropriate accomplishment for the scientific service, he was, while waiting for his commission, entered as a student in the Government school of design, then as now under the management of the Board of Manufactures. With the opportunity, his natural taste for art quickly developed itself, and his industry and progress were such that his father was persuaded to allow him to adopt it as his profession. Captain Watson was himself a skilful draughtsman, and his brother George Watson, afterwards president of the Scottish Academy, stood high as a portrait painter, second only to Sir Henry Raeburn, who also was a friend of the family. Between the studios of his uncle and his friend, John Watson seems to have thought he had every necessary assistance a young artist required, and neither then nor at a future period showed any desire for foreign study; his art consequently is more purely of native growth than that of any of his contemporaries. In the year 1808 he sent to the exhibition of the Lyceum in Nicolson Street a subject from the *Lay of the Last Minstrel*, and continued for some years to exhibit fancy subjects; but, although freely and sweetly painted, they were altogether without the force and character which in his own proper walk stamped his portrait pictures as the works of a master. After the death of Sir Henry Raeburn in 1823, he succeeded to much of his practice; and as there were at that time in Edinburgh four artists of the name of Watson, all of them portrait painters, he assumed in 1826 the name of Gordon, by which he is best known. Mixing a good deal in literary and scientific society, he painted most of the notabilities who lived in or visited the northern metropolis during his career; one of the earliest of his famous sitters was Sir Walter Scott, who sat for a first portrait in 1820. Then came J. G. Lockhart in 1821; Professor Wilson, 1822 and 1850, two portraits; Sir Archibald Alison, 1839; Dr. Chalmers, 1844; a little later De Quincey; and Sir David Brewster, 1864, being the last picture he painted. Among his most important works may be mentioned the earl of Dalhousie, 1833, now in the Archers' Hall, Edinburgh; Sir Alexander Hope, 1835, in the county buildings, Linlithgow; Lord President Hope, in the Parliament House; and Dr. Chalmers, 1844. These are all full lengths, and were exhibited in London, where they attracted great attention (the Chalmers portrait was purchased some years later by Sir Robert Peel, and is now in the Peel Gallery); they belong to his middle period, and are distinguished by great sweetness in execution, and, unlike his later works, are generally rich in color. The full length of Dr. Brunton, 1844, and Dr Lee, the principal of the university, 1846, both in the staircase of the College Library, mark a modification of his style, which ultimately resolved itself into extreme simplicity, both of color and treatment.

During the last twenty years of his life he painted many distinguished Englishmen who came to Edinburgh to sit to him. And it is significant of the position he held in the esteem of artists themselves that David Cox, the landscape painter, on being presented with his portrait, subscribed for by many friends, chose to go to Edinburgh to have it executed by Watson Gordon, although he neither knew the painter personally nor had ever before visited the country. Among the portraits painted during this period, in what may be termed his third style, are De Quincey, the opium eater, in the National Portrait Gallery, London; General Sir Thomas Macdougall Brisbane, in the Royal Society; the prince of Wales, Lord Macaulay, Sir M. Packington, Lord Murray, Lord Cockburn, Lord Rutherford, and Sir John Shaw Lefevre, in the Scottish National Gallery, and a host of others, for latterly he not only possessed great facility of brush but was industrious to a fault. These latter pictures are mostly clear and grey, sometimes showing little or no positive color, the flesh itself being very grey, and the handling extremely masterly, though never obtruding its cleverness. He was very successful in rendering acute observant character, and there is a look of mobility of feature, in repose it is true, but suggesting that the eye could twinkle and the lips relax. As an example of his last style, showing pearly flesh painting freely handled yet highly finished, the head of Sir John Shaw Lefevre will hold its own in any school.

John Watson Gordon was one of the earlier members of the Royal Scottish Academy, and was elected its president in 1850; he was at the same time appointed limner to her majesty for Scotland, and received the honor of knighthood. Since 1841 he had been an associate of the Royal Academy, and in 1851 he was elected a Royal Academician. Sir John continued to paint with little if any diminution of power until within a very few weeks of his death, which occurred on the 1st of June, 1864.

GORDON, Patrick (1635–1699), of Auchleuchries, a Russian general, was descended from a Scotch family of Aberdeenshire, who possessed the small estate of Auchleuchries and were connected with the house of Haddo. He was born in 1635, and after completing his education at the parish schools of Cruden and Ellon, entered in his fifteenth year, the Jesuit college at Braunsburg, Prussia; but as "his humor could not endure such a still and strict way of living," he soon resolved to return home. He changed his mind, however, before re-embarking, and after journeying on foot in several parts of Germany, ultimately, in 1655, enlisted at Hamburg in the Swedish service. In the course of the next five years he served alternately with the Poles and Swedes as he was taken prisoner by either. In 1661, after changing his resolution more than once, he took service in the Russian army under Alexis I., and in 1666 he was sent on a special mission to England. After his return he distinguished himself in several wars against the Turks and Tartars in southern Russia, and in recognition of his services he in 1678 was made major-general, in 1679 was appointed to the chief command at Kieff, and in 1683 was made lieutenant-general. He visited England in 1686, and, after his return to Russia, he in 1687 and 1689 took part as quartermaster-general in the expeditions against the Crim-Tartars in the Crimea. On the breaking out of the revolution in Moscow in the latter year, Gordon with the troops he commanded virtually decided events in favor of the czar Peter I., and against the czarina Sophia. He was therefore during the remainder of his life in high favor with the czar, who confided to him the command of his capital during his absence from Russia, employed him in organizing his army according to the European system, and latterly raised him to the rank of general-in-chief. He died November 29, 1699. The czar, who had visited him frequently during his illness, was with him when he died, and with his own hands closed his eyes.

General Gordon left behind him a diary of his life, written in English. Several of those parts of the diary connected with the military history of Russia were at an early period translated into German—then the literary language of St. Petersburg—but never printed, although made use of for various other works. A complete German translation, by Prince M. A. Kolenski and Mr. M. C. Powell, was published, the first volume at Moscow in 1849, the second at St. Petersburg in 1851, and the third at St. Petersburg in 1853; and *Passages from the diary of General Patrick Gordon of Auchleuchries*, 1635–1699, was printed under the editorship of Joseph Robertson, for the Spalding Club, Aberdeen, 1859.

GORE, Mrs. Catherine Grace (1799–1861), an exceedingly prolific English novelist, was born in 1799 at

East Retford, Nottinghamshire, and was the daughter of Mr. Moody, a wine-merchant. In 1823 she was married to Captain Charles Gore; and in the same year, she published her first work, *Theresa Marchmont, or the Maid of Honor*. Then followed in rapid succession, the *Letter de Câchet* and *The Reign of Terror* (1827), *Hungarian Tales, Manners of the Day* (1830), *Mothers and Daughters* (1831), and *The Fair of May Fair* (1832). At this point the critics began to say that Mrs. Gore had written enough; and she accordingly went to France to extend her range of observation, and did not publish till 1836, when her next novel, entitled *Mrs. Armytage*, appeared. Every succeeding year saw several volumes from her pen; and in 1839, *The Cabinet Minister*, *Preferment*, and *The Courtier of the Days of Charles II.* were issued from the press. But in 1841 Mrs Gore fairly eclipsed her other novels by the publication of *Cecil, or the Adventures of a Coxcomb*, which produced a great sensation. This year also appeared *Greville, or a Season in Paris*. Then followed, in 1842, *Ormington, or Cecil a Peer*, *Fascination*, and *The Ambassador's Wife;* and in 1843 Mrs. Gore produced another masterpiece, entitled *The Banker's Wife*. She continued to write, with unfailing fertility of invention, till her death in January, 1861. Mrs. Gore also published some dramas and translations from the French; but it is as a fashionable novelist that she is remembered. Her life was one of extraordinary literary industry, as may be inferred from the fact that she is the author of more than seventy distinct works. Among her best novels are *Cecil, or the Adventures of a Coxcomb*, *Greville*, and *The Banker's Wife*. *Cecil* gives extremely vivid sketches of London fashionable life, and is full of happy epigrammatic touches. It displays great knowledge of London clubs, for which Mrs. Gore was indebted to Mr. Beckford, the author of *Vathek*. The narrative is varied by occasional glimpses of Continental life. *Greville* is marked by faithful pictures of English country life, and of the ease and grace of French society. *The Banker's Wife* is distinguished for masterly studies of character, especially in the persons of Mr. Hamlyn, the cold calculating moneymaker, and his warm-hearted country neighbor, Colonel Hamilton.

Mrs. Gore's works are characterized by great cleverness in invention, lively satire, shrewd insight into character, and keen observation of life. They are exceedingly deficient in feeling; and the lover of fiction passes a pleasant hour or two over her novels, not much excited by the triumphs, or vexed by the sufferings of her characters. Sometimes her novels weary the reader; but this does not arise from any failing in her style, which is always clear, animated, and full of point, nor from lack of inventiveness, but from the endless repetitions involved in writing so many books on a subject of such comparatively limited range as fashionable life. Mrs. Gore's novels have not only achieved an immense temporary popularity, but possess genuine historic value as eminently readable, and on the whole faithful, pictures of the life and pursuits of the English upper classes.

GOREE (in French *Gorée*, and in the native tongue *Bir* or *Berr*, that is, a belly, in allusion to its shape), a small island off the west coast of Africa, belonging to the French colony of the Senegal. It lies immediately to the south of Cape Verd, and, according to the *Annuaire du Sénégal* for 1878, in 14° 39′ 55″ N. lat. and 12° 16′ 40″ W. long. The distance from the mainland in one direction is about 8 miles, and in another from 3 to 4. Though little more than a barren rock, Goree is of importance as a commercial and military post, and all the more as it has the advantage of a milder climate than the neighboring mainland. The greater part of its area is occupied by the town, which was constituted a commune in 1872, and placed under the government of a municipal council of 14 members. The streets are narrow, and the houses, built for the most part of dark red stone, are flat-roofed. Among the principal buildings are the castle of St. Michael, which occupies the rocky eminence in the south of the island, the governor's residence, the hospital, and the barracks. The summit of the rock within the citadel is levelled to an esplanade, and in the centre is a deep Artesian well, the only source in the otherwise arid island, which is dependent on its rain-water tanks for its ordinary supplies. Goree is a free port, and forms a convenient centre for the distribution of European goods. It is regularly visited by the vessels of the British and African Steam Navigation Company. The harbor is formed in a small sandy bay on the north-east side of the island. Telegraphic communication with St. Louis dates from 1862. A chamber of commerce was established in 1870, and a sanitary commission in 1874. The town was reported in 1878 to have a population of 3243, and the arrondissement of Gorée-Dakar, of which it is the administrative centre, had a total population of 61,394. Dakar is a new settlement on the mainland, with a port constructed since 1857 for the vessels of the Messageries Maritimes; but with the exception of the public buildings the town has still to be built. Goree owes its name to the Dutch, who took possession of it in the beginning of the 17th century, and called it Goeree or Goedereede, in memory of the island on their own coast now united with Overflakkee. It was taken from them in 1663 by the English under Commodore Holmes, but recovered in the following year by De Ruyter. They were finally expelled, in 1677, by the French under Admiral D'Estrées, whose conquest was confirmed in 1678 by the peace of Nymwegen. In 1758 the island was captured for the English by Commodore Keppel, but a few years afterwards it was restored to France. With the exception of a few months in 1804, when the island was held by the French, the English were again in possession from 1800, when it was seized by Sir Charles Hamilton, till the peace of 1814.

GORGIAS of Leontini, in Sicily, a rhetorician and sophist, of whose personal history nothing is known beyond the facts that in 427, when already a comparatively old man, he was sent by his fellow-citizens at the head of an embassy to ask Athenian protection against the aggression of the Syracusans; that he then settled in Athens, and supported himself by the practice of oratory and by teaching rhetoric; and that he ended his days at Larissa, in Thessaly. His birth and death may be approximately dated respectively at 483 and 375 B. C. He was the author of a lost work *On Nature or the Non-existent* (περὶ τοῦ μὴ ὄντος ἢ περὶ φύσεως), the substance of which may be gathered from the writings of Sextus Empiricus, and also from a treatise (ascribed to Theophrastus) *De Melisso, Xenophane Gorgia*. His philosophical opinions may be summed up in three propositions, which stand in direct relation to the teachings of the Eleatic school. He held (1) that there is nothing which has any real existence; (2) that, even if anything did really exist, it could not be known; and (3) that, supposing real existence to be knowable, the knowledge would be incommunicable. On the first point his argument was that a real existence must either have come into being or have been eternal. But the first alternative would require it to have been produced, either from the existent or from the non-existent; the second alternative would require us to identify it with the infinite, but the infinite exists nowhere (for that would involve the absurdity of its existing either within itself or within something else), but what exists nowhere is nothing. In support of the second proposition he argued that, if existence could be known, then thought would be existence, and the non-existent would be unthinkable and error would be impossible. The third point for which he argued was the inadequacy of language to convey ideas, and the impossibility of the idea being the same in different minds. In natural philosophy his opinions, so far as these are known, appear to have been similar to those of Empedocles. See the monograph, *De Gorgia Leontino Commentatio*, by Foss, 1828.

GORGON, γοργώ, according to Hesychius, is a word akin to γοργός, which means terrible, lively, rapid. Sophocles (fr. 167) calls the sea-nymphs γοργίδες and γοργάδες is quoted as a title of the daughters of Oceanus. Now it is a well-established fact that the sea was at one time the sea of air and its nymphs the clouds. Hence we may infer that words from this stem are employed in the sense of quick-moving as epithets of the clouds.

The various forms in which the Gorgon appears in Greek mythology originate probably from the rapidly gathering terrible thunder-cloud. When the cloud covered the heaven and hid the sun, a primitive race, whose thoughts and words were few and simple, said that the sun was united in marriage to the cloud. From this union sprang the lightning and the thunder. Now the sun, in its different aspects and relations, was conceived in different ways, which developed, as thought unfolded itself, into distinct deities; and, as connected with clouds, rain, and the fertility that springs therefrom, he is the original of the Vedic Savitar and Tvashtar and of the Greek Poseidon. Accordingly (Hes., *Theog.*, 273 ff.) Poseidon on a meadow (*i. e.*, the heaven, thus often in mythology) begat from the Gorgon Medusa Chrysaor and

Pegasus. Chrysaor, Gold-sword, is obviously the lightning; and Pegasus, who bears the thunder and lightning for Zeus (*ibid.* 286), was probably at first simply the thunder. Gorgo and Erinys are merely tribal or local varieties of the same conception; Gorgo is specially Attic, Erinys Minyan. A similar legend occurs about children of Erinys and Poseidon (Paus., viii. 37). Hence Æschylus (*Cho.*, 1048) compares the Erinyes to Gorgons.

Gorgo is always the impersonation of the atmospheric terrors, and is conceived in connection with the deities that are armed with thunder and lightning—Zeus and Athene. With Athene in particular is the connection very close, and some facts of ritual and nomenclature almost suggest an original identity of the two. Palæphatus says that Athene was worshipped in the island of Cerne under the name Gorgo; Sophocles (*Al.*, 450) calls her *γοργῶπις*; and Plutarch (*Arat.*, 32) says that her wooden statue at Pallene, if brought out of the temple, destroyed human life (compare the description of the birth of Athene in Pindar, *Ol.*, vii. 65 ff., which strongly suggests the phenomena of the thunderstorm). Here we have preserved to us a relic from the very earliest thought among the Indo-European race. When a phenomenon in the heavens attracted their attention, they naturally spoke of it as of an animated being. The storm appeared to act out its own natural course, to live its own life. But afterwards the phenomenon was conceived with reference to human needs: beneficent and hostile deities worked in nature; a hostile power denies to men what a friendly power after a conflict grants. Among the Greeks this opposition appears in the antithesis of Olympian and older or Chthonian gods. The goddess who ruled the storm for man was set in opposition to the actual thundercloud—Athene to Gorgo (see GRACES). Accordingly the usual Greek account is that the *γοργόνειον* or *γοργείη κεφαλή*, a terror-striking countenance, is fixed in the middle of the ægis of Zeus. Zeus gives the ægis (*Iliad*, v. 736 ff., comp. Æsch., *Eum.*, 825) to Athene, the goddess of the air. The Gorgoneion is always said to have been won in battle, viz., in the conflict of the beneficent gods against the older nature-powers, who would scorch the earth with heat and deny the needed rain. Zeus then assuming the ægis (the shield of the storm-cloud) overthrows the Titans or the Giants in the aerial battle; the rain descends, and a clearer and cooler sky succeeds. Or in other accounts the whole array of gods engages in the battle; Athene then appears naturally as *γοργοφόνη*, *i. e.*, she clears the atmosphere, her own special domain, from the terrible cloud, which she keeps on her shield threatening death to all her foes. The Attic tradition was that the Gorgon was a monster produced by Earth to aid her distressed sons the Giants, and was slain by Pallas (Eur., *Ion*, 1002). In Homer Gorgo appears also in connection with Apollo, Agamemnon, Hector, and Persephone,—a connection which might be justified by an examination into the mythological ideas that underlie these names.

Later accounts, beginning from Hesiod (*Theog.*, *l. c.*), mention three Gorgons; but Medusa alone inherits the character and history of the older Gorgo, while two sisters are added to make up the sacred number, in analogy with the Moiræ, Grææ, Erinyes, etc. The Argive story has established itself in all later literature as the standard account of the Gorgons. Perseus, the light-giving hero, aided by Athene and the other gods, goes to the abode of the Gorgons, beside Oceanus, far away in the dark West, and cuts off the head of Medusa. Then from the streaming neck sprang Chrysaor and Pegasus, her two sons by Poseidon. This head, which, like the lightning, had the power of turning into stone all that looked on it, was given to Athene, who placed it in her shield. According to another account, Perseus buried the head in the Agora of Argos. Beside it was buried his daughter Gorgophone, who is obviously a mere impersonation of the old epithet of the Gorgon-slaying goddess.

These ideas of sun and storm give only the starting point for the myths; the history of their further growth involves the whole subsequent history of the nation. Just as in Germany, after Christianity was introduced, many old myths and customs lived on applied to Christ and his apostles instead of the old gods, so must the Greek myths as we know them bear traces of the historical vicissitudes of the race. Hence Böttiger (*Kunst-Myth.*, i. 369) has possibly some ground for referring the Perseus tale to the extinction of Phœnician human sacrifices by the Greeks.

The gradual development in art from the old hideous and terrible representation of the Medusa head to the calm repose of a beautiful dead face is described in detail by Müller, *History of Ancient Art*, and *Denkmäler der Alten Kunst*. See also Rosenberg, *Die Erinyen*.

GORI, in Georgia, an ancient fortress, is now the chief town of a district of the same name in the government of Tiflis, and a station on the Poti-Tiflis railroad. It is built at the foot of an isolated hill crowned by the old fortifications, in a luxuriantly fertile plain on the left bank of the Kour, at the junction of the Bleejah'va and Medjoura, 48 miles west of Tiflis. The population, about 5000, is almost exclusively Armenian, engaged in commerce. The women are noted for their beauty. This town, at one time celebrated for its silk and cotton stuffs, is now famous for corn, reputed the best in Georgia; the wine is also esteemed, 5200 acres being laid out in vineyards. The climate is excellent, delightfully cool in summer, owing to the refreshing breezes from the mountains of the great Caucasian range, which, however, are at times disagreeably felt in winter. Gori was founded (1123) by David II., "the Restorer," for the Armenians who fled their country on the Persian invasion. The earliest remains of the fortress are Byzantine, but it was thoroughly restored in 1634–58, during the reign of Rustam, and destroyed by Nadir Shah. Besides the Armenian and Georgian churches, and some good schools, there is a church constructed in the 17th century by Capuchin missionaries from Rome. Gori was the birthplace (1773) of Stephàn Peshanegishvyly, a distinguished and popular poet. Eight miles from Gori is the remarkable rock-cut town of Ouplytz-tzykhè, consisting of several large dwellings having their interiors ornamented with mouldings, imitation beams, and designs sculptured in relief, and innumerable smaller habitations, the majority being divided into chambers with doorways, openings for light, and sundry provisions for domestic comfort. The whole have been hewn out of the solid rock, the groups being separated by streets, where steps for facilitating communication and grooves for water courses are cut. This "Fortress of Ouplytz" was projected and completed, according to the annals of Georgia, by Ouphlis, an immediate descendant of Noah (see GEORGIA). It was a fortress in the time of Alexander of Macedon, and an inhabited city in the reign of Bagrat III. (980–1014).

GORILLA. See APE, vol. ii. p. 130.

GÖRITZ, See GÖRZ.

GÖRLITZ, a town in the Prussian province of Silesia, capital of a circle in the government district of Liegnitz, is situated on the left bank of the Neisse, and at the junction point of several railways, 55 miles east of Dresden. The Neisse at this point is crossed by a railway bridge half a mile long and 120 feet high, with 32 arches. The town is the seat of a provincial office, a circle court, and a chamber of commerce. It is surrounded by beautiful walks and fine gardens, and although its old walls and towers have now been demolished, many of its ancient buildings remain to form a picturesque contrast with the signs of modern industry. From the hill called Landskrone, about 1500 feet high, an extensive prospect is obtained of the surrounding country. The principal buildings are the fine church of St. Peter and St. Paul, dating from the 15th century, with a famous organ and a very heavy bell; the church of Our Lady erected about the end of the 15th century, and possessing a fine portal and choir in pierced work; the Catholic church, founded in 1853, in the Roman style of architecture, with beautiful glass windows and oil-paintings; the town house, containing the arms of King Matthias of Hungary, and having at its entrance a fine flight of steps; the old bastion, named Kaisertrutz, now used as a guardhouse and armory; the gymnasium buildings in the Gothic style, erected in 1851; the fine new middle school, the real school, the provincial trade school, the theatre, and the barracks. Near the town is the chapel of the Holy Cross, in connection with which there is a model of the Holy Grave at Jerusalem. In the public park there is a bust of Schiller and a monument to Alexander von Humboldt; and a monument has also been erected in the town in commemoration of the war of 1870–71. In connection with the National History Society there is a valuable museum, and the Scientific Institute possesses a large library and a rich collection of antiquities, coins, and articles of vertu. Görlitz, next to Breslau, is the largest and most flourishing commercial town of Silesia. Besides cloth, which forms its staple article, it has manufactories of various linen and woollen wares, machines, railway wagons, sago, tobacco, leather, chemicals, and tiles.

Görlitz existed as a village from a very early period, and at the beginning of the 12th century it was made a borough by Duke Sobieslaus I. of Bohemia. It was then known as Drebenau, but on being rebuilt after its destruction by fire in 1131 it received the name of Zgorzelice (burnt town). About the end of the 12th century it was strongly fortified, and in 1346 it joined the league of the six towns. It was several times besieged and taken during the Thirty Years' War, and it also suffered considerably in the Seven Years' War. In the battle which took place near it between the Austrians and Prussians, 7th September 1757, Winterfield, the general of Frederick the Great, was slain. In 1815 the town, with the greater part of Upper Lusatia, came into the possession of Prussia. The population in 1831 was only about 8000, but in 1849 it had increased to 19,032, and in 1875 it was 45,310.

GÖRRES, Joseph Johann (1776–1848), a distinguished controversialist and writer on religious, political, and scientific subjects, was born January 25, 1776, at Coblentz. His father was a man of moderate means, who sent his son, after he had passed through the usual elementary school, to a Latin college under the direction of the Roman Catholic clergy. The sympathies of the young Görres were from the first strongly with the Revolution, and the dissoluteness and irreligion of the French exiles in the Rhineland confirmed him in his hatred of princes. He harangued the revolutionary clubs, and in his first political tract, called *Universal Peace, an Ideal*, he insisted on the unity of interests which should ally all civilized states to one another. He then commenced a republican journal called *Das Rothe Blatt*, and afterwards *Rübezahl*, in which he strongly condemned the administration of the Rhenish provinces by France.

After the peace of Campo Formio (1797) there was some hope that the Rhenish provinces would be constituted into an independent republic. In 1799 the provinces sent an embassy, of which Görres was a member, to Paris to put their case before the directory. The embassy reached Paris on the 20th of November, 1799; two days before this Napoleon had assumed the supreme direction of affairs. After much delay the embassy was received by him; but the only answer they obtained was "that they might rely on perfect justice, and that the French Government would never lose sight of their wants." Görres on his return published a tract called *Results of my Mission to Paris*, in which he reviewed the history of the French Revolution. During the thirteen years of Napoleon's dominion Görres lived a retired life, devoting himself chiefly to art or science. In 1801 he married Catherine de Lassaulx, and those of Görres's admirers who claim him as a radical have laid great stress on the fact that this lady was a free-thinker. He published *Aphorisms* on art and physiology—fanciful but suggestive. He was for some years teacher at a secondary school in Coblentz, and in 1806 moved to Heidelberg, where he lectured at the university. He sought, with Brentano, Arnim, and others, to stir up the old national spirit by the republication of some of the old Teutonic ballads, but fruitlessly. He returned to Coblentz in 1808, and again found occupation as a teacher in a secondary school, supported by civic funds. He now studied Persian, and in two years produced a really valuable translation of part of the *Shahnamah*, the epic of Firdousi.

It was in the year 1810 that he seems to have conceived the notion of arousing the people to efforts by means of the press; and after the battle of Leipsic, in the year 1814, he set his paper going. It bore the name of a paper which had been a mere echo of Prussia, the *Rheinischer Merkur*. The intense earnestness of the paper, the bold outspokenness of its hostility to Napoleon, and its fiery eloquence secured for it almost instantly a position and influence unique in the history of German newspapers. Blücher read it every day; Gentz, the brothers Grimm, Varnhagen von Ense, were all loud in praise of it; Stein used it as an instrument to move the public in the direction he desired, and continually sent it information of his plans; Napoleon himself called it *la cinquième puissance*. The ideal it insisted on was a united Germany, with a representative government, but under an emperor after the fashion of other days,—for Görres now abandoned his early advocacy of republicanism. When Napoleon was at Elba, Görres wrote an imaginary proclamation issued by him to the people, the intense irony of which was so well veiled that many Frenchmen mistook it for an original utterance of the emperor. He inveighed bitterly against the second peace of Paris (1815) declaring that Alsace and Lorraine should have been demanded back from France.

Stein was glad enough to use the *Merkur* at the time of the meeting of the congress of Vienna as a vehicle for giving expression to his hopes. But Hardenberg, in May, 1815, warned Görres to remember that he was not to arouse hostility against France, but only against Bonaparte. There was also in the *Merkur* an antipathy to Prussia, a continual expression of the desire that an Austrian prince should assume the imperial title, and also a tendency to pronounced liberalism, all of which made it most distasteful to Hardenberg, and to his master King Frederick William III. Görres disregarded warnings sent to him by the censorship and continued the paper in all its fierceness. Accordingly it was suppressed early in 1816, at the instance of the Prussian Government; and soon after Görres was dismissed from his post as teacher at Coblentz. From this time his writings were his sole means of support, and he became a most diligent political pamphleteer. He was not himself a member of the *Tugendbund*, but he watched that society with deep interest, and believed, as did all the patriots of his time, that the clubs of students, or *Burschenschaften*, were calculated to restore the pristine greatness of Germany. The agitation continued, and finally Kotzebue's denunciation of young Germany led to his assassination. In the wild excitement which followed, the reactionary decrees of Carlsbad were framed, and these were the subjects of Görres's celebrated pamphlet *Deutschland und die Revolution*. In this work he reviewed the circumstances which had led to the murder of Kotzebue, and, while expressing all possible horror at the deed itself, he urged that it was impossible and undesirable to repress the free utterance of public opinion by reactionary measures. The success of the work was very marked, despite its ponderous style. It was suppressed by the Prussian Government, and orders were issued for the arrest of Görres and the seizure of his papers. He escaped to Strasburg, and thence went to Switzerland. Two more political tracts, *Europa und die Revolution* (1821), and *In Sachen der Rhein Provinzen und in eigener Angelegenheit* (1822), also deserve mention.

In Görres's pamphlet *Die Heilige Allianz und die Völker auf dem Congress von Verona* he asserted that the princes had met together to crush the liberties of the people, and that the people must look elsewhere for help. The "elsewhere" was to Rome; and from this time Görres became a vehement Ultramontane writer. He was summoned to Munich by King Louis of Bavaria, and there his writings enjoyed very great popularity. His *Christliche Mystik* gave a series of biographies of the saints, together with an exposition of Roman Catholic mysticism. But his most celebrated Ultramontane work was a polemical one. Its occasion was the deposition and imprisonment by the Prussian government of the archbishop Clement Wenceslaus, in consequence of the refusal of that prelate to sanction in certain instances the marriages of Protestants and Roman Catholics. Görres in his *Athanasius* fiercely upheld the power of the church, although the liberals of later date who have claimed Görres as one of their own school deny that he ever insisted on the absolute supremacy of Rome. *Athanasius* went through several editions, and originated a long and bitter controversy. In the *Historisch-politische Blätter*, a Munich journal, Görres and his son Guido continually upheld the claims of the church. Görres received from the king the order of merit for his services. He was terribly disturbed when the king sunk under the dominion of Lola Montez, and he died July 29, 1848.

See A. Denk, *Joseph von Görres*, 1870; J. J. Sepp, *Görres und sein Zeitgenossen*, 1877. A complete edition of Görres's works was published at Munich in 1854. (L. A. M.)

GORTSCHAKOFF (Gorchakov), a noble Russian family, descended from Michael Vsevolodovich, prince of Chernigoff, who, in 1246, was assassinated by the Mongols. The following are the most distinguished members of this family. Petr Dimitrievich (1790–1868) served under Kamensky and Kutuzoff in the campaign against Turkey, and afterwards against France in 1813–1814. In 1820 he suppressed an insurrection in the Caucasus, for which service he was raised to the rank of major-general. In 1828–29 he fought under Wittgenstein against the Turks, occupied Aidos, and signed the treaty of peace at Adrianople. In 1839 he was made governor of eastern Siberia, and in 1851 retired into private life. When the Crimean war broke out he offered his services to the emperor Nicholas, by whom he was appointed general of the 6th army corps in the Crimea. At the battles of Alma and Inkerman he commanded the left wing of the Russian army. In 1855 he retired, and died at Moscow, March 18, 1868. MIKHAIL DIMITRIEVICH (1792–1861), brother of the preceding, was born in 1792. In 1807 he entered the Russian army, in 1810 he took part in the campaigns against Persia, and in 1812–1815 against France. During the Russo-Turkish war of 1828–29, he directed the operations of the sieges of Silistria and Shumla. After being appointed, in 1830, general of artillery, he was present in the campaigns in Poland, and was wounded at the battle of Grochow, February 25, 1831. He also distinguished himself at the battle of Ostrolenka and at the taking of Warsaw. For these services he was promoted to the rank of lieutenant-general. In 1846 he was nominated military governor of Warsaw. In 1849 he commanded the Russian artillery against the Hungarians, and in 1852 he visited London as a representative of the Russian army at the funeral of the duke of Wellington. Upon Russia declaring war against Turkey in 1853, he was appointed commander-in-chief of the troops, numbering in all some 60,000 men, which occupied Moldavia and Wallachia. On the 23d March, 1854, he crossed the Danube and besieged Silistria, but was superseded in April by Prince Paskievich, who, however, resigned on the 8th of June, when Gortschakoff resumed the command. In July the siege of Silistria was raised, and the Russian armies recrossed the Danube; in August they withdrew to Russia. In 1855 he was appointed commander-in-chief of the Russian forces in the Crimea in place of Prince Mentshikoff. Gortschakoff's defence of Sebastopol, and final retreat to the northern part of the town, which he continued to defend till peace was signed in Paris, were conducted with skill and energy. In 1856 he was appointed governor-general of Poland. He died at Warsaw on the 30th May, 1861.

GORTYNA, or GORTYN, an important ancient city on the southern side of the island of Crete. It stood on the banks of the small river Lethæus (Mitropolipotamo), at a short distance from the sea, with which it communicated by means of its two harbors, Metallum and Lebena. It had temples of Apollo Pythius, Artemis, and Zeus. Near the town was the famous fountain of Sauros, inclosed by fruit-bearing poplars; and not far from this was another spring, overhung by an evergreen plane-tree which in popular belief marked the scene of the amours of Jupiter and Europa. Gortyna was, next to Cnossus, the largest and most powerful city of Crete. The two cities combined to subdue the rest of the island; but when they had gained their object, they quarrelled with each other, and the history of both towns is from this time little more than a record of their feuds. Neither plays a conspicuous part in the history of Greece. Under the Romans Gortyna became the metropolis of the island. Some ruins may still be traced at the modern village of Hagii Deka.

GÖRZ, with GRADISCA, is one of the crown-lands of the Austrian monarchy, between 45° 36′ 3″ and 46° 27″ N. lat., and bounded N. by Carinthia, E. by Carniola, Istria, and the Triestine territory, S. by the Triestine territory and the Adriatic, and W. by Italy. On all sides, except towards the south-west, where it unites with the Friulian lowland, it is surrounded by mountains, and four-sixths at least of its area of 1140 square miles is occupied by mountains and hills. From the ridge of the Julian Alps, which rise in an almost unbroken line to a height of 6000 or 7000 feet, the country descends in successive terraces towards the sea, and may roughly be divided into the upper highlands, the lower highlands, the hilly district, and the lowlands. The highest summit is the Terglou, 9370 feet, in the north-west. Geologically the country is a great limestone district, comprising limestones of many different formations, Rhætian, Jurassic, Neocomian, and Nummulitic; and the strata have evidently undergone a series of powerful disturbances. The hydrography is sufficiently peculiar, a considerable proportion of the circulation of the waters taking place by underground channels. The limits of the country coincide in the main with that of the basin of the Isonzo, which rises in the extreme north at a height of 2650 feet, and pursues a strange zigzag course for a distance of 78 miles before it reaches the Adriatic. At Görz the Isonzo is still 138 feet above the sea, and it is navigable only in its lowest section, where it takes the name of the Sdobba. Its tributaries, of which the most important are the Idria, the Torre, and the Wippach, are little more than mountain streams. Of special interest not only in itself but for the frequent allusions to it in classical literature is the Timavus or Timavo. In ancient times it appears, according to the well-known description of Virgil (*Æn.*, i. 244) to have rushed from the mountain by nine separate mouths and with much noise and commotion, but at present it usually issues from only three mouths and flows quiet and still. It is strange enough, however, to see the river coming out full formed from the rock, and capable at its very source of bearing vessels on its bosom. According to a probable hypothesis it is a continuation of the river Reka which is lost in a cleft of the rock in the south-east of the country near S. Canziano. The coast-line of Görz and Gradisca, though extending for 25 miles, presents no harbor of much importance. It is fringed by alluvial deposits and lagoons which are for the most part of very modern formation; for as late as the 4th or 5th centuries Aquileia was a great seaport. The harbor of Grado is the only one accessible to the larger kind of coasting craft. A large part of the country formerly covered with forest has been recklessly cleared, but the Tarnova plateau is still a fine wooded district with an area of about 35 or 40 square miles. The red beech is the predominant and in some parts almost the exclusive tree, but it is being displaced by the fir and the pine. A number of pits in the plateau are full of ice all the year round, and yield about 16,000 cwts. annually for the consumption of the neighboring countries. More than a fifth of the area of the country is pasture-land, and less than a twenty-fourth is under the plough.

The vine is largely cultivated, being not only planted in regular vineyards but introduced in long lines through the ordinary fields and carried up the hills in terraces locally called ronchi. Wheat, maize, buck-wheat, and potatoes are the usual crops. Silk growing is largely carried on, especially in the lowlands, and furnishes the material for the most extensive industry of the country. There are about 2000 workers in silk, and the produce is worth upwards of £200,000, while the cotton manufacture, which is next in importance, employs about 1000, and produces £100,000. Leather, linen, paper, and soap are manufactured on a smaller scale. The trade of the country is of very little importance. Görz and Gradisca, according to the constitution of 1861, have a diet consisting of six representatives of the landed proprietors, seven representatives of the towns and industrial interests, and eight representatives of the rural communes. The elector for the landed interest must pay 100 florins (about £10) of land-tax in the Italian circle, and 50 florins (about £5) in the Slovenian circle. Two representatives are sent to the imperial council. The political administration is in the hands of the lieutenant of the coast-lands, which include not only Görz and Gradisca but also Trieste and Istria. Roman Catholicism is the exclusive religion, the only Protestant community being in the town of Görz, and the Jews numbering only some 400. Ethnographically the population must contain much more various elements, but in 1857, out of a total of 196,276 inhabitants, 130,748 were registered as Slovenians, 47,841 as Friulians, 15,134 as Italians, and only 2150 as Germans.

Görz first appears distinctly in history about the close of the 10th century, as part of a district bestowed by the emperor Otto III. on John, patriarch of Aquileia. In the 11th century it became the seat of the Eppenstein family, who frequently bore the title of counts of Gorizia; and in the beginning of the 12th century the countship passed from them to the Lurngan family which continued to exist till the year 1500, and acquired possessions in Tyrol, Carinthia, Friuli, and Styria. In the course of the 13th and 14th centuries the counts often appear as protectors (*Schirmvogt* or *Advocatus*) of the church of Aquileia and as captains-general of Friulia. When the Venetians took possession of Friulia they gave Count Henry the title of hereditary marshal as a compensation for his loss of office. The right of coining was exercised by the counts from the 13th century. On the death of Count Leonhard (12th April, 1500) the fief reverted to the house of Hapsburg.

GÖRZ, GÖRTZ, or GÖRIZ (Italian, *Gorizia;* Modern Latin, *Goritia*), the chief town of the crown-land, is beautifully situated in the fruitful valley of the Isonzo, 25 miles N. N. W. of Trieste by railway. It is the seat of an archbishop, of a circle court, and of a head tax-office. The principal buildings are the cathedral, the former Jesuit church and college now converted into barracks, the convents of the brothers and sisters of mercy, of the Franciscans, of the Capuchins, and of the Ursulines, the municipal buildings, the theatre, the house of the bishop, and the old castle of the former counts of Tyrol and Görz now converted into a prison. Among the educational establishments are a central episcopal seminary, a gymnasium, an upper real-school, a deaf and dumb institute, and an agricultural school. The industries include cotton and silk weaving, sugar refining, brewing, the manufacture of leather, and the making of rosoglio. There is also a considerable trade in wooden work, fruit, and wine. On account of its mild climate the town is coming to be much resorted to by invalids in winter. Charles X., the exiled king of France, died at Görz 6th November, 1836. The population of the town in 1869 was 16,659.

Besides the great monograph of K. von Czörnig, *Das Land Görz und Gradisca*, Vienna, 1873 and 1874, see Siegmund, *Südliche Klimatische Kurorte*, Vienna, 1875; Coronini, *Fastorum Goritiensium*, lib. i. Vienna, 1769, and *L'Antica moneta Goriziana*, Görz, 1785; Schweizer, *Abrégé de l'histoire des comtes de Gorice*, Trieste, 1859; Carlo Morelli of Schönfeld, *Istoria della Contea di Gorizia*, Görz, 1855–56; Della Bona, *Sunto istorico di Gorizia e di Gradisca*, Görz, 1853; Siebert, *Görz, Stadt und Land*.

GOS-HAWK, *i. e.*, Goose-Hawk, the *Astur palumbarius* of ornithologists, and the largest of the short-winged Hawks used in Falconry. Its English name, however, has possibly been transferred to this species from one of the long-winged Hawks, or true Falcons, since there is no tradition of the Gos-Hawk, now so called, having ever been used in Europe to take Geese or other large and powerful birds. The genus *Astur* may be readily distinguished from *Falco* by the smooth edges of its beak, its short wings (not reaching beyond about the middle of the tail), and its long legs and toes—though these last are stout and comparatively shorter than in the Sparrow-Hawks (*Accipiter*). In plumage the Gos-Hawk has a general resemblance to the Peregrine Falcon (see FALCON, vol. ix. p. 4), and it undergoes a corresponding change as it advances from youth to maturity—the young being longitudinally streaked beneath, while the adults are transversely barred. The irides, however, are always yellow, or in old birds orange, while those of the Falcons are dark brown. The sexes differ greatly in size. There can be little doubt that the Gos-Hawk, now-a-days very rare in Britain, was once common in England, and even towards the end of the last century Thornton obtained a nestling in Scotland, while Irish Gos-Hawks were of old highly celebrated. Being strictly a woodland-bird, its disappearance may be safely connected with the disappearance of our ancient forests, though its destructiveness to Poultry and Pigeons has doubtless contributed to its present scarcity. In many parts of the continent of Europe it still abounds. It ranges eastward to China, and is much valued in India (see FALCONRY, vol. ix. p. 11). In North America it is represented by a very nearly allied species, *A. atricapillus*, chiefly distinguished by the closer barring of the breast. Three or four examples corresponding with this form have been obtained in Britain. A good many other species of *Astur* (some of them passing into *Accipiter*) are found in various parts of the world, but the only one that need here be mentioned is the *A. novæ-hollandiæ* of Australia, which is remarkable for its dimorphism—one form possessing the normal dark-colored plumage of the genus, and the other being perfectly white, with crimson irides. It must be stated, however, that some writers hold these two forms to be distinct species, and call the dark-colored one *A. cinereus* or *A. raii*. (A. N.)

GOSHEN (גֹּשֶׁן), or the land of Goshen, a territory of Egypt in which the Israelites were settled from Jacob's immigration to the Exodus. In the Septuagint the equivalent is usually the land Gesem (Γεσέμ), but in Gen. xlv. 10 "the land Gesem of Arabia," Arabia being here either the Arabian nome (Ἀραβίας νομός) or the extreme east of Lower Egypt. According to Dr. Brugsch the Arabian nome was the 20th of Lower Egypt in the older division known to us, the 32d in the later, the alteration in the number being due to a new division under the Ptolemies (*Dict. Géogr.*, List following preface). The Egyptian name of the nome was Supt, and the capital was Kesem, probably Kosem, also called Kesem-Abot, Kesem of the East (Arabia), equivalent to the Gesem of the Septuagint, preserved in the classical Phacusa (Pa-Kesem), and the modern Fakoos, where mounds mark the site of the ancient town (*cf.* Brugsch, *Ib.*, 876–7, 1049–50). The etymology is doubtful; probably the name is like many others in the same part of Egypt of Semitic origin, as another land of Goshen, with a capital city of the same name, is mentioned in southern Palestine. It is therefore certain that the land of Goshen was around the town of Phacusa. The site of this town lies within the easternmost part of Lower Egypt, under 20 miles in a direct line south of Sán, the site of Tanis. These conditions suit those of the Biblical narrative. It is obvious that Goshen was a pastoral country, that it was suited for a Shemite settlement, and was in the Shemite part of Lower Egypt, its north-eastern portion. It was near the seat of government in that part of the country, which at this time was Tanis-Rameses, which town, or another of the same name, was the starting-point at the Exodus. In one place (Gen. xlvii. 11) the "land of Rameses" occurs where we should expect "the land of Goshen." We are not sufficiently acquainted with the administrative divisions at this early time to be able to explain this. It may, however, be conjectured that if the Rameses of the Exodus journey was the same as Tanis-Rameses, the archaic Tanite nome may have included the land of Goshen.

GOSLAR, a town in the district of Hildesheim, Prussia, province of Hanover, is situated on the Gose, an affluent of the Ocker, at the foot of the Harz, 24 miles S. E. of Hildesheim. It is surrounded by walls, and has a very antique appearance. Among the noteworthy buildings are the market church, in the Romanic style, restored since its partial destruction by fire in 1844, and containing the town archives, and a library in which are some of Luther's manuscripts; the old town-house, possessing many interesting antiquities; the Kaiserworth, with the statues of the German emperors; the Kaiserhaus, founded by Henry III. in 1050, and along with the adjoining Ulrich's chapel restored in 1873 at the cost of the Prussian Government; the small chapel, which is all that remains since 1820 of the old cathedral founded by Henry III. in 1040, containing among other antiquarian relics of the cathedral an old altar supposed to be that of the idol Krodo which formerly stood on the top of the Burgberg near Neustadt-Harzburg; the church of the monastery of Neuwerk, in the Roman style, with wall paintings of considerable merit; and the house of the bakers' guild, the birthplace of Marshal Maurice of Saxony. There are four Evangelical churches, one Catholic church, a synagogue, a real school of the first order, a higher girls' school, and a number of small foundations. The population are chiefly occupied in connection with the sulphur, copper, silver, and other mines in the neighborhood. The town has also been long noted for its beer, and possesses some small manufactures, and a considerable trade in fruit. The population in 1875 was 9838.

Goslar was founded by Henry the Fowler about 920, and when in the time of Otto the Great the mineral treasures in the neighborhood were discovered it increased rapidly in prosperity. It was frequently the seat of German diets, and the residence of the emperor. About 1350 it joined the Hanseatic League. It was unsuccessfully besieged in 1625, during the Thirty Years' War, but was taken by the Swedes in 1632, and nearly destroyed by fire. Additional conflagrations in 1728 and 1780 gave a severe blow to its ancient prosperity. It was a free town till 1802, when it came into possession of Prussia. In 1807 it was joined to Westphalia, in 1816 to Hanover, and in 1866, it was, along with Hanover, reunited to Prussia.

GOSLICKI, WAWRZYNIEC (1533–1607), a learned Pole, better known under his Latinized name of Laurentius Grimalius Goslicius, was born about 1533. After having studied first at Cracow and afterwards at Padua, he entered the church, and was successively appointed bishop of Kaminietz and of Posen. Goslicki, although an ecclesiastic, was an active man of business, was held in high estimation by his contemporaries, and was frequently engaged in political affairs. It was chiefly through his influence, and through the letter he wrote to the pope against the Jesuits, that they were prevented from establishing their schools at Cracow. He was also a strenuous advocate of religious toleration in Poland. He died October 31, 1607.

His principal work is *De optimo senatore*, etc. (Venice, 1568). There are two English translations published respectively under the titles *A commonwealth of good counsaile*, etc. (1607), and

The Accomplished Senator, done into English by Mr. Oldisworth (1733).

GOSPELS. SYNOPTICAL GOSPELS. Of the four canonical Gospels[1] (*god*, God or good; *spell*, discourse or tidings, *cf.* *εὐαγγέλιον*) the first three (differing from the fourth) agree in narrating nearly the same events in somewhat similar language, and are hence called synoptical (*σύν*, together; *ὄψις*, view). It will be advantageous to begin with the treatment of these, as to their origin, date, and objects, so far as can be determined from (1) internal evidence and (2) external evidence.

Internal Evidence.

In discussing the internal evidence, it will be convenient to speak, first, of those portions of the synoptic narrative which are found in three Gospels; then of those which are found in only two; and, lastly, of those which are found in only one.

Originality of Mark.

The Triple Tradition.—Few are aware of the very small extent to which independent narrators of the same events use the same words. A comparison of a few specimens of independent narratives (of such events, for example, as the attempt to assassinate King Humbert, or the recent death of the Prince Imperial) would show that the narratives often contain scarcely two or three consecutive words in common, and rarely or never a whole clause of five or six words. The same statement applies to narratives of discourses of any length reported from memory, and not from notes taken at the moment. Now it is well known that in many parts of the first three Gospels the same words and phrases are curiously interlaced, in such a way as to suggest that the writers have borrowed either from each other or from some common source. For example, in describing the healing of the sick (Mat. viii. 16; Mk. i. 32; Lu. iv. 40), Matthew begins thus: *ὀψίας δὲ γενομένης*; Mark, *ὀψίας δὲ γενομένης ὅτε ἔδυσεν ὁ ἥλιος*; Luke, *δύνοντος δὲ τοῦ ἡλίου*. From this and many similar passages it might seem natural to infer that Mark borrowed one of these expressions from Matthew and the other from Luke, and that the narrative of Mark is little more than a combination of passages from Matthew and Luke. This is an inference which has actually been drawn by many critics both before and since De Wette; but at present it finds comparatively little support among competent investigators. However, the oscillations of New Testament criticism have been so numerous that it may be of use to indicate a method by which the originality of Mark may be established on an immovable basis. That Mark (at all events in many parts) contains the original document or tradition from which Matthew and Luke have borrowed can be proved to demonstration by a necessary inference from the following specimen of narrative common to the three writers.[2]

It will be observed in the extracts on p. 703[3] that (up to verse 11 of Mark), besides the matter common to all three writers, Mark and Luke have a good deal of additional matter in common (*ἤρξατο*, the dat. term. (*καιρ*)*ῷ*, *ἵνα ἀπὸ*, *ἐξαπέστειλαν αὐτὸν κενόν*, *κἀκεῖνον*, *καὶ ἠτίμασαν*, *ἀλαπητόν*, *πρός*, *ἡμῶν*, *ἐλεύσεται καί*, *τοὺς γεωργούς*); Mark and Matthew have also much additional matter in common (*καὶ περιέθηκεν φραγμὸν καὶ ὤρυξεν* (*ὑπο*)*λήν*(*ιον*) *καὶ ᾠκοδόμησεν πύργον*, *καὶ λαβόντες*, *πάλιν ἀπέστειλεν*, *ἄλλ*(*ον*), *ἀπέκτειναν*, *πρὸς αὐτοὺς λέγων ἑαυτ*(*οὺς*), *εἰπ*(*ο*)*ν*, *δεῦτε*, *λαβόντες*, *παρὰ*, *κυρίου ἐγένετο αὕτη καὶ ἔστιν θαυμαστὴ ἐν ὀφθαλμοῖς ἡμῶν*; but, in striking contrast, Matthew and Luke have no additional matter in common, except that in verse 3 of Mark they insert *οἱ γεωργοί* for clearness; in verse 7 they insert *ἰδόντες*; and in verse 9 they insert *οὖν*. Are these facts compatible with the theory that Mark compounded his narrative out of Matthew and Luke?

We may begin by dismissing the three trifling words which Matthew and Luke agree in adding to the Triple Tradition (by which we mean the matter common to the three Gospels), as being words that any early editor of Mark might naturally insert. The insertion of the subject in verse 3, for clearness, requires no comment. The *οὖν* in verse 9 softens an abruptness which (however characteristic of Mark) would naturally repel readers and editors. Again, in verse 7 the omission of some phrase to denote that the husbandmen saw the son approaching before they formed their plan, is so abrupt that *ἰδόντες* or *θεασάμενοι* has been actually supplied in Mark by several manuscripts and versions (possibly, of course, influenced by Matthew and Luke), and might naturally be supplied by still earlier editors. Having therefore accounted for these words, we are led to this result, that, from Mk. xii. 1 to Mk. xii. 11, Matthew and Luke contain nothing in common which is not also found in a slightly modified edition of Mark.[4] This being the case it can be proved by *reductio ad absurdum* that Mark did not copy from Matthew and Luke. For suppose that he did so copy, it follows that he must not only have constructed a narrative based upon two others, borrowing here a piece from Matthew and here a piece from Luke, but that he must have deliberately determined to insert, and must have adapted his narrative so as to insert, every word that was common to Matthew and Luke. The difficulty of doing this is enormous, and will be patent to any one who will try to perform a similar literary feat himself. To embody the whole of even one document in a narrative of one's own, without copying it *verbatim*, and to do this in a free and natural manner, requires no little care. But to take two documents, to put them side by side and analyze their common matter, and then to write a narrative, graphic, abrupt, and in all respects the opposite of artificial, which shall contain every phrase and word that is common to both—this would be a *tour de force* even for a skilful literary forger of these days, and may be dismissed as an impossibility for the writer of the Second Gospel.

For example, Mark might have begun his narrative, *Καὶ ἔλεγεν αὐτοῖς*, omitting *παραβολήν*; he might have borrowed *οἰκοδεσπότης* from Matthew and have dropped *ἄνθρωπος*; he might have borrowed *πέμψαι* from Luke (ver. 11) instead of *ἀπέστειλε*. Had he done these things (all natural enough), we should have at once had, as additional "common matter" for Matthew and Luke, *παραβολήν*, *ἄνθρωπος*, and *ἀπέστειλεν*, and all in the space of three verses, and "common matter" proportionally in the rest of the narrative. We may assume, therefore, that Mark did not copy Matthew and Luke in this passage, nor in other passages where a similar phenomenon occurs. But it occurs throughout by far the greater part of Mark's narrative. We may, therefore, regard it as absolutely certain that by far the greater part of Mark is not borrowed from Matthew and Luke, and that the duality of phrase, which is undoubtedly a characteristic of Mark, must be explained by other causes. (For other passages where Matthew and Luke have little or no additional matter in common, compare more especially the passages parallel to Mk. ii. 13–17; iii. 1–6; v. 1–39; x. 17–31; xi. 1–10; xii. 13–27; xiii. 1–19; xiv. 1–16; xv. 1–11.)

Evidence of an original source.

The question remains, Were Matthew and Luke entirely dependent upon Mark for that part of their narrative which covers the same ground as Mark? It would not be difficult, from a comparison of the three columns above, to make it probable that both Matthew and Luke did not borrow from the complete Mark as we have it. For though each of the three additions *οὖν*, *ἰδόντες*, *οἱ γεωργοί*, is in itself natural enough, yet the hypothesis that Matthew and Luke independently adopted precisely these and no other additions is most improbable. From a comparison of many such passages the improbability of the borrowing hypothesis might be increased. But as the process of proof could not be complete, and would certainly be long, it will be better to bring forward some short passages which are wholly irreconcilable with the hypothesis of deliberate borrowing, and which point to an original source, either

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[1] For Apocryphal Gospels, see APOCRYPHA, vol. ii. p. 162.

[2] From a *Harmony of the Synoptic Gospels*, now in preparation, by Mr. W. G. Rushbrooke, B. A., formerly Scholar of St. John's College, Cambridge. The text followed here and throughout this article has been generally that of Tischendorf.

[3] The ordinary type on page 703 exhibits the words and phrases common to all three writers, which we will henceforth call the "Triple Tradition;" the underlined type that which is common to each pair (in addition to the matter common to the three); and the spaced type that which each writer has peculiar to himself alone. The black type in the first column represents that which (in addition to the matter common to the three) is common to Matthew and Mark; in the second column it represents that which is common to Luke and Matthew; in the third column, that which is common to Mark and Luke. It follows that the same words which are found as underlined type in the first, second, and third columns will be found as small black type in the second, third, and first columns respectively.

[4] The verse added in Mat. xxi. 44 is omitted by Tischendorf, and is perhaps not part of the text of Matthew. But if genuine, it is a reference to the "winnowing-stone" in Daniel ii. 44, 45, which might naturally be added by some early editor of the original tradition, and might readily be adopted into the subsequent editions of it, which are known to us as the Gospels according to Matthew and Luke.

MATTHEW XXI. 33—44.	LUKE XX. 9—18.	MARK XII. 1—11.
33 Ἄ-λ-λ-η-ν παραβολὴν ἀ-κ-ο-ύ-σ-α-τ-ε. Ἄνθρωπος ἦ-ν οἰ-κ-ο-δ-ε-σ-π-ό-τ-η-ς, ὅ-σ-τ-ι-ς ἐφύτευσεν ἀμπελῶνα, καὶ φραγμὸν α-ὐ-τ-ῷ περιέθηκεν καὶ ὤρυξεν ἐ-ν α-ὐ-τ-ῷ ληνὸ-ν καὶ ᾠκοδόμησεν πύργον, καὶ ἐξέδετο αὐτὸν γεωργοῖς, καὶ ἀπεδήμησεν. 34 ὅ-τ-ε δ-ὲ ἤ-γ-γ-ι-σ-ε-ν ὁ- καιρ-ὸ-ς τ-ῶ-ν κ-α-ρ-π-ῶ-ν, ἀπέστειλεν τ-ο-ὺ-ς δούλ-ο-υ-ς α-ὐ-τ-ο-ῦ πρὸς τοὺς γεωργοὺς λαβ-ε-ῖ-ν το-ὺ-ς καρπ-ο-ὺ-ς α-ὐ-τ-ο-ῦ. 35 καὶ λαβόντες οἱ γεωργοὶ τ-ο-ὺ-ς δ-ο-ύ-λ-ο-υ-ς α-ὐ-τ-ο-ῦ ὃ-ν μὲν ἔδειραν, ὃ-ν δὲ ἀπέ-κτ-ε-ι-ν-α-ν, ὃ-ν δ-ὲ ἐ-λ-ι-θ-ο-β-ό-λ-η-σ-α-ν.	9 Ἤρξατο δ-ὲ π-ρ-ὸ-ς τ-ὸ-ν λ-α-ὸ-ν λ-έ-γ-ε-ι-ν τ-ὴ-ν παραβολὴν τ-α-ύ-τ-η-ν. Ἄνθρωπος ἐφύτευσεν ἀμπελῶνα καὶ ἐξέδετο αὐτὸν γεωργοῖς, καὶ ἀπεδήμησεν χ-ρ-ό-ν-ο-υ-ς ἱ-κ-α-ν-ο-ύ-ς. 10 καὶ καιρῷ ἀπέστειλεν πρὸς τοὺς γεωργοὺς δοῦλον, ἵνα ἀπὸ το-ῦ καρπο-ῦ τοῦ ἀμπελῶνος δ-ώ-σ-ο-υ-σ-ι-ν α-ὐ-τ-ῷ· οἱ δ-ὲ γεωργοὶ ἐ-ξ-απέστειλαν αὐτὸν δείρ-α-ν-τ-ε-ς κενόν.	1 Κ-α-ὶ ἤρξατο α-ὐ-τ-ο-ῖ-ς ἐ-ν παραβολ-α-ῖ-ς λ-α-λ-ε-ῖ-ν. Ἀμπελῶνα ἄνθρωπος ἐφύτευσεν, καὶ περιέθηκεν φραγμὸν καὶ ὤρυξεν ὑ-π-ο-λήν-ι-ο-ν καὶ ᾠκοδόμησεν πύργον, καὶ ἐξέδετο αὐτὸν γεωργοῖς, καὶ ἀπεδήμησεν. 2 καὶ ἀπέστειλεν πρὸς τοὺς γεωργοὺς τ-ῷ καιρῷ δοῦλον, ἵνα π-α-ρ-ὰ τ-ῶ-ν γ-ε-ω-ρ-γ-ῶ-ν λάβ-η ἀπὸ τῶ-ν καρ-π-ῶ-ν τοῦ ἀμπελῶνος· 3 καὶ λαβόντες αὐτὸν ἔδειραν κ-α-ὶ ἀπέστειλαν κενόν.
36 πάλιν ἀπέστειλεν ἄλλ-ο-υ-ς δούλ-ο-υ-ς π-λ-ε-ί-ο-ν-α-ς τ-ῶ-ν π-ρ-ώ-τ-ω-ν, κα-ὶ ἐ-π-ο-ί-η-σ-α-ν α-ὐ-τ-ο-ῖ-ς ὡ-σ-α-ύ-τ-ω-ς.	11 καὶ π-ρ-ο-σ-έ-θ-ε-τ-ο ἕ-τ-ε-ρ-ο-ν π-έ-μ-ψ-α-ι· ο-ἱ δ-ὲ κἀκεῖνον δ-ε-ί-ρ-α-ν-τ-ε-ς καὶ ἀ-τιμάσ-α-ν-τ-ε-ς ἐ-ξ-α-π-έ-σ-τ-ε-ι-λ-α-ν κ-ε-ν-ό-ν. 12 καὶ π-ρ-ο-σ-έ-θ-ε-τ-ο τ-ρ-ί-τ-ο-ν π-έ-μ-ψ-α-ι· ο-ἱ δ-ὲ κα-ὶ τ-ο-ῦ-τ-ο-ν τ-ρ-α-υ-μ-α-τ-ί-σ-α-ν-τ-ε-ς ἐ-ξ-έ-β-α-λ-ο-ν.	4 καὶ πάλιν απέστειλεν π-ρ-ὸ-ς α-ὐ-τ-ο-ὺ-ς ἄλλ-ο-ν δοῦλ-ο-ν· κἀκεῖνον ἐ-κ-ε-φ-α-λ-ί-ω-σ-α-ν καὶ ἠ-τίμασ-α-ν. 5 καὶ ἄ-λ-λ-ο-ν ἀ-π-έ-σ-τ-ε-ι-λ-ε-ν· κἀ-κ-ε-ῖ-ν-ο-ν ἀ-π-έ-κ-τ-ε-ι-ν-α-ν, κ-α-ὶ π-ο-λ-λ-ο-ὺ-ς ἄ-λ-λ-ο-υ-ς, ο-ὓ-ς μὲν δ-έ-ρ-ο-ν-τ-ε-ς ο-ὓ-ς δὲ ἀπ-ο-κτ-έ-ν-ν-υ-ν-τ-ε-ς.
37 ὕ-σ-τ-ε-ρ-ο-ν δὲ ἀπέστειλεν πρὸς αὐτοὺς τ-ὸ-ν υἱὸν α-ὐ-τ-ο-ῦ λέγων· Ἐντραπήσονται τὸν υἱόν μου. 38 οἱ δὲ γεωργοὶ ἰδόντες τ-ὸ-ν υ-ἱ-ὸ-ν εἶπ-ο-ν ἐ-ν ἑαυτ-ο-ῖ-ς· Οὗτός ἐστιν ὁ κληρονόμος· δεῦτε ἀποκτείνωμεν αὐτὸν καὶ σ-χ-ῶ-μ-ε-ν τ-ὴ-ν κληρονο-μ-ί-α-ν α-ὐ-τ-ο-ῦ. 39 καὶ λαβόντες αὐτὸν ἐξέβαλον ἔξω τοῦ ἀμπελῶνος καὶ ἀπέκτειναν. 40 ὅ-τ-α-ν οὖν ἔ-λ-θ-ῃ ὁ κύριος τοῦ ἀμπελῶνος, τί ποιήσει τ-ο-ῖ-ς γ-ε-ω-ρ-γ-ο-ῖ-ς ἐ-κ-ε-ί-ν-ο-ι-ς; 41 λ-έ-γ-ο-υ-σ-ι-ν α-ὐ-τ-ῷ· Κ-α-κ-ο-ὺ-ς κ-α-κ-ῶ-ς ἀπολέσει α-ὐ-τ-ο-ύ-ς, καὶ τὸν ἀμπελῶνα ἐ-κ-δώσ-ε-τ-α-ι ἄλλοις γεωργοῖς, ο-ἵ-τ-ι-ν-ε-ς ἀ-π-ο-δ-ώ-σ-ο-υ-σ-ι-ν α-ὐ-τ-ῷ τ-ο-ὺ-ς κ-α-ρ-π-ο-ὺ-ς ἐ-ν τ-ο-ῖ-ς κ-α-ι-ρ-ο-ῖ-ς α-ὐ-τ-ῶ-ν.	13 ε-ἶ-π-ε-ν δὲ ὁ- κ-υ-ρ-ι-ο-ς τ-ο-ῦ ἀ-μ-π-ε-λ-ῶ-ν-ο-ς· Τ-ί π-ο-ι-ή-σ-ω; π-έ-μ-ψ-ω τὸν υἱόν μου τ-ὸ-ν ἀγαπητόν· ἴ-σ-ω-ς τ-ο-ῦ-τ-ο-ν ἐντραπήσονται. 14 ἰδόντες δὲ α-ὐ-τ-ὸ-ν οἱ γεωργοὶ δ-ι-ε-λ-ο-γ-ί-ζ-ο-ν-τ-ο πρὸς ἀ-λ-λ-ή-λ-ο-υ-ς λ-έ-γ-ο-ν-τ-ε-ς· Οὗτός ἐστιν ὁ κληρονόμος· ἀποκτείνωμεν αὐτόν ἵ-ν-α ἡμῶν γ-έ-ν-η-τ-α-ι ἡ κληρονομία. 15 καὶ ἐκβαλ-ό-ν-τ-ε-ς αὐτὸν ἔξω τοῦ ἀμπελῶνος ἀπέκτειναν. τί οὖν ποιήσει α-ὐ-τ-ο-ῖ-ς ὁ κύριος τοῦ ἀμπελῶνος; 16 ἐλεύσεται καὶ ἀπολέσει τοὺς γεωργοὺς τ-ο-ύ-τ-ο-υ-ς, καὶ δώσει τὸν ἀμπελῶνα ἄλλοις. ἀ-κ-ο-ύ-σ-α-ν-τ-ε-ς δ-ὲ ε-ἶ-π-α-ν, Μ-ὴ γ-έ-ν-ο-ι-τ-ο.	6 ἔ-τ-ι ἕ-ν-α ε-ἶ-χ-ε-ν υἱὸν ἀγαπητόν· ἀπέστειλεν α-ὐ-τ-ὸ-ν ἔ-σ-χ-α-τ-ο-ν πρὸς αὐτοὺς λέγων ὅ-τ-ι Ἐντραπήσονται τὸν υἱόν μου. 7 ἐ-κ-ε-ῖ-ν-ο-ι (?) δὲ οἱ γεωργοὶ πρὸς ἑαυτ-ο-ὺ-ς εἶπ-α-ν ὅ-τ-ι οὗτός ἐστιν ὁ κληρονόμος· δεῦτε ἀποκτείνωμεν αὐτόν, καὶ ἡμῶν ἔ-σ-τ-α-ι ἡ κληρονομία. 8 καὶ λαβόντες ἀπέκτειναν αὐτὸν, καὶ ἐξέβαλον α-ὐ-τ-ὸ-ν (?) ἔξω τοῦ ἀμπελῶνος. 9 τί ποιήσει ὁ κύριος τοῦ ἀμπελῶνος; ἐλεύσεται καὶ ἀπολέσει τοὺς γεωργούς, καὶ δώσει τὸν ἀμπελῶνα ἄλλοις.
42 λ-έ-γ-ε-ι αὐτοῖς ὁ- Ἰ-η-σ-ο-ῦ-ς· Οὐδ-έ-π-ο-τ-ε ἀνέγνωτε ἐ-ν τα-ῖ-ς γραφ-α-ῖ-ς· Λίθον ὃν ἀπεδοκίμασαν οἱ οἰκοδομοῦντες, οὗτος ἐγενήθη εἰς κεφαλὴν γωνίας· παρὰ Κυρίου ἐγένετο αὕτη, καὶ ἔστιν θαυμαστὴ ἐν ὀφθαλμοῖς ἡμῶν; 43 δ-ι-ὰ τ-ο-ῦ-τ-ο λ-έ-γ-ω ὑ-μ-ῖ-ν ὅ-τ-ι ἀ-ρ-θ-ή-σ-ε-τ-α-ι ἀ-φ' ὑ-μ-ῶ-ν ἡ-β-α-σ-ι-λ-ε-ί-α τ-ο-ῦ Θ-ε-ο-ῦ κ-α-ὶ δ-ο-θ-ή-σ-ε-τ-α-ι ἔ-θ-ν-ε-ι π-ο-ι-ο-ῦ-ν-τ-ι τ-ο-ὺ-ς κ-α-ρ-π-ο-ὺ-ς α-ὐ-τ-ῆ-ς.	17 ὁ- δ-ὲ ἐ-μ-β-λ-έ-ψ-α-ς αὐτοῖς ε-ἶ-π-ε-ν Τ-ί ο-ὖ-ν ἐ-σ-τ-ὶ-ν τὸ- γ-ε-γρα-μ-μ-έ-ν-ο-ν τ-ο-ῦ-τ-ο· Λίθον ὃν ἀπεδοκίμασαν οἱ οἰκοδομοῦντες, οὗτος ἐγενήθη εἰς κεφαλὴν γωνίας;	10 Οὐδ-ὲ τὴ-ν γραφ-ὴ-ν τ-α-ύ-τ-η-ν ἀνέγνωτε, Λίθον ὃν ἀπεδοκίμασαν οἱ οἰκοδομοῦντες, οὗτος ἐγενήθη εἰς κεφαλὴν γωνίας· 11 παρὰ Κυρίου ἐγένετο αὕτη καὶ ἔστιν θαυμαστὴ ἐν ὀφθαλμοῖς ἡμῶν;
44 Κ-α-ὶ ὁ πεσὼν ἐπ-ὶ τὸν λίθον τ-ο-ῦ-τ-ο-ν συνθλασθήσεται· ἐφ' ὃν δ' ἂν πέσῃ, λικμήσει αὐτόν.	18 π-ᾶ-ς ὁ πεσὼν ἐπ' ἐ-κ-ε-ῖ-ν-ο-ν τὸν λίθον συνθλασθήσεται· ἐφ' ὃν δ' ἂν πέσῃ, λικμήσει αὐτόν.	

written or oral, round which the three narratives play. Those passages will be most convincing where there are traces that some original tradition has been differently understood by the different writers.

(α) One natural error in interpreting a terse tradition (perhaps translated from Aramaic into Greek) would be to supply different subjects to the same verbs, as in the following important passages, which variously describe the message of the angel or angels to the women at the tomb of Jesus:

(1) Mat. xxviii. 7, *προάγει ὑμᾶς εἰς τὴν Γαλιλαίαν· ἐκεῖ αὐτὸν ὄψεσθε· ἰδοὺ, εἶπον ὑμῖν*—"behold, *I* have told you."

(2) Mk. xvi. 7, *προάγει ὑμᾶς εἰς τὴν Γαλιλαίαν· ἐκεῖ αὐτὸν ὄψεσθε, καθὼς εἶπεν ὑμῖν*—"as *He* told you."

On the other hand, Luke, who records several appearances of the Lord to the disciples in or near Jerusalem, and who does not take the Galilean view of the resurrection, finds the words *εἰς τὴν Γ.* out of place in his narrative. Yet his memory or knowledge of the common tradition is too strong to allow him to omit all mention of Galilee, and he therefore inserts it, but differently.

(3). Lu. xxiv. 6, *μνήσθητε ὡς ἐλάλησεν ὑμῖν ἔτι ὢν ἐν τῇ Γαλιλαίᾳ*—"remember how He spake unto you *while He was* still *in* Galilee."

(β) (1) Mat. iii. 5, *ἐξεπορεύετο πρὸς αὐτὸν . . . πᾶσα ἡ περίχωρος τοῦ Ἰορδάνου.*

(2) Mk. i. 5 (agreeing here with Matthew), *ἐξεπορεύετο πρὸς αὐτὸν . . . πᾶσα ἡ Ἰουδαία χώρα.*

(3) Lu. iii. 3, *ἦλθεν εἰς πᾶσαν τὴν περίχωρον τοῦ Ἰορδάνου.*

(γ) In some cases the confusion is so important as seriously to affect the context, as in—

(1) Mat. xix. 16, *Διδάσκαλε, τί ἀγαθὸν ποιήσω*—which is followed (in the correct text) by "Why askest thou me about the good?"

(2) Mk. x. 17, *Διδάσκαλε ἀγαθέ, τί ποιήσω*—which is followed by "Why callest thou me good?"

(3) Luke (xviii. 18) agrees with Mark: *Διδάσκαλε ἀγαθέ, τί ποιήσας.* Note that a scribe has endeavored to combine the two traditions by inserting *ἀγαθέ* in Matt. xix. 16.

In the following the confusions are between only two narratives:—

(δ) (1) Mk. iv. 19, *αἱ μέριμναι . . . εἰσπορευόμεναι συνπνίγουσι*—"cares, *going into the heart*, choke (the word)."

(2) Lu. viii. 14, *ὑπὸ μεριμνῶν . . . πορευόμενοι συνπνίγονται*—"(the men) *going their way* (or *gradually* as in LXX.), are choked by cares or under the influence of cares."

(ε) In the following, Matthew and Mark concur in attributing "desire" and "fear;" but Matthew attributes the "desire" to Herod, Mark to Herodias; again, Matthew makes the object of the "fear" to be the "crowd," Mark "John the Baptist."

(1) Mat. xiv. 5, *Καὶ θέλων αὐτὸν ἀποκτεῖναι ἐφοβήθη τὸν ὄχλον.*

(2) Mk. vi. 19, *Ἡ δὲ Ἡρωδιὰς . . . ἤθελεν αὐτὸν ἀποκτεῖναι, καὶ οὐκ ἠδύνατο· ὁ γὰρ Ἡρώδης ἐφοβεῖτο τὸν Ἰωάννην.*

(ζ) In a record of dialogue, the phrases, "said he," "answered they," would naturally vary (as they do, Matthew, Mark, and Luke having peculiarities in this respect), and they might sometimes be omitted, with the important result of transmuting a statement of fact (Mark) into an utterance of Jesus (Matthew), thus:—

(1) Mat. xxvi. 2, *Οἴδατε ὅτι μετὰ δύο ἡμέρας τὸ πάσχα γίνεται.*

(2) Mk. xiv. 1, *Ἦν δὲ τὸ πάσχα καὶ τὰ ἄζυμα μετὰ δύο ἡμέρας.*[1]

(η) The following is another case of difference in the grammatical subject of the verb; the resemblance will appear demonstrative proof of confusion to those who compare the context, and who also remember that *ἀκολουθεῖν* is used habitually of others following Jesus, but not of Jesus following others.

(1) Mat. ix. 19, *Καὶ ἐγερθεὶς ὁ Ἰησοῦς ἠκολούθει αὐτῷ.*

(2) Mk. v. 24, *Καὶ ἀπῆλθεν μετ' αὐτοῦ, καὶ ἠκολούθει αὐτῷ ὄχλος πολύς.*

(θ) In the following there is a curious confusion from the omission of some words by Luke, so that what is the apodosis in Matthew becomes the protasis in Luke:—

(1) Mat. xii. 26, *Καὶ εἰ ὁ Σατανᾶς [τὸν Σατανᾶν ἐκβάλλει], ἐφ' ἑαυτὸν ἐμερίσθη· πῶς [οὖν] σταθήσεται ἡ βασιλεία αὐτοῦ;*

(2) Lu. xi. 18, *εἰ δὲ καὶ ὁ Σατανᾶς ἐφ' ἑαυτὸν διεμερίσθη, πῶς σταθήσεται ἡ βασιλεία αὐτοῦ;*

(ι) The following suggests that some Aramaic word meaning to "question" and to "try" or "tempt" may have been diversely rendered by—

(1) Mat. xii. 10, *Καὶ ἐπηρώτησαν αὐτόν, λέγοντες εἰ ἔξεστι θεραπεύειν.*

(2) Lu. vi. 7, *Παρετηροῦντο δὲ αὐτὸν εἰ θεραπεύει.*

(κ) (1) Mat. xxvii. 49, *Οἱ δε λοὶποι ἔλεγον, Ἄφες, ἴδωμεν εἰ ἔρχεται Ἠλίας σώσων αὐτόν.*

(2) Mk. xv. 36, *λέγων, Ἄφετε, ἴδωμεν εἰ ἔρχεται Ἠλίας καθελεῖν αὐτόν.*

Here (1) in Matthew the bystanders address the man who brings the drink to Jesus; but (2) in Mark the man addresses the bystanders. In (1) the meaning is "desist from giving the drink;" in (2) it appears to be "desist from mocking." But in any case, the meaning differs in Matthew and Mark.

Many other instances might be given (*e. g.*, Matt. xiv. 2; Mk. vi. 16; Lu. ix. 9; Mk. ix. 5; Lu. ix. 34); but we will conclude with one in which two traditional versions of a saying of our Lord, blended into one by Mark, appear to have caused a confusion: (*a*) "Every sin and blasphemy shall be remitted to *men*, but blasphemy against the Spirit shall not be remitted; (*b*) "Whosoever speaketh a word against the *Son of Man* it shall be remitted to him; but whosoever speaketh against the Holy Spirit, it shall not be remitted to him." Matthew gives both these versions, Luke one of them (with slight variations). But Mark, combining the former part of the first version with the latter part of the second, so as to omit the phrase "Son of Man," and yet feeling that some mention of "Son of Man" was made in the tradition, substitutes for "men" "sons of men," a phrase that is not found elsewhere in the whole of the Gospels:—

(λ) (1) Mat. xii. 31, 32, (*a*) [*διὰ τοῦτο λέγω ὑμῖν πᾶσα ἁμαρτία καὶ βλασφημία ἀφεθήσεται τοῖς ἀνθρώποις, ἡ δὲ τοῦ πνεύματος βλασφημία οὐκ ἀφεθήσεται καὶ*] (*b*) *ὃς ἐὰν εἴπῃ λόγον κατὰ τοῦ υἱοῦ τοῦ ἀνθρώπου, ἀφεθήσεται αὐτῷ, ὃς δ' ἂν εἴπῃ κατὰ τοῦ πνεύματος τοῦ ἁγίου οὐκ ἀφεθήσεται αὐτῷ οὔτε ἐν τούτῳ τῷ αἰῶνι οὔτε ἐν τῷ μελλοντι.*

(2) Lu. xii. 10 (using *εἰς* for *κατὰ*, *ἐρεῖ* for *ἂν εἴπῃ*, and borrowing from (*a*) the word *βλασφημεῖν*), (*b*) *καὶ πᾶς ὃς ἐρεῖ λόγον εἰς τὸν υἱὸν τοῦ ἀνθρώπου ἀφεθήσεται αὐτῷ, τῷ δὲ εἰς τὸ ἅγιον πνεῦμα βλασφημήσαντι οὐκ ἀφεθήσεται.*

(3) Mk. iii. 28, 29 (probably transposing *υἱὸς*, and using the dative instead of *κατὰ* or *εἰς*), (*a*) *λέγω ὑμῖν ὅτι πάντα ἀφεθήσεται τοῖς υἱοῖς τῶν ἀνθρώπων τὰ ἁμαρτήματα καὶ αἱ βλασφημίαι ὅσα ἐὰν βλασφημήσωσι*; (*b*) *ὃς δ' ἂν βλασφημήσῃ εἰς τὸ πνεῦμα τὸ ἅγιον οὐκ ἔχει ἄφεσιν εἰς τὸν αἰῶνα.*

Even those who may reject this explanation of the *ἅπαξ λεγόμενον* in Mark will probably feel that this passage, and all those previously quoted, point to some original tradition (whether written or oral) upon which our three synoptic Gospels are based. These then are the results to which (so far) we are led:—(1) Mark certainly did not borrow from Matthew and Luke; (2) Matthew and Luke, though clearly influenced by some form of Mark, yet probably borrowed, not from Mark, but from some original tradition upon which Mark also is based.

The Triple Tradition.

The Nature of the Triple Tradition.—What was the original tradition upon which our three synoptic Gospels are based? Was it Aramaic or Greek? oral or written? single or manifold? Did the earliest of our synoptists receive it fresh from its first source, or after it had passed through many recensions? Few or none of these questions (to some of which reference will be made hereafter) can be answered with absolute certainty; but it is evident that, if Matthew, Mark, and Luke are all based upon an earlier original tradition, then those words and phrases which are common to Matthew, Mark, and Luke (to which we have given the name of the Triple Tradition) must have a peculiar weight, as approximating to the original tradition itself. If it be found that these scattered words and phrases make up of themselves an almost continuous narrative, we may fairly suppose that we are approximating very closely indeed to the original tradition. We shall not expect to find a perfectly continuous narrative. On the contrary, a perfectly continuous narrative, identical in Matthew, Mark, and Luke, would imply, not a floating early variable tradition, but a document simply copied by the authors of our Gospels.

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[1] Here, as elsewhere in this article, it has not been thought necessary to mention by name those critics whose statements are traversed. For a brief summary of the history of recent criticism on the Gospels, see the end of this article.

An early tradition, circulated perhaps in various churches, in Antioch, in Rome, in Ephesus, in Corinth, before being embodied in a document, will naturally have been modified, supplemented, and sometimes (as above) confused. More especially in certain unimportant and constantly recurring words and phrases we may expect variations. The words "said," "answered," "went," "journeyed," "asked," "questioned," "tempted," "refused," "rebuked," etc., may naturally be expected to differ in the three versions. But greater differences will soon arise. One version will lay greater stress on the details of miracles; another on the relations between Jesus and John the Baptist; another on the law; another on the forgiveness of sins; and this varying emphasis will produce certain modifications of the original tradition. Again, in the early times of the church, the Greek of slaves and freedmen may pass without offence; but in later times an editor of the Gospel, writing for readers of higher rank and better education, will substitute less uncouth words for the original barbarisms. Thus, from varying causes, the different versions of the tradition will deviate; and when we come to compare three of them together, and to write down the words common to the three, we shall no longer find the original continuous tradition. Gaps in the sense will occur every now and then, owing to the omission of some necessary word. On the other hand, although the literary cement (so to speak) which fills up the interstices between the words and deeds of the Lord may naturally vary, we may expect that the words of the Lord Himself will be more carefully preserved, and more identically reported by all three synoptists, so that they will give a more continuous sense, and will enable us to approximate to the original tradition. Let us now take the Gospel of Mark, and set down, from the first two chapters of it, all such words as it contains in common with Matthew and Luke, merely adding in italics such words as may enable the reader to perceive the structure of each sentence; and let us see whether the words thus collected show any traces of a continuous narrative:—[1]

"Esaias | the prophet: ‖ the voice of one crying in the wilderness, Prepare the way of the Lord, make His paths straight. | John | in the wilderness preaching | repen(t). | All | wen(t) forth | *to be* baptiz(ed) by him. ‖ There cometh one stronger than I | whose shoe-latchet [Mat. shoes] | I am not worthy to loose [Mat. bear]. | I baptiz(e) you with water, He | shall baptize you with the Holy Spirit ‖ Jesu(s) *was* bapti(zed). ‖ The heaven[2] | and the Spirit, as a dove, descend(ing) on Him. And a voic(e) from | heaven | My beloved Son, in Thee [Mat. whom] I am well pleased. | The Spirit *drives Him;* | in the wildern(ess) forty days tempt(ed) by [Satan; Lu. devil]. ‖ *He came* into Galilee. ‖ Com(eth) into the house of Simon [Mat. Peter]. | Stepmother *sick of* a fever. ‖ And the feve(r) left her; | she ministered to the(m). ‖ He heale(d). ‖ He preache(d) in the synagogu(es) of Galil(ee). ‖ *There came* a leper | saying to Hi(m), If Thou wilt, Thou canst make me clean. And stretching forth His hand, He touched him | I will, be thou clean. And immediately *there departed* from him the leprosy. ‖ And *He said* to him, Tel(l) no one, but | show thyself to the priest, and offer *that which* Moses ordained as a testimony to them." Chap. ii. "‖ And they brin(g) Hi(m) a paralyti(c). ‖ And seeing their faith, ‖ *He said,* Thy sins are forgive(n). | The scribes *said,* This man blasphem(eth). ‖ Jesus said to the(m), | Why *reason ye* in your hearts? Which is easier, to say | Thy sins are forgive(n), or to say, Ris(e) | and walk. But that ye may know that the Son of Man hath power on earth to forgive sins, He *saith* to the paralyti(c), | Rise, take thy *bed,* | *go* to thy house. And | having taken it up, he went. ‖ And they glorifi(ed) God. And *He saw* one sitting at the receipt of custom, and *said* to him, Follow Me, | and arising he followe(d) Him. | And he *feasted* Him in his house, and man(y) publican(s) | were feast(ing) ‖ And the Pharisee(s) sai(d) to His disciple(s), W(hy) eat with publicans and sinners? | H(e) | *said* to them, They that are strong [Lu. healthy] have no need of a physician, but they that are sick. I cam(e) not to call the righteous but sinners. | The disciples of John | *say* to Hi(m): | *The disciples of John* and *of the* Pharisee(s) fas(t), but Thin(e) *do not.* Jesus said to the(m), Ca(n) the son(s) of the bride-chamber *fast?* | The bridegroom is with them. ‖ But the days shall come when the bridegroom shall be taken from them, Then shall they fast. | No one put*teth* on a | patch upon an ol(d) garmen(t). No on(e) putte(th) new wine into old bottles. Else, it will burs(t) the bottle(s), and the *wine* will peris(h) and the bottles also. But new wine into new bottles. ‖ *On the* Sabbath, *they were* going through corn-fields; His disciples plucke(d) the wheat-ears. | The Pharisee(s) *said, They* are doin(g) on the Sabbat(h) that which is not lawful. *He said* to the(m), Have ye not read *what* David did when he was an hungered, and they that were with him? how he went into the house of God, | and ate the shewbread, whic(h) it is not law(ful) to eat, save for the priest(s)? ‖ The Son of Man is Lord of the Sabbath."

Few will have any difficulty in following the above narrative which represents the Triple Tradition of the synoptists. It will be generally admitted that, so far as it extends, it omits little of importance; and its continuity will commend it as likely to be, if not the original tradition, at all events a closer approximation to it than we are likely to find elsewhere. It therefore becomes an important business to consider the scope and variations of the Triple Tradition,—where it is full and ample, where it is meagre, where it begins and where it ends.

The commencement of the Triple Tradition has been given in the specimen quoted above. It begins with the proclamation made by John the Baptist, of the advent of the Stronger One. Describing (Mk. iii.) the cure of the withered hand, the choice of the Twelve, the discourse on blasphemy against the Holy Spirit, and the answer to the question, "Who is My mother and My brethren?" it passes (chap. iv.) to the parables of the sower and the mustard seed, which it gives very fully; the rebuking of the wind and the exorcism of the legion (Mk. v.) are given as follows:—

Mk. iv. 35. "*Let us go across* to the other side. *They took* Hi(m) | *in* a boat. ‖ They wak(e) Hi(m) say(ing), We perish: and He, arising, rebuked the win(d). ‖ And there was a calm. *He said* to them, | Your faith! ‖ They said, *Who* is this that even the wind obey(eth) Him?" Mk. v. 1. "And they *came* across into the land of the [Gadarenes, Gerasenes, or Gergesenes]. There met Him | *one* [Mat. two] in the ‖ tombs ‖ crying, | What is there *between me* and Thee, Thou Son of God? ‖ Torment *me not.* ‖ And he [Mat. they] besought Him . . . into . . . ‖ And He . . . them, | goin(g) forth, they come to (or into) the swine, and the herd rushed down the steep place into the sea [Lu. lake] and were choked, [Mat. perished]. | Those that were feeding them | fled and brought word into the city. | They came | Jesus. ‖ And | *they besought* Him *to depart* from | them."

This is given as a specimen of those passages where the narrative is not so continuous, and where there is some appearance of confusion. The evidence of confusion is confirmed (1) by the fact that a word is used here (*δαίμων*) to denote "spirit" or "demon," which is not found once elsewhere in the whole of the Gospels, nor, indeed, anywhere in the New Testament (except in the Apocalypse twice), whereas *δαιμόνιον* is used forty-five times, and *πνεῦμα* twenty-seven times in the three Gospels alone; (2) by the difference of the names for the locality, Gadara, Gerasa, Gergesa; (3) by the fact that Matthew speaks of two demoniacs instead of one.[3]

The restoring to life of the daughter of a ruler (Mk. and Lu., ruler of a synagogue) is next thus briefly related: "*He came* into the house. | *She* is not dead, but sleepeth. And they mocked him. ‖ Having taken

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[1] A gap in the narrative of Mark is signified by |, a longer gap by ‖. Bracketed parts of words signify that the word occurs in the three Gospels, but in different forms.

[2] Here Mark uses a strong word, meaning "cleaving" or "rending;" Matthew and Luke prefer the more usual word, meaning "opening." Hence the gap.

[3] It has been suggested (Abbott, *Through Nature to Christ*, p. 447) that this extremely difficult narrative may have arisen from a misunderstanding of the phenomena of possession. Compare the story in the *Evangelium Infantiæ Arabicum* (a Gospel which shows special traces of Mark's influence) in which (chap. xi.) it is said of a certain demoniac that "demons, in the shape of crows and serpents, began to go forth, fleeing from out his mouth." But it is perhaps more likely that the variation in the name of the place points to some misunderstanding as to the origin of the story. The name Gadara, גדרה, sometimes means a "sheepfold;" and *gâdâr*, though not a Syriac word, is yet given in the Syriac lexicons as Hebrew for "flock." Again, the correct reading in Mark is probably "Gerasene," not "Gadarene;" and the word גֵרֵשׁ means "to cast out." Lastly, the third reading, "Gergesa," supported by Origen, is expressly said by that author (*Comm. in Ev. Joann.*, vi. 24) to mean "παροικία ἐκβεβληκότων," "the district of those who cast out;" and he suggests that the name was probably prophetical, referring to our Lord's expulsion from the district (ἐπώνυμος οὖσα τάχα προφητικῶς). Now when a narrative of an event reported to have occurred at a certain place contains three different names of the place, and when each of the three names is adapted to the event, such a triple adaptation is obviously likely to be not a mere casual coincidence, but rather a convergence pointing to some misunderstanding or non-historical nucleus as the centre and origin of the narrative. What the misunderstanding was may be a matter of conjecture, but that there was some misunderstanding is a probability approaching to certainty.

her by the hand | Arise." Then follow (chap. vi.) the mission of the twelve, Herod's conjecture about the new prophet, and the feeding of the five thousand, which runs thus (Mk. vi. 44):—

Send *them* away, that *they may go* into villages. | Give ye them to eat. | *We have* five loaves and two fishes. || Having taken the five loaves and the two fishes, looking up to heaven, He blessed, and having broke(n) them, *He gave them* to the disciples. | And they all ate and were filled. | And they to(ok) up twelve bask(ets) of fragments. They were | five thousand men."

The walking on the waves is much more briefly recorded. (Mk. vi. 46–51). "*He went* to the mountain. | *It was* late. || *They see Him* walking on the sea. || It is I; be not afraid." Then follows a blank, in which Matthew and Mark generally agree, while Luke is altogether wanting; and, after this, the famous confession of Peter, followed closely by the transfiguration.

Mk. viii. 27. "He aske(d) them, | saying, | Whom | do they say that *I* am? They answered, | John the Baptist; | others Elias; but *others* a prophe(t). | He *said*, But whom do ye say that I am? Peter | answering *said*, Chris(t). *Tell* no one. *He said* that *He* must needs | suffer many things | from the elders and chief priests and scribes, and be slain, and after three days [or, on the third day] He must be raised up [Mk. ἀναστῆναι, Lu. and Mat. ἐγερθῆναι]. || *If* any one wishes *to come* after Me, let him deny himself, and take up his cross and follow Me. For whosoever wishes to save his life shall lose it, but whosoever los(eth) his life for My sake *shall save it*. For what is a man profit(ed), to ga(in) the whole world, *and* be lost? || The Son of Man *shall come* in glory with the angels." || Mk. ix. "I say unto you, There are some of those stand(ing) *here* who shall not taste death till they see th(e) kingdo(m). | After six [Lu. eight] day(s) he take(th) | Peter and James and John | into a mountain. || His garment(s) *become* white. || And there appear(ed) Elias and Moses speak(ing) with *Him*. | Peter *said to* Jesu(s), It is good for us to be here; let us mak(e) three tabernacles, one for thee, and one for Moses, and one for Elias. || A cloud overshadow(ed) the(m), and there *was* a voice from the cloud, This is my Son: hear Him. | *They saw* Jesus alone.

From Mark ix. 14 to x. 16 there is a break in the common tradition, which here records little except three or four sayings of the Lord.

"O faithless generation, how long shall I be with you?" "The Son of man is to be betrayed into the hands of men." "Whosoever receiveth a child in My name receiveth Me." "*If any one* cause one of these little ones to stumble, *a millstone* round his neck, and *let him be cast into* the se(a)." "Salt *is good*, but if the salt *lose its savour*, wherewith shall it be salted?" "Suffer the children; forbid them not; for of such is the kingdom."

In contrast to this discontinuity, Mark x. 17–52 gives a continuous tradition about the rich young man, the promise of reward to the disciples, the predictions of betrayal, and the healing of the blind man near Jericho. The entry into Jerusalem and the purification of the temple (xi. 1–17) are also fairly continuous. The disputes in the temple touching the baptism of John (xi. 27–33), the wicked husbandmen (xii. 1–12), and the tribute-money (xii. 13–17) are very continuous. A brief denunciation of the Pharisees, who love the first seats in synagogues and at feasts, is found in Mark xii. 38–40. The Triple Tradition then touches on the second coming of Jesus. Luke has here omitted many important passages which are recorded by Matthew and Mark alone, and which will be given hereafter (see p. 707). Here we will set down nothing but the common tradition, marking Luke's omissions.

Mk. xiii. 1. "And || He said, || Not a stone shall be left on stone, which shall not be cast down. || *They asked* Him, || When shall these things be? And what *is* the sign? He *answered*, Take heed lest *any* deceiv(e) you. Many shall come in My name saying, I am He. || *When* ye hea(r) of wars, be not *alarmed* [Lu. substitutes the usual LXX. word πτοηθῆτε for the LXX. ἅπαξ λεγόμενον, θροεῖσθε, which is in Mat. and Mk.]. *These things* must needs come to pass, but the end is not yet. Nation shall rise against nation, and kingdom against kingdom. There shall be earthquakes in places, *there shall be* famines. || They shall deliver you to . . . for a witness . . . || And ye shall be hated by all men for My name's sake, *but he that* remain(eth) *shall be saved*. When ye see | desolat(ion), then let them that are in Judea flee *to* the mountains. || He that is on the housetop let him not descend, | and he that is in the field let him not turn back.[1] || But woe to them that are with child, and to them that give suck in those days." [Here Luke leaves a blank in which Matthew and Mark predict "false Christs" and "the darkening of the sun."] "And the powers of (or *in*) the heavens shall be shaken. And then shall they see the Son of Man coming *in* the cloud(s) with great power and glory. || From the fig-tree ye know that the summer *is* near. So also ye, when ye see these things. || Heaven and earth shall pass away; but My words shall never pass away."

In Matthew and Mark there follows the avowal that "of that day or hour none knoweth, not even the angels in heaven, nor even the Son, but only the Father." But Luke omits this. The Triple Tradition passes to the betrayal of Jesus. The traitor's compact (Mk. xiv. 10, 11) and the visit to the city to eat the Passover are briefly narrated. From this point the Triple Tradition becomes more and more scanty, till it leaves us at last little more than a few disconnected sayings of Jesus.

Mk. xiv. 21. "The Son of Man *goeth* indeed, as it is *written; but* woe to that man by whom He is to be betrayed. || Having taken bread, He brake it, and ga(ve) it. | This is My body. And *taking* the cup, This *is* My blood of *the* testamen(t), that is shed . . . || I say unto you, I will never drink of the fruit of the vine until the kingdom. || And | they wen(t) forth to the Mount of Olives. || I say unto thee, *Before* the cock crow, thou shalt deny Me thrice. || He pray(ed), If *it be possible* . . . || He sai(d), Fath(er), *take* this cup from Me; || *yet not as I* wil(l), but *as Thou wilt*. || And *having* foun(d) them *sleeping, He said*, Pray, that ye enter not into temptation. || While He was still speaking, *came* Judas, | one of the twelve, | *and* a multitud(e) *with* him. || *He* kiss(ed) Him. || One *smote* [Mk. ἔπαισε, for which Mat. and Lu. substitute the more appropriate and common word ἐπάταξε] the servant of the high priest, and cut off his ea(r). | Jesus said, As against a thief have ye com(e) out with swords and staves? I *was* daily | in the temple; *and* ye *took Me* not. || They led *Him* to th(e) high pries(t). || Peter followe(d) afar off | and sat in | the hall. Art thou the Son of God [Mk. the Blessed]? || Thou shalt see the Son of Man seated on the right hand of the Power. || What need have we yet of witnesses? || They sai(d) unto Him, Prophesy. || A maid-servan(t) *spake unto* Pete(r). || But he denied, saying, I do not know *Him*. || Verily *thou art one of them*, for . . . || And Peter remembered, Before the cock crow, thou shalt deny Me thrice, and he wep(t)."

Mk. xv. "*They led Him to* Pilat(e). || He aske(d) Him, | Art Thou the King of the Jews? He *said* to him, Thou sayest || . . . Barabbas . . . || Cruci(fy) *Him*. Why, what evil hath He done? | Crucif(y) Him. | Pilate released *Barabbas*, and delivered over Jesus. || And they le(a)d Him away. || *They made* Simon a Cyrenian *carry* the cross. || *They came to* the place of the Skull. || They divide(d) His garments and cast lots. || *There was written up*, The King of the Jews. || On the right hand and on the left . . . || He saved others; let *Him* save (Him)self. || About the sixt(h) hou(r) there was darkness over the earth until the ninth hour. || Jesus *with* a loud voice *emitted* his breath. || And the women | who in [or from] Galilee had followed Him behel(d) [Mk. and Mat. θεωρεῖν, Lu. ὁρᾶν, reserving θεωρεῖν for v. 55] these things from afar. || Joseph of Arimathæa | cam(e) to Pilate and begged the body of Jesus, || and wound [Mk. ἐνείλησεν; Mat. and Lu. ἐνετύλιξεν] it in linen | and laid it in a tomb."

At this point the tradition not only becomes discontinuous, but also shows marks of confusion. The tradition appears to have been that the women "beheld," or came to "behold" (another tradition added at "dawn"), and came to the tomb; but what "dawn" is meant, and what was the object of their beholding, is left uncertain.

(1) Matt. xxvii. 61; xxviii. 1. "There were there Mary Magdalene and the other Mary sitting over against the tomb. Late in the Sabbath, at the hour of dawning (τῇ ἐπιφωσκούσῃ), before the first day of the week, came Mary Magdalene and Mary to behold (θεωρῆσαι) the tomb (τάφον)."[2]

(2) Mk. xv. 47; xvi. 1. "Mary Magdalene and Mary the mother of Joses beheld (ἐθεώρουν) where He was laid (τέθειται). When the Sabbath was passed, Mary Magdalene and Mary the mother of James and Salome brought spices that they might come and anoint Him."

(3) Lu. xxiii. 54. "And the Sabbath was dawning (ἐπέφωσκε); and having followed Him (to the grave), the women who had come with Him from Galilee beheld (ἐθεάσαντο) the tomb, and how His body was *laid* (τέθειται), and returning they brought spices."

The only remaining words of the tradition are: " . . . the first day of the week . . . roll(ed) away [*i. e.* the stone at the opening of the tomb] . . . He is not here; He is risen . . . Galilee . . . *they fled* from the tomb." Matthew and Mark continue for a few lines a narrative based upon some common tradition; but even here there occurs the confusion mentioned above—Mark, "as *He* told you;" Matthew, "behold, *I* told you;" and the narrative of Mark ends at xvi. 9. The remaining verses of Mark are an appendix added by some later editor; and henceforth the narratives of Matthew and Luke—having lost Mark—present no further traces of agreement.

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[1] This passage is found in Matthew and Mark here, but in Luke elsewhere (xvii. 32).

[2] It may be observed that the same Syriac word is used to denote evening as well as morning twilight. See Gildemeister, *De Evangeliis in Arabicum e simplici Syriaca translatis*, Bonn, 1865, p. 20.

To sum up the contents of the common tradition, it omits the genealogies, miraculous incarnation, and the picturesque details of the infancy; it lays emphasis on the relations between John the Baptist and Jesus; it contains none of the parables except the sower, the mustard seed, and the wicked husbandmen, and few of the long discourses of Jesus, except an abridged prediction of the second coming. The disputes between Jesus and the Pharisees about the Sabbath, about fasting, about exorcism, about the baptism of John, and the tribute, and Christ the Son of David, and the dialogue with the Sadducees about the resurrection, are very fully given; and so also is the dialogue with the rich young man. Indeed it is a collection of dialogues and anecdotes rather than a set treatise of doctrine or biography. The sayings of Jesus recorded in it are short, pithy, and abrupt,[1] and many of them are polemical. Only now and then do we find a sentence which goes down deep below all polemics, and reveals a deep-laid spiritual plan. But putting such sentences together we perceive that the Triple Tradition describes a prophet wholly different from any that had before appeared in Israel; a prophet who not only (like Isaiah) protested against sabbaths and purifications as ends in themselves, but who also preached the Fatherhood of God in a manner entirely peculiar to Himself, and who set aside the Mosaic law of divorce (Mk. x. 2–11). He also instructed His disciples to enter into the kingdom as little children (x. 15), and seems to have attached a certain symbolic mystery to childhood as representing Himself (ix. 37). He taught His disciples further to devote their lives to Him, and to ignore all life apart from Him (viii. 34), ("to confess Christ, to deny themselves"). From the first He claims the power of forgiving sins (ii. 7); and, as soon as one of His disciples confessed Him to be the Messiah, he prepared for death, predicting that He should die, but rise again. Then, after prophesying the fall of the temple, and great distress in all nations, He predicted a final triumph for His disciples; and after bequeathing Himself, His body and His blood, as at a funeral feast, as His final legacy to His disciples, He was arrested and put to death.

Several miracles of healing are recorded, and, in addition to these, the exorcism of the Gadarene (in which, however, great confusion is apparent), the stilling of the storm, the feeding of the five thousand, and the transfiguration. From the beginning of the discourse on the second coming, Luke diverges more and more from Matthew and Mark. After the death of Jesus, Matthew and Mark continue to agree in words and phrases, but a little confusion is apparent; and the tradition suddenly terminates without any record of the appearance of Jesus to His disciples. However we may regret this, it is perhaps what may be naturally expected on the hypothesis that we have before us an early tradition originated at a time when the numerous manifestations of Jesus after His death were still attested by living witnesses; when as yet it had been found impossible to reduce the experiences and impressions of those who had seen Him—impressions necessarily variable and transient, blended with fear and with an excitement bordering on ecstasy—to a consistent and historical shape; and when it had not yet been found necessary to define and harden the narrative so as to adapt it for the purpose of meeting doubts and objections.

Additions common to Matthew and Mark.

The Additions common to Matthew and Mark.—The additions to the Triple Tradition which are found in Matthew and Mark, but not in Luke, are the following:—

(1) The description of John the Baptist (Mat. iii. 4; Mk. i. 6); (2) the ministering of the angels (Mat. iv. 11; Mk. i. 13); (3) the calling of the fishermen (Mat. iv. 18–22; Mk. i. 14–20); (4) the murmuring of His friends at Nazareth (Mat. xiii. 53–57; Mk. vi. 1–4); (5) the influence of Herodias in procuring John's execution (Mat. xiv. 8–13; Mk. vi. 25–29); (6) the walking on the water (Mat. xiv. 22–28; Mk. vi. 45–51); (7) the disputes with the scribes from Jerusalem (Mat. xv. 1–20; Mk. vii. 1–23); (8) the story of the Syro-Phœnician woman, which is narrated by Matthew and Mark in widely divergent language, but with an almost identical conclusion (Mat. xv. 21–28; Mk. vii. 24–30); (9) the feeding of the four thousand (Mat. xv. 32–38; Mk. viii. 1–9) and the comparison between this miracle and that of the five thousand (Mat. xvi. 5–12; Mk. viii. 14–21); (10) the saying of Jesus that Elias had already come (Mat. xvii. 12; Mk. ix. 13); (11) the discussion of the enactments of Moses concerning divorce (Mat. xix. 4–8; Mk. x. 2–9); (12) the saying (but Luke inserts it elsewhere) that "many that are first shall be last" (Mat. xix. 30; Mk. x. 31); (13) the petition of the sons of Zebedee for the chief places (Mat. xx. 20–28; Mk. x. 35–45); (14) the withering of the fig-tree (Mat. xxi. 18–22; Mk. xi. 13, 14, 20); (15) the introductory question of the lawyer, "Which is the great commandment?" (Mat. xxii. 36; Mk. xii. 28); (16) in the discourse on the last day, Luke omits reference to the "consummation," συντέλεια (Mat.), συντελεῖσθαι (Mk.); "these things are the beginning of troubles;" "the abomination of desolation," etc.; "he that readeth let him understand;" "pray that your flight may not be in winter;" "(tribulation) such as was not from the beginning till now, nor ever shall be;" the expression about the "shortening" of the days "for the elects' sake;" "He shall send His angels, and gather together the elect;" "of this hour the Son knoweth not;" (17) later on, Luke omits the anointing of Jesus "for His burial" (Mat. xxvi. 6–13; Mk. xiv. 3–9); (18) "I will smite the Shepherd," etc., and "I will go before you into Galilee" (Mat. xxvi. 31, 32; Mk. xiv. 27, 28); (19) the compact of Judas with the priests that a kiss should be the signal (Mat. xxvi. 48; Mk. xiv. 44); (20) the false witness about "destroying the temple in three days" (Mat. xxvi. 59, 62; Mk. xiv. 55–60); (21) the taunt "Thou that destroyest the temple" (Mat. xxvii. 40; Mk. xv. 29); (22) the utterance of Jesus, "My God, my God, why hast Thou forsaken Me?" with the consequent misunderstanding of the bystanders (Mat. xxvii. 46–49; Mk. xv. 34–36); (23) the utterance of the angel (or angels) at the tomb, "He goeth before you into Galilee: there shall ye see Him" (Mat. xxviii. 7; Mk. xvi. 7).

In considering these passages it is natural to ask whether any reason (besides ignorance of them) can be alleged why Luke should have omitted them. It is scarcely possible to fail to see design in some of these omissions,—for example, in those which relate to John the Baptist and Elias (1), (5), and (10). The author of the Acts of the Apostles is by general consent admitted to be identical with the author of the Third Gospel. Now remembering that Luke in the Acts (xix. 3) informs us that, many years after the death of Jesus, there were in Ephesus several disciples who were baptized with the baptism of John, and knew nothing of the Holy Spirit, we may well understand that the author of the Acts finds it necessary, when writing a gospel, to put in as clear a light as possible the subordination of John to Jesus. Accordingly, in place of the graphic description of the austere food and garb of the prophet, he gives (iii. 10–14) a description of his teaching, as containing the elements of a simple and almost commonplace morality, intended merely to prepare the way for a higher teaching, and he adds an express negative from the prophet in answer to those who doubted whether John were the Messiah. Repeatedly does Luke deviate from the common tradition of Matthew and Mark on the subject of Elias; and in each case the object is apparent. Only a close inspection of a harmony of the Gospels will make this clear; but three or four passages may be mentioned which point in this direction. Luke has already (i. 17) declared that John will go before Jesus "in the spirit and power" of Elias, but he cautiously avoids committing himself to the tradition (Mk. ix. 13; Mat. xvii. 13) that John was Elias. The belief in an actual transmigration of souls he will allow the multitude to entertain (ix. 8, 19), but not Herod: for whereas in Mark (vi. 16) Herod says, "Whom I beheaded, viz., John, this man (οὗτος, corr. text), is risen from the dead," Luke, by a slight transposition of the traditional words, converts the proposition into a question: "John I beheaded; but who is this man?" And, further, in order to prepare the way for the interview between Herod and the Lord—which he purposes to describe at the end of his Gospel (xxiii. 8, 9), and to refer to in his continuation of the Gospel (Acts iv. 27)—he adds the words, "And he (Herod) was desirous to see Him." Again Mark (ix. 6) tells us that Peter "not knowing *what to answer*," proposed to build three tabernacles for Jesus, Moses, and Elias; but Luke reads (ix. 33), "not knowing *what he said*," as if to caution the reader against supposing that Elias or Moses could be seriously placed on the same level as Jesus. For the same reason he omits the irreverent misunderstanding of the bystander who supposed that Jesus in his last moments called for Elias, and even the utterance itself (Mat. xxvii. 49; Mk. xv. 36).

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[1] *Cf.* Justin, *Apol. I.* (Kirchhofer, p. 89), βραχεῖς τε καὶ σύντομοι παρ αὐτοῦ λόγοιγεγόνασι.

Luke's omissions.

With reference to many of the other omissions it will be noticed that Luke seems to have before him somewhat different versions of the narratives, which different versions he inserts elsewhere. For example, he gives a version of the calling of the apostle-fishermen, which adds a miraculous draught of fishes, thereby approximating to the narrative in the Fourth Gospel (xxi. 6–11). Again Luke places the murmuring of the Nazarenes much earlier, in the fore-front of the ministry of Jesus, as was very natural, and gives an entirely different version of it. The ministry of the angels after the temptation he omits; but he alone records the ministry of the angel (xxii. 43) when Jesus was tempted in Gethsemane, for which temptation he carefully prepares the way by saying (iv. 13) that the devil departed from Jesus only "for a season." As regards the anointing "for the burial," it is probable we have a different version of it in his story of the woman that was "a sinner" (vii. 37). The reasons for the omission of the feeding of the four thousand and the withering of the fig-tree are not so obvious. The omission could hardly have been dictated by any desire to minimize the supernatural (seeing that Luke contains many miracles peculiar to himself, and that he does not shrink from giving in full detail the exorcism of the Gadarene). It is possible that he omitted the former as being too similar to the feeding of the five thousand to require to be repeated; and if he regarded it (as the author of the Fourth Gospel does) as having a sacramental meaning, one story of the kind may have seemed sufficient. If the story of the withered fig-tree was regarded by him in the same way (rather as emblematic than as historical), then it may have been replaced in his narrative by the story of the barren fig-tree (peculiar to Luke), to which the master came seeking fruit and finding none. It is also noticeable that the moral (on the power of faith) deduced from the withering of the fig-tree in Matthew and Mark is contained in Luke, but in a different form. In Matthew and Mark it runs: "If ye say to this *mountain*, Be raised up and cast into the sea;" whereas in Luke (xvii. 6) it is, "Ye might have said to this *sycamine tree*, Be rooted up and planted in the sea." This perhaps slightly confirms the supposition that Luke regarded the narrative of the fig-tree rather as a parable than as a fact. But it is important to bear in mind that we have little more than the evidence of conjecture to explain some of Luke's omissions. For example, the story of the walking on the waves, as told by Matthew and Mark, represents the disciples as being alarmed by the thought that the apparition of the Lord was only a spirit (*φάντασμα*); unless Luke considered that the ground of this narrative was occupied by his account of a similar fear when the disciples beheld the Lord after the resurrection, it is hard to suggest any reason for its omission. This class of omissions may be terminated with that numbered (19) above—the compact of Judas concerning the signal. It is obvious here that Luke has another version of the tradition in his mind. He alone of the three records the words of Jesus, "Betrayest thou the Son of Man with a kiss," thereby making it unnecessary to explain (with Matthew and Mark) that the kiss was a signal fixed by the traitor.

Another class of passages may possibly have been omitted as being not of interest to the Gentile world, or as being liable to misunderstanding or perversion. The story of the Syro-Phœnician woman perhaps appeared to the editor of the Gentile Gospel to exhibit Jesus in too harsh a light; the application to Jesus of the prophecy "I will smite the Shepherd," appeared more liable to misunderstanding than "He was reckoned with transgressors" (not found in Mark's genuine text); the discussion of the law of divorce and of the regulations touching uncleanness, and the part played by Herodias in the execution of the Baptist, may have seemed to lack interest for readers outside Palestine. In the discourse on the second coming it would be natural for an editor of the tradition writing after the siege of Jerusalem to substitute "encircled by armies" for the "abomination of desolation"—a phrase that would perplex a Gentile reader, and also to modify some of the hyperbolic and emblematic expressions. Lastly, the mention of the "false witness" concerning the destruction of the temple, and the raising up of a new temple in three days, may have begun to present a difficulty in times when the temple actually had been destroyed, and when the Lord Jesus Himself had come to be regarded as the new temple not made with hands. Although therefore Luke does not go so far as the author of the Fourth Gospel (who exhibits Jesus as actually predicting the destruction of the temple and as promising to raise it up in three days), yet he not only omits the "false witness," but also the allusion to it contained in the taunts addressed to Jesus on the cross, "Thou that destroyest the temple and raisest it again in three days, save Thyself" (Mat. xxvii. 40; Mk. xv. 29).

The above explanation of Luke's omissions may only partially commend itself to the reader; but few will fail to see that there is at least some method and motive in most of them. It is a matter of certainty that in the Triple Tradition many of Luke's omissions and modifications of phrases and words are not accidental but editorial: it is but natural therefore to suppose (especially when reasons can easily be assigned) that editorial reasons may also explain omissions and modifications of narratives and discourses. Of course it is not maintained that Luke, or any individual editor, made these changes on his own responsibility. Many of them are probably the result of a "Gentile use" which had gradually sprung up in certain churches, and which was not created but adopted and expressed by the author of the Third Gospel. Consequently we are not obliged to suppose that the omissions resulted from ignorance. The very fact that it is easy to supply motives and reasons for the omission of these narratives increases their credibility, by diminishing the probability that they were late traditions unknown to the author of the Third Gospel. The passages omitted are generally in the style of the common tradition, and they contain incidents of a similar kind to the incidents of the common tradition. It only remains to add that (except in the story of the Syro-Phœnician woman, and, in a lesser degree, in the question of the lawyer about the great commandment) Matthew and Mark closely agree whenever Luke separates himself from them. This is also found frequently to be the case in the Triple Tradition.[1] In the midst of very similar context, if Mark is identical, or nearly so, with Matthew, in the expression of some action, it will be found that Luke often suddenly diverges, or makes some omission. Thus—

(1) Mat. xxi. 12. Καὶ εἰσῆλθεν Ἰησοῦς εἰς τὸ ἱερὸν καὶ ἐξέβαλε πάντας τοὺς πωλοῦντας καὶ ἀγοράζοντας ἐν τῷ ἱερῷ, καὶ τὰς τραπέζας τῶν κολλυβιστῶν κατέστρεψε, καὶ τὰς καθέδρας τῶν πωλούντων τὰς περιστεράς.

(2) Mk. xi. 15. Καὶ εἰσελθὼν εἰς τὸ ἱερόν, ἤρξατο ἐκβάλλειν τοὺς πωλοῦντας καὶ τοὺς ἀγοράζοντας ἐν τῷ ἱερῷ· καὶ τὰς τραπέζας τῶν κολλυβιστῶν, καὶ τὰς καθέδρας τῶν πωλούντων τὰς περιστερας κατέστρεψε.

(3) Lu. xix. 45. Καὶ εἰσελθὼν εἰς τὸ ἱερόν, ἤρξατο ἐκβάλλειν τους πωλοῦντας, omitting the rest.

So, in the midst of the story of the rich young man, where Matthew and Mark have *ἀπῆλθε λυπούμενος, ἦν γὰρ ἔχων κτήματα πολλά*, Luke, suddenly diverging, has *περίλυπος ἐγενήθη· ἦν γὰρ πλούσιος σφόδρα* (Mk. x. 22; Mat. xix. 22; Lu. xviii. 23). Sometimes the divergence appears to arise from literary motives, and especially from the dislike of repetition (Lu. iv. 32; Mat. vii. 29; Mk. i. 22); but in other cases it cannot be so explained:—Lu. v. 29, 30; Mat. ix. 10, 11; Mk. ii. 15, 16; Lu. v. 33, 34; Mat. ix. 14, 15; Mk. ii. 18, 19 (see also, in a parable, Lu. v. 36; Mat. ix. 16; Mk. ii. 21); Lu. vi. 11; Mat. xii. 14; Mk. iii. 6; Lu. viii. 13; Mat. xiii. 21; Mk. iv. 17: Lu. viii. 44; Mat. ix. 21; Mk. v. 29. In some of these cases the agreement between Matthew and Mark is so close as to suggest that both writers may have used some common document (not oral tradition) which contained little more than certain words of the Lord in a scanty framework of narrative. But this common matter adds little to our knowledge of Christ. The most important narrative in it is the story of the Syro-Phœnician, showing how Jesus, as it were, acknowledged in the woman's persistent faith a divine revelation, extending His gospel even to the heathen. And this narrative is written in language so divergent as to indicate not a document but an oral tradition.

Additions of Mark and Luke.

The Additions of Mark and Luke.—Additions of any length are very few:—

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[1] In the words of the Lord the three Gospels are often closely similar, but seldom in the deeds.

(1) An exorcism of an unclean spirit (Mk. i. 21–25; Lu. iv. 31–35); (2) the account of Jesus retiring to a solitary place, when He declares that he must carry the gospel elsewhere (Mk. i. 35–39; Lu. iv. 42–44); (3) the saying of John the son of Zebedee, "Master, we saw one casting out devils in Thy name, and we forbade him," and the reply of Jesus (Mk. ix. 38–40; Lu. ix. 49, 50); (4) the short denunciation of the Pharisees that devour widows' houses (Mk. xii. 38–40; Lu. xx. 46, 47); (5) the story of the widow's mite (Mk. xii. 41–44; Lu. xxi. 1–4). Shorter similarities are—(6) a mention of Jesus as being in retirement (Mk. i. 45; Lu. v. 16); and (7) a mention of "Tyre and Sidon" as places to which the fame of Jesus had spread (Mk. iii. 8; Lu. vi. 17). There is a close verbal agreement between Mark and Luke in the exorcism of the "legion" (a name that does not occur in Mark); in the raising of the daughter of Jairus; and in the stilling of the storm. But gradually as Matthew approximates to Mark, Luke deviates from Mark. There is a return to similarity in the preparation for the Passover (Mk. xiv. 12–16; Lu. xxii. 7–13); but from this point Luke deviates more and more, and, with the exception of two words (στάσις and φόνος) in the incident of Barabbas, and of a somewhat closer approximation in the incident of Joseph of Arimathæa, it may be almost said that Luke has henceforth nothing in common with Mark, except what is found in the Triple Tradition.

Most of the incidents common to Mark and Luke are so few and so simple that their omission by Matthew requires no explanation. It is possible that the names Jairus and Legion did not exist in the earliest tradition, as it presented itself to Matthew; the "authority" which Mark illustrates (compare i. 22 with i. 27) by exorcism, Matthew applies (and perhaps justly) rather to our Lord's method of teaching (vii. 28, 29); but it is difficult to suppose that any other cause than ignorance could have caused the omission of the saying of Jesus concerning the widow's mite. It is certain that, in some at least of these passages, Mark represents the earlier, and Luke a modified tradition. Luke (see below, p. 717), writing with a literary purpose, has softened many early irregularities, which in Mark retain their original harshness. For example, the ungrammatical *οἱ κατέσθοντες* (Mk. xii. 40) is altered (Tischendorf and Tregelles, *pace* Lachmann) into *οἳ κατεσθίουσι* (Lu. xx. 47); and instead of *θελόντων* before *ἀσπασμούς* (Mk. xii. 38) Luke inserts *φιλούντων* (Lu. xx. 46). In the story of the widow also, Luke, disapproving of the epithet "beggar" (*πτωχή*) applied to the poor widow, substitutes the more respectable *πενιχρά*, yet with a natural but inconsistent reverence declines to cancel the same epithet (*πτωχή*) when (Lu. xxi. 3) it occurs in the words of the Lord. The rarer and less correct (ambiguous also when followed by the feminine *αὐτῆς*) *ὑστερήσεως* (Mk. xii. 44) is altered into *ὑστερήματος* (Lu. xxi. 4); and, lastly, the lengthy duality of Mark, "as many things as she had; all her livelihood" (which looks as if it had arisen from combining two different renderings of the same Aramaic original), is condensed by Luke (who takes one part of one rendering, and another part of the other) into all the "livelihood that she had." It is probable that not only in these but in all passages common to Mark and Luke alone, wherever Mark and Luke differ, Mark represents an earlier, and Luke a later version of the original. And generally it may be said that Luke follows the tradition of Mark most faithfully when it deals with Galilee, and least when it deals with Jerusalem.

Additions common to Matthew and Luke.

Additions common to Matthew and Luke.—These introduce an altogether new element into the tradition. Hitherto the Triple Tradition of Matthew, Mark, and Luke (as well as the double tradition of Matthew and Mark, and of Luke and Mark) has consisted mostly of short "words of the Lord," set in a framework of short narratives, and very seldom agreeing exactly for more than seven or eight consecutive words. But we now come upon "words of the Lord" in Matthew and Luke, some of which agree exactly for several sentences. What was the origin of this close agreement? In order to gain some view of the data for solving this problem, we must briefly consider the principal passages common to Matthew and Luke alone.

The temptation (Mat. iv. 1–10; Lu. iv. 1–12) and the healing of the centurion's servant (Mat. viii. 1–13; Lu. vii. 1–10) are the principal narratives of *fact* common to Matthew and Luke alone. They resemble the narratives of the Triple Tradition in agreeing so far as concerns the words of Jesus, and of those who address Him, much more than in the general narrative. In the narrative of *facts*, the story of the centurion in Luke differs altogether from that in Matthew; in the temptation, the difference is less. Dismissing these, we pass to the "words of the Lord." As Luke's avowed object was to write "in order," we will adhere to his arrangement in our enumeration.

(1) Mat. iii. 8–10; Lu. iii. 8, 9. "Generation of vipers," etc.; this agrees *verbatim*, except that Luke has *ἄρξησθε*, where Matthew has *δόξητε*.

(2) After a break in which (Mk. intervening) Matthew and Luke have no more than a general agreement with Mark and one another, we come to another passage describing the purifying of the threshing-floor with fire unquenchable (Mat. iii. 12; Lu. iii. 17); the two agree *verbatim*.

(3) Mat. v., vi., vii.; Lu. vi. Here are some scattered sayings of the Sermon on the Mount, such as, "Blessed are the poor," "the hungry," etc. In these the agreement is not *verbatim*. The only passage that agrees almost *verbatim* is that about the mote and the beam.[1]

(4) Mat. xii. 35; Lu. vi. 45. "The good man out of the good treasure of his heart," etc., nearly *verbatim*, but curiously transposed to suit the differing context.

(5) Mat. xi. 2–11; Lu. vii. 19–28. John the Baptist sends two of his disciples to say, "Art thou He that is to come?" With the exception that Luke (*a*) introduces some cures wrought by our Lord, for the special purpose of convincing John's disciples, and (*b*) avoids the repetition of *ἐν μαλακοῖς ἱματίοις* by using *ἐν ἱματισμῷ ἐνδόξῳ*, this passage shows an agreement almost *verbatim*.

(6) Mat. xi. 16–19; Lu. vii. 31–35. "We have piped unto you, and ye have not danced," etc., almost *verbatim*, except that Matthew has *ἐκόψασθε*, Luke *ἐκλαύσατε*.

(7) Mat. (*a*) ix. 37, 38, and (*b*) x. 16; Lu. (*a*) x. 2, and (*b*) x. 3. (*a*) "The harvest truly is great," etc.; (*b*) "I send you as sheep among wolves." The agreement, though not *verbatim*, is considerable. But note (*a*) that Matthew takes the prayer for the increase of the laborers, as a preface to the choice of the twelve, while Luke places it after the choice of the twelve, and uses it as a preface to the choice of the seventy, an incident which he alone records; (*b*) Luke applies to the seventy the warning against danger which Matthew applies to the twelve.

(8) Mat. xi. 21–25; Lu. x. 12–15. "Woe unto thee, Chorazin;" almost *verbatim*, except that where Matthew has *καταβήσει*, "thou shalt come down," Luke has (if the reading be correct) *καταβιβασθήσει*, "thou shalt be brought down."

(9) In Matthew no interval occurs between the last and the following passage; but in Luke intervenes (x. 17–20) the return of the seventy, and a mention of a vision in which Satan was seen falling from heaven, together with the imparting of a power to tread on serpents (compare the late appendix to Mark's Gospel, xvi. 18): then comes Mat. xi. 25–28; Luke x. 21–22, "I thank thee, Father, Lord of heaven and earth," etc. There is but a trifling exception to the agreement. Note also that Luke apparently considers the two sayings which are continuous in Matthew to have been discontinuous, for between vers. 21 and 22 he inserts (so Lachmann, Tischendorf, and Tregelles) "and turning to His disciples, He said."

(10) Mat. xiii. 16, 17; Lu. x. 23, 24. "Blessed are the eyes," etc.; here, again Luke inserts his usual note of a discontinuous saying by inserting "and turning to His disciples, He said privately." Matthew *ἐπεθύμησαν*, Luke *ἠθέλησαν*; Matthew *δίκαιοι*, Luke *βασιλεῖς*. Otherwise *verbatim*.

(11) Mat. vi. 10–13; Lu. xi. 2–4. The Lord's Prayer. Here, where (if anywhere) we should expect identity, there is considerable difference. Luke, after *Πάτερ*, omits (*a*) *ἡμῶν ὁ ἐν τοῖς οὐρανοῖς*, and (*b*) *γενηθήτω τὸ θέλημά σου, ὡς ἐν οὐρανῷ καὶ ἐπὶ τῆς γῆς*. Further, Luke substitutes (*c*) *δίδου* for *δός*; (*d*) *τὸ καθ' ἡμέραν* for *σήμερον*; (*e*) *τὰς ἁμαρτίας* for *τὰ ὀφειλήματα*; (*f*) *ἀφίομεν* for *ἀφήκαμεν*; (*g*) *πάντι τῷ ὀφείλοντι* for *τοῖς ὀφειλέταις ἡμῶν*; and he also (*h*) omits the clause *ἀλλὰ ῥῦσαι ἡμᾶς ἀπὸ τοῦ πονηροῦ*.

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[1] It is noteworthy that whereas Matthew explains "poor" or "hungry" spiritually, "blessed are the poor *in spirit*; . . . Blessed are they that hunger and thirst *after righteousness*," Luke, on the other hand, gives these sayings without Matthew's explanations, "Blessed are ye poor; blessed are ye that hunger now." It is possible that Luke lays greater stress than any of the other evangelists on the sin of covetousness (see the parables of Lazarus and Dives, the "rich fool," the narrative of the "would-be heir," etc.; and note also the evident gratification with which the author of this Gospel records in the Acts (iv. 32) the communism of the early church in Jerusalem); and this might predispose us to attribute Luke's rejection of the spiritual modification of these words to doctrinal grounds. But it must be borne in mind that the tendency in the history of the Gospels is everywhere to accretion and addition rather than to rejection, so that shorter forms are generally more likely to be genuine than longer forms. Moreover, elsewhere Luke (xiv. 26) retains a stronger form of the words of Jesus, "If any man *hate* not his father and mother," while Matthew (x. 37) has a weaker one. On the whole, therefore, it is more probable that Luke, in omitting the words "after righteousness," etc., represents the letter of the original words of Jesus more closely than Matthew (as perhaps also in the Lord's Prayer, see below), however much the latter may better represent the spirit of them.

If any words of the Lord have been handed down by oral tradition, the Lord's Prayer would seem necessarily to have been thus handed down, and from the earliest times. Internal evidence also leaves little doubt that here oral tradition, and not a document, is the origin, and that Luke represents the original most closely in his omissions, though not in his changes. If the Lord's Prayer had been early committed to writing, and had contained Matthew's additional clauses, it is inconceivable that Luke should have omitted them. The same tendency which led a later generation to insert (and us in modern times to retain) the interpretation, "For thine is the kingdom, the power, and the glory," etc., would no doubt in the earliest times favor the insertion, rather than the rejection, of any appropriate clauses that had once gained a footing in the prayer. The abruptness of the simple Πάτερ, which is distasteful to us, as implying too great familiarity, would naturally commend to the early church Matthew's (*a*) insertion. Matthew's second insertion (*b*) is no less natural. It, or something much like it, is found in 1 Mac. iii. 60, "Whatsoever be His will in heaven, so let Him (or will He) do" (ὡς δ' ἂν ᾖ θέλημα ἐν οὐρανῷ, οὕτως ποιήσει); moreover, Luke himself assigns very similar words to our Lord himself, xxii. 42 (μὴ τὸ θέλημά μου ἀλλὰ τὸ σὸν γινέσθω), and to the friends of St. Paul (Acts xxi. 14). The fact that our Lord Himself used this prayer may have seemed sufficient cause in the earliest times, and especially to Matthew, who is in the habit of massing together doctrine of a certain kind, as in the Sermon on the Mount, for inserting it in the Lord's Prayer. (*c*) Luke's change of the aor. imperative into a present implies a desire to represent a continuous and not an isolated action; and (*d*) the change of σήμερον into καθ' ἡμέραν is explicable by the same motive. The word ἐπιούσιος, common both to Matthew and Luke, and not found elsewhere in the whole of Greek literature, seems to indicate that a Greek tradition, and not an Aramaic tradition, of this prayer, was the basis of both Matthew's and Luke's version, It is probably derived from ἡ ἐπιοῦσα (Prov. xxvii. 1, οὐ γὰρ οἶδας τι τέξεται ἡ ἐπιοῦσα (יוֹם), "Thou knowest not what the day will bring"), and, probably (though this is disputed), means "for the immediate future, the *instant*."[1] This meaning is consistent both with Matthew's σήμερον and with Luke's τὸ καθ' ἡμέραν. Luke's next three changes, (*d*), (*e*), and (*f*), substitute the more intelligible word "sin" for the less intelligible ".debt," and the more intelligible present "we forgive" for the less intelligible past "we forgave;" and increase the emphasis by adding "every one (that is our debtor)." In all these cases Matthew's seems to be the earlier form; for it is more likely that the comparatively difficult version of Matthew should have been altered into the comparatively easy version of Luke than *vice versa*. Besides, the retention of the metaphorical ὀφείλοντι by Luke, in the second clause, indicates that the metaphor of "debt," appeared in the original (*g*). Matthew's insertion of the clause "deliver us from the evil" may naturally have arisen from the reluctance to end a prayer with a negative petition, "lead us not into temptation." The inserted clause resembles many passages in the Psalms (xvii. 49, LXX.; A. V. xviii. 48, ἀπὸ ἀνδρὸς ἀδίκου ῥύσῃ με), and early commended itself to the church (2 Tim. iv. 18). In any case, there is no reason why Luke should omit such a clause, if it were known to him; and there are many reasons why such a clause should be introduced (even though it were not in the original), and why, when introduced, it should be speedily accepted. To sum up the inferences from this most important passage: the variations (and the nature of the passage) indicate a source oral and not documentary, Greek and not Aramaic; Matthew appears to have massed together a number of prayers taught by, or perhaps used by, the Lord Jesus, while Luke seems to have adhered to an earlier form, which, however, has received late modification for the purposes of daily use. Though, however, we may follow Luke here, as more closely approximating to the original form of the prayer it does not result that on this account we must commit ourselves to the statement that the Lord's Prayer was actually given at the exact time, and in the exact manner, which Luke describes. Just as Matthew supplies grouping, so Luke supplies motives and occasions. Often it may be more probable that the grouping and continuity of Matthew may be closer to the historical fact than the attempt at orderly arrangement, and at assignment of motive and cause and time, which characterizes Luke. Instances of this will be given hereafter. .

(12) Mat. vii. 7–12; Lu. xi. 34–36. "Ask, and it shall be given unto you," etc. Luke prefaces this by a parable peculiar to himself, and of a peculiar type,—the argument being that if an indolent man grants requests, influenced by mere importunity, much more will the perfectly good God listen to earnest prayer. There is no reason, in the style or thought of this and similar parables, for supposing that we have the exact words of Jesus. Luke inserts in the part common to him and Matthew a clause about an "egg and scorpion;" and where Matthew has "good things" Luke has "the Holy Spirit." With these exceptions, the agreement is nearly *verbatim*.

(13) Mat. vi. 22–23; Lu. xi. 9–13. "The light of the body is the eye." Similar in the first part; but varies (seemingly through confusion) towards the end.

(14) Matt. xii. 30, 43–45; Lu. xi. 23–26. "He that is not with Me is against Me, and he that gathereth not with Me scattereth," followed by "When the unclean spirit goeth forth from the man," etc., nearly *verbatim*, but apparently better placed by Matthew than by Luke, who has transposed the passage into the neighborhood of the discourse on Beelzebub, moved possibly by the superficial resemblance of subject ("unclean spirit" and "Beelzebub"), not perhaps perceiving that it is the climax of a condemnation of "this evil generation," which last words (Mat. xii. 45) Luke omits.

(15) Mat. xii. 41, 42; Lu. xi. 31, 32. "The queen of the south shall rise up," etc. The queen of the south is placed by Luke before, by Matthew after, the "men of Nineveh;" and in one of the clauses (very curiously, but perhaps with a desire to bring out the antithesis between the "women" and the "men") Luke substitutes "the men of this generation" for "this generation," and "them" for "it." Otherwise the agreement is almost *verbatim*.

(16) Mat. xxiii. 23–39; Lu. xi. 37–52. A denunciation of those who tithed mint and anise, yet were the true children of the murderers of the prophets. Matthew makes this a part of a long and public denunciation of the Pharisees, in Jerusalem; Luke places it early, and as an utterance in the house of a Pharisee, his host. It is certainly remarkable that here, and nowhere else, a Pharisee is addressed in the singular number, "Thou blind Pharisee" (Mat. xxiii. 26). The "Pharisee" is clearly generic; but if the use of the singular were misunderstood, it might originate a tradition that the speech was delivered to a single Pharisee, in whose house Jesus was dining; and though Luke does not insert the "Pharisee," he may have been influenced by this traditional misunderstanding. Internal evidence is here strongly for Matthew's, and against Luke's place and time. Luke has probably been led to place this discourse at the table of a Pharisee, by the metaphor of the "cup and platter." But the metaphor suits Matthew's version equally well; and it is in defiance at once of good taste and probability, to attribute to Jesus such a denunciation of a host at his own table, and to place it so early in our Lord's ministry. The use (Lu. xi. 39) of ὁ Κύριος (see below, 22) makes it probable that this is a late tradition; and, if it is rejected, there falls with it an accusation brought against Jesus, of neglecting the decencies of life, by coming to a repast with unwashed hands. The agreement is here by no means *verbatim;* and, besides other differences, Matthew has τὸ ἐντὸς καθάρισον, where Luke has τὰ ἐνόντα δότε ἐλεημοσύνην (a change, as in the Lord's Prayer, from the metaphorical to the real). The original and Judæan expression σοφοὺς καὶ γραμματεῖς Luke alters into the Christian ἀποστόλους; he also omits the somewhat difficult σταυρώσετε. It is especially noteworthy that, whereas in Matthew Jesus says, "Wherefore, behold *I* send unto *you* prophets," etc., in Luke Jesus says, "Wherefore, also *the Wisdom of God said*, I will send unto *them* prophets," etc. Here Luke probably represents the earlier form, although the explanation may be doubtful. It is possible that the book containing the "words of the Lord," from which Matthew and Luke borrowed this saying, gave to Jesus the name of "the Wisdom of God" (*cf.* 1 Cor. i. 24, "Christ the Wisdom of God"), and that this title was retained by Luke, but applied, not to Jesus, but to the divine providence. Matthew adds to Zachariah the words "son of Barachiah;" Luke omits them. Here again Luke probably represents the earlier tradition. The Zachariah here mentioned was the son of Jehoiada. But Matthew, whose manner it is to lay especial stress upon all matters connected with the prophets (Schenkel's *Bibel-Lexicon*, "Sacharja"), having in his mind either Zechariah, the son of Jeberechiah (Is. viii. 2), or Zechariah the prophet, the son of Berechiah (Zech. i. 1), inserted the erroneous words. The agreement here is by no means *verbatim*. Matthew makes the utterance continuous, but Luke (xi. 45), introducing a remonstrance from a "lawyer," turns the denunciation from the Pharisees to the "lawyers."

(17) Mat. x. 28–31; Lu. xii. 4–8. "Fear not them which kill the body," etc. Instead of Matthew's "shall fall to the earth without your father," Luke has the more general phrase, "is forgotten in the presence of God." In other parts of the passage there is considerable dissimilarity.

(18) Mat. x. 32, 33; Lu. xii. 8, 9. "Whosoever shall confess me before men," etc. Not *verbatim*. Besides other differences, instead of Matthew's ἔμπροσθεν τοῦ πατρός μου, Luke has ἔμπροσθεν or ἐνώπιον τῶν ἀγγέλων τοῦ Θεοῦ twice. This expression occurs in another passage peculiar to Luke (xv. 10), and nowhere else.

(19) Mat. vi. 25–34; Lu. xii. 22–34. "Wherefore I say unto you, Take no thought," etc. This is the second passage (see above, Mat. xxiii. 34; Lu. xi. 49) common to Matthew and Luke, introduced by "wherefore," though the context is different. Matthew (vi. 25) introduces the passage by a single sentence, to

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[1] There appears to be a reference to the manna which (Exod. xvi. 4) the people of Israel were to gather from day to day. So Philo, *Alleg.*, iii. 57, "Let the soul therefore collect the food of the day for the day (τὸ τῆς ἡμέρας εἰς ἡμέραν)."

the effect that no one can serve two masters, God and mammon. Luke, on the other hand, after narrating the refusal of Jesus to become a "judge or a divider," and after describing in language and thought peculiar to himself (for to Luke alone belong the parables of soliloquy) the death of the rich fool, continues thus: "And He said unto His disciples, *Therefore* I say unto you, Take no thought," etc. The comparison of this passage is most useful as illustrating the difference between Matthew's and Luke's handling of their subject matter, and also as throwing light on the object (and perhaps on the origin) of many of the parables peculiar to Luke. They seem intended as tales to prepare the way for some famous saying of the Lord as the conclusion and moral. The agreement in language here is not *verbatim*. Besides other differences, Luke changes the πετεινὰ τοῦ οὐρανοῦ into κόρακας, moved perhaps by the memory of the ravens, for whom God "provideth food" (Job xxxviii. 41; Ps. cxlvii. 9). But Luke's καὶ μὴ μετεωρίζεσθε, instead of ἤ τὶ περιβαλώμεθα, suggests some difference of original text, or some different rendering of the same original rather than a mere alteration.

(20) Mat. vi. 19–21; Lu. xii. 33, 34. "Lay not up for yourselves treasure," etc. There is little exact similarity of language here, except in the last sentence.

(21) Mat. xxiv. 42–51; Lu. xii. 39–46. "But know this, that if the goodman of the house had known," etc. In Matthew this sentence comes towards the end of a long discourse on the second coming, uttered in Jerusalem; in Luke it is spoken in Galilee, and it is preceded by a passage peculiar to Luke, and reminding one of the Epistles: "Let your loins be girded about, and your lights burning," etc. With the exception of Matthew εἴασε, Luke ἀφῆκε (probably the original word), the passages agree almost *verbatim*.

(22) Mat. xxiv. 45; Lu. xii. 42. "Who then is the faithful and just," etc. Here there is precise agreement, except where Luke has altered the text with an object. Finding this parable, in the book or tradition from which he extracted it, connected with the name of Peter, and desiring to distinguish the "steward" or upper "servant," who is placed over the household, from the common slaves, he (*a*) inserts a question of Peter, "Speakest Thou this parable unto us or even unto all?" (*b*) alters the first δοῦλος ("slave") into οἰκονόμος ("steward"); (*c*) alters οἰκετείας ("household," the true reading of Matthew) into a word with somewhat higher associations, θεραπείας ("suite" or "retinue"); and (*d*) changes συνδούλους ("fellow-slaves" into "the man-servants and maid-servants." One or two other changes are also made (μεθύσκεσθαι and τε) to improve the text. Luke's σιτομέτριον and ἀπίστων, for Matthew's τροφήν and ὑποκριτῶν, might be early variations arising from the varying translation of some Aramaic original. There remains the curious fact that, in introducing this parable, Luke uses the rare Κύριος (used not as a vocative in speech of address, but in narration), instead of Ἰησοῦς: "*The Lord* said unto Peter." This is an almost sure sign of a late addition to the Gospels, often of an interpolation. The word Κύριος is not used once thus in the correct text of Matthew, It is not used once in the genuine Mark; but it is used twice in the short interpolated appendix to Mark (xvi. 19, 20). In Luke it is used about twelve times, always in prefaces or other passages peculiar to Luke, and of these twelve passages three are connected with Peter (xii. 42; xxii. 31; xxii. 61).

(23) Mat. x. 34–36; Lu. xii. 51–55. "Think ye that I came to send peace on earth?" The agreement is not *verbatim*, and suggests two independent translations from an Aramaic original. Instead of Matthew's μάχαιραν, "a sword," Luke has διαμερισμόν, "division." This might either be the divergence of translators (so חרב is translated in the LXX. both μάχαιρα and πόλεμος), or it might be a mannerism of Luke (*cf.* ἐπισιτισμόν, ix. 12; ιματισμῷ, vii. 25; ix. 29, where Matthew has severally βρώματα, μαλακά, and ἱμάτια).

(24) Mat. v. 25, 26; Lu. xii. 58, 59. "Agree with thine adversary," etc. This passage is not *verbatim* in Matthew and Luke, except in the last sentence. The word ὑπάγειν in Luke (which Luke as a rule systematically alters or omits whenever it is found in the common tradition of Matthew and Luke [see Mk. i. 44; ii. 11; x. 21;[1] xiv. 21]) indicates that therein Luke is following some early tradition: but κατασύρῃ, πράκτωρ, and λεπτόν (Luke's "half-farthing," instead of Matthew's "farthing") seem all later touches added to give graphic variety and climax.

(25) Mat. xiii. 33; Lu. xiii. 21. "The kingdom of heaven is like unto leaven," etc. Nearly *verbatim*.

(26) Mat. viii. 11, 12; Lu. xiii. 28, 29. "Many shall come from the east and the west," etc. In Matthew these words are uttered by Jesus as a comment upon the marvellous faith of the centurion. In Luke they follow a parable peculiar to himself. The clause "there shall be weeping and gnashing of teeth" (which, except in this instance, is peculiar to Matthew) is transferred from the end to the beginning; and there are other variations, seemingly purposed. The agreement is far from *verbatim*.

(27) Mat. xxiii. 37–39; Lu. xiii. 34, 35. "Jerusalem, Jerusalem," etc. This is a conspicuous instance of the manner in which Luke has sometimes deviated from the true chronological order. He represents these words to have been uttered in Galilee, when the Pharisees warn Jesus to flee from fear of Herod. But Matthew represents them as having been uttered in Jerusalem, and in the temple. The reason for Luke's transposition is possibly contained in the last words, "Ye shall not see Me till the time come when ye shall say, Blessed is He that cometh in the name of the Lord." Now these very words, "Blessed is He," etc., were uttered by the crowd welcoming Jesus on his entrance into Jerusalem (xix. 39). Luke therefore, regarding the words of Jesus, "Ye shall not see Me," as a prediction necessarily preceding its fulfilment, is bound to place these words before the entry of Jesus into Jerusalem. But all internal evidence is on the side of Matthew's order, and against Luke's. The agreement is very nearly *verbatim*, but Luke (whose arrangement does not require the word) dispenses with the "henceforth" of Matthew.

(28) Mat. xxii. 1–14; Lu. xiv. 15–24. The parable of the wedding feast. These parables differ entirely in language, and somewhat in thought. In Matthew those who are first invited slay the messengers, and are slain by the king; and among those who are subsequently invited, one is rejected for being without a wedding garment. In Luke the guests are simply discourteous, and the host merely invites others (the poor and the maimed, and then the wanderers in the streets) in the place of the first. Matthew's parable is therefore political, Luke's social. Note, however, that in the parable of the pounds (Mat. talents, xxv.), Luke introduces (xix. 27) the missing political element, whereas Matthew there omits it. Clearly no common document nor even detailed tradition originated these parables. They are rather (as also are the parables of the talents and the pounds) of the nature of sermons or stories based upon short "words of the Lord" as texts. It is obvious that Matthew lays special stress upon the exclusion of the unfit intruder, Luke upon the inclusion of all the world.

(29) Mat. x. 37–39; Lu. xiv. 26, 27. "He that loveth father and mother more than Me," etc. In Matthew these words are addressed by Jesus to the twelve in Galilee; in Luke to the multitude following Him during His journey to Jerusalem. Here Luke seems to have preserved the older (because more difficult) form of the tradition: "Whosoever *hateth not*" (Marcion altered μισεῖ into καταλείπει) "his father, . . . yea, his own life also," etc. It seems more probable that this was the original form than that Luke intensified the form by any alteration of his own. There is scarcely any agreement of language between Matthew and Luke here.

(30) Mat. xviii. 12–14; Lu. xv. 4–7. "What man having an hundred sheep," etc. The thought is the same, but there is scarcely any similarity of language; and even the conclusion characteristically differs, Matthew having "it is not the will of *your Father in heaven* that one of these little ones should perish;" Luke having "there is joy *in heaven* over one sinner that repenteth." The contrast between the negative ("not the will") and the positive ("joy"), between the "non-perishing" and the "repenting," is typical of the contrast between the whole of Matthew and the whole of Luke.

(31) Mat. vi. 24; Lu. xvi. 13. "No (servant) can serve two masters," etc. With the exception of "servant" added by Luke for definiteness, this saying is the same *verbatim* in Matthew and Luke.

(32) Mat. xi. 12 and v. 18; Lu. xvi. 16, 17. "The law and the prophets were till John," etc., and "Not one tittle shall pass from the law." There seems little connection in these sayings as they stand in Luke, and there is very little similarity of language between Matthew and Luke.

(33) Mat. xxiv. 26–28, 37–41; Lu. xvii. 23–27, 34–37. These are scattered sayings on the second coming, likening it to the "days of Noah" and to "lightning," and predicting the severance of those who are "at one mill" and "in one bed." Luke, after his manner, introduces a question, "Where, Lord?" to which the reply comes, "Wheresoever the body is, thither will the eagles be gathered together." Matthew, on the other hand, introduces the sentence in the midst of the discourse, "So shall also the coming of the Son of Man be, for wheresoever the body is," etc. The agreement of language is not considerable, except in the last part.

(34) Mat. xxiii. 12; Lu. xviii. 14, and xiv. 11. "Every one that exalteth himself shall be abased," etc. This again furnishes a striking instance of the manner in which Luke utilizes words of the Lord as texts for discourses. The saying is introduced by Matthew in the midst of the discourse against the Pharisees; but it is made by Luke the conclusion and moral of the parable of the publican and the Pharisee, and of the discourse on choosing the lower room.

(35) Mat. xxv. 14–30; Lu. xix. 1–28. The parable of the

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[1] It is curious that, in the only passage where Luke agrees with Mark in reading ὑπάγετε (Mk. xi. 2; Lu. xix. 30), Matthew differs (xxv. 2), using the word πορεύεσθαι. There may be noted a general tendency of Luke to diverge from Mark, and of Matthew to diverge from Mark, wherever Mark agrees exactly with the narrative (as distinct from the words of the Lord) in Matthew and Luke respectively.

talents or pounds. There is no similarity of language, except in the dialogue between the idle servant and the master. Luke, after his manner, inserts a question from the bystanders ("And they said to him, Lord, he hath ten pounds"); and Luke here, as Matthew above (28), introduces a political element, making the master a king, and narrating a royal vengeance.

In the consideration of the passages quoted above, one fact strikes us at once, that the Lord's Prayer is not *verbatim* the same in Matthew and Luke. If *this* is not identical, it might be thought that we cannot expect any words of the Lord to be identical. And indeed, as a matter not of hypothesis but of fact, those words which have most strongly appealed to men's hearts, and have been most frequently on their lips, from the earliest times of the church: those sayings which have given the tone to Christian life, which have encouraged martyrs, and stimulated waverers, such as (17), "Fear not them which kill the body;" (18), "Whosoever shall confess," etc.;" (29), "He that loveth father or mother more than Me," etc.—all these, though identical as regards thought, and similar as regards words, are nevertheless not exactly similar in Matthew and Luke. The exactly similar passages are of a very different nature: they are for the most part passages of a prophetic or historical rather than a doctrinal character, with application to individuals. Some, (1), (2), (5), (6), describe the relations between John the Baptist and Christ; another, (8), calls down woe on Chorazin; another, (9), in language that reminds us of the thoughts, though not of the words, of the Fourth Gospel, thanks God for revealing to babes what He has hidden from the wise and prudent; another, (27), pours forth lamentations over doomed Jerusalem. All these passages, dealing as it were on a large scale with the will of God, as it affects religions and nations rather than as it affects individuals, are better fitted for reading in the services of the church than for being transmitted from mouth to mouth in the family from father to son, or from catechist to catechumen, for personal and individual guidance; and consequently they seem more likely to have been handed down in a book than by means of oral tradition. The same conclusion applies to (21), "But know this, that if the goodman," etc. and to (22), "Who then is the faithful and just steward," etc.—both of which passages agree *verbatim*, and both of which appear to have an ecclesiastical rather than an individual reference, at all events in their primary application. In proportion as a rhetorical passage limits itself to individual application, it seems to have been modified by oral tradition so as to deviate from exact agreement: compare in (3) the "mote and the beam;" also (12), "Ask, and it shall be given unto you;" and (19), "Take no thought for the morrow." The only exception perhaps to this rule is in the denunciation of the Pharisees (16). This passage, being of the historical type, ought (according to our rule) to be identical; but Luke differs from Matthew considerably. Possibly, in the earliest days of the church, and especially in the synagogues of Palestine a few years after the death of Christ, the angry conflicts between the disciples of the Lord and the Pharisees may have frequently reproduced and modified by traditional influences the original form of our Lord's denunciation; so that perhaps this subject comes naturally under the head of traditional doctrine. It must also be remembered that, as Luke approaches the later period of the work of Christ in Judæa, he deviates more and more both from Matthew and from Mark; perhaps because there was a Judæan as well as a Galilean tradition of the life of Jesus, and Luke, in the latter part of his history, depended mainly on the former. These two considerations may explain the deviation of Luke from Matthew in the denunciation of the Pharisees.

That the parables should diverge is natural. Their length and number would prevent them from being remembered, or passed from mouth to mouth, with the same fidelity with which the shorter words of the Lord would be preserved; and as they were probably often repeated by Jesus in varied shapes, no one particular shape of any parable would seem to claim a place in the written document of the words of the Lord, as being of the same importance as the "Woe to Jerusalem," or the other strains of poetic prophecy. The parable of the sower, coming first in order, and being typical of the rest of the parables, and having appended to it an explanation of the motive of the parabolic teaching, would naturally attract attention from the earliest times, and consequently it found a place in the Triple Tradition; but this privilege was accorded to no other parable. There is therefore no ground whatever for inferring from the discrepancy of the language of a parable in Matthew and Luke (*e.g.*, the parable of the lost sheep) that it was not actually uttered by Jesus. The exact similarity of thought and sequence of incident in that parable, as recorded by Matthew and Luke, proves to demonstration that the two records are derived from one source.

The following are our conclusions therefore about the additions to the Triple Tradition made jointly by Matthew and Luke. (1.) Their omission by Mark furnishes no argument for their rejection, inasmuch as Mark also omits the Lord's Prayer, and obviously aims at narrating the acts rather than the sayings of the Lord. (2.) Of the additions, some appear to be based upon common tradition, or on documents modified by tradition,—principally those short trenchant sayings (including the Lord's Prayer) which are of a universal and private application. (3.) Others appear to be based upon a common document; and in these documentary additions (as perhaps to some extent in the rest) Luke seems to have modified the original tradition, in words and phrases, with a view to purity of style and intelligibility, or to remove difficulties. (4.) In chronological order and arrangement Matthew and Luke pursue divergent paths; Matthew's object being to group and mass the teaching of the Lord, while Luke aims at supplying motive, occasion, place, and time for each utterance. It is scarcely possible to doubt that the arrangement of neither is to be implicitly adopted. There is much reason to doubt whether what is called the Sermon on the Mount was actually delivered at one time in the shape in which Matthew presents it; and it is equally questionable whether the lamentation over Jerusalem was delivered in a village of Galilee, and whether the denunciation of the Scribes and Pharisees (as murderers, on whom should be avenged all the innocent blood shed from the beginning of the world) was uttered at the table of a Pharisee. (6.) As regards the parables, we have to depend—in our conjecture as to the degree to which the thoughts of Jesus have been preserved—mainly upon the presence in them of the same spiritual power and insight which are perceptible in His other recognized genuine sayings. But the dissimilarity of the language of the parables in Matthew and Luke (where the thought is the same) gives no ground for denying that parables on the same subjects, and to the same effect, were actually delivered by Him. (7.) Since the hypothesis that Luke borrowed from Matthew is untenable, and since therefore we must suppose that Matthew and Luke borrowed these additions independently from some early document, we may infer that, before the times of Matthew and Luke, a document containing words of the Lord had existed long enough, and had acquired authority enough, to induce two editors or writers of Gospels, apparently representing different schools of thought and writing for different churches, to borrow from it independently.

This last conclusion is of the greatest importance; for though the document may be, and almost certainly was, later than the Triple Tradition, yet it would have the advantage of preserving the original utterances of the Lord comparatively unimpaired by traditional transmutations. When to this consideration is added the authoritative nature of the words of the Lord in this document, their direct reference to events, and the extreme improbability that any disciple would have, or could have, invented them,—for which of the apostles or subordinate disciples could have invented the discourse on "the lilies of the field," or the lamentation over Jerusalem, or the speech which likens John to "a reed shaken by the wind," and pronounces him the greatest of the prophets, yet less than the least in the kingdom of God?—we are led to infer that in all probability we have in these additions of Matthew and Luke a very close approximation to some of the noblest and most impressive utterances of Jesus Himself. With the exception of the healing of the son of the centurion, and the narrative of the temptation, the additions common to Matthew and Luke introduce no new supernatural element.

Additions peculiar to Mark.

The Additions and Peculiarities of Mark.—It might be expected that when we come to the additions peculiar to each of the three synoptists we should find some increase to the accounts of supernatural events. Now it seems to be a striking proof of the antiquity of the Second Gospel that we find in it no additions of this kind. Not that Mark does not lay stress on what appears to be supernatural; on the contrary, he records acts of instantaneous healing with greater minuteness of detail than any other evangelist (vii. 31–37; viii. 22–26; ix. 14–27); but we find in Mark no mention of our Lord's birth or childhood, and only the barest prediction of His resurrection. As an explanation of the deficiency of information on the resurrection, it has been frequently suggested that the latter part of the Gospel may have been lost; and, less frequently (Weiss, *Marcusevangelium*, p. 511), that the Gospel was deliberately closed with the prediction of the resurrection by the mouth of an angel, because "the manifestations of the risen Saviour belong (according to the earliest notions) no longer to the earthly sphere of the action of Jesus, and therefore do not fall within the province of the Gospel." Few Greek scholars, however, will be induced to believe that the author of the Second Gospel deliberately chose to end a book on the good news of Christ with the words *ἐφοβοῦντο γάρ*. From a literary point of view the *γάρ*, and from a moral point of view the ill-omened *ἐφοβοῦντο*, make it almost incredible that these words represent a deliberate termination assigned by an author to a composition of his own. Others have suggested that the last page of the MS. may have been accidentally destroyed. But this suggestion seems to overlook the consideration that the MS. was in all probability written not for a private library but for use in the church, and that it would immediately be multiplied by copies. Again, we know, from reference to Mat. xxviii. 8 and Lu. xxiv. 9, that the common tradition ceases with the return of the women from the Lord's tomb. But it is precisely at this point that the genuine Mark (xvi. 8) also terminates. Now, that a page should have been torn out containing just that part of Mark which followed after the close of the common tradition would be a most remarkable and unlikely coincidence. It seems far more probable that Mark ends his Gospel here because the common tradition ended here, and because he scrupled to add anything to the notes and traditions which he knew to rest upon a higher authority than his own. If this be the true explanation, it stamps with the seal of a higher authority such traditions as have been preserved to us by so scrupulous an author. We proceed therefore to an investigation of the peculiarities of Mark, with a confidence in him increased rather than diminished by the fact that he has neither the introductions nor the appendices which are found in the rest of the Gospels.

The first thing that strikes us in Mark is his duality. Verbosity we might be tempted to call it at the first sight; but though there is a certain disproportion in the space assigned to detail, duality, and not verbosity, is the better word. It is this duality which gave rise (see above, p. 702) to the erroneous supposition that Mark had borrowed from Matthew and Luke. But it may be shown, by reference to passages where there can be no possibility that Mark borrowed from Matthew and Luke (Mk. ii. 19; iii. 5; iii. 27; iii. 22, 30; v. 3, 5; xii. 44), that this duality is a part of Mark's style. In many cases, *e.g.*, iii. 22, 30 (*Βεελζεβοὺλ ἔχει* and *πνεῦμα ἀκάθαρτον ἔχει*), it is almost forced on the reader that the evangelist had before him two versions of one saying, and that in his "anxiety to omit nothing"[1] he inserted both. Whether there be any definite traces of translation in his Gospel will be considered hereafter. But, so far, we merely note that some of Mark's dualities of expression might be explained as double renderings of the same original. Only one parable is peculiar to Mark; it is one that illustrates (iv. 26–29) the spread of the kingdom of God by the quiet, unperceived, and gradual growth of corn. The subdued tone of this (one of the most interesting of all the parables) was perhaps the reason why it was not at first widely known, as it undoubtedly is the reason why modern readers pay it too little attention. Mark also amplifies the story of the Baptist's execution (vi. 20–28), and the graphic story of the exorcism of the "legion." For the rest, the other additions peculiar to Mark consist either of dual expressions and amplifications of detail, or of realistic details which would naturally be subordinated in later times, as likely to be stumbling-blocks. For amplifications which treat of the resistance and ultimate submission of unclean spirits see i. 26, 27; i. 44; iii. 7–12; ix. 14–27; for others which relate to the crowding of people round Jesus, the publicity of His work, and His desire for solitude, see i. 28; i. 35–37; i. 45; ii. 1–4; ii. 15; iii. 10–12; vi. 32–33, etc. The narrative also, from first to last, abounds with expressions as to the manner and look and minute action of Jesus during dialogues or miracles (*cf.* iii. 5; vii. 31–37; viii. 22–26). In many of these additions Aramaic words are given as the very utterances of Jesus, *e.g.*, v. 41, *Ταλιθά κοῦμι*; vii. 34, *Ἐφφαθά*; xiv. 36, *Ἀββά*; sometimes, also, names that are given by no other writer, *e.g.*, Bartimæus, Boanerges, and Dalmanutha.[2] Unquestionably, under ordinary circumstances, this elaboration of unimportant detail[3] (and especially the introduction of names—for instances of which see the Apocryphal Gospels *passim*) is a mark of a late writer, and of a composer of fiction rather than history. But all the characteristics of Mark support the belief that in his case they are rather the excrescences and redundancies of one who trusted his memory rather than his judgment, and who preferred to report rather than to select and arrange.

One proof of the early composition of Mark is the rudeness and even vulgarity of his Greek. He uses a great number of words which are expressly forbidden by the grammarians. For example, of Mark's phase *ἐσχάτως ἔχει* (Mk. v. 23), Phrynichus says (ed. Lobeck, p. 389), "only the *canaille* use it in this sense;" the same grammarian also warns his readers against *κράββατος* (Mk. ii. 4, 9, 11, 12). Other words noted by Phrynichus, and used by Mark (some of which are also used by Matthew) but avoided by Luke, are *μονόφθαλμος* (ix. 47); *εὐσχήμων* (for *πλούσιος*, xv. 43); *κολλυβισταί* (xi. 15); *κοράσιον* (v. 41); *ὁρκίζω* (v. 7); *ῥάπισμα* (xiv. 65); *ῥαφίδος* (x. 25).[4] Such words as these might naturally find their place in the mongrel Greek of the slaves and freedmen who formed the first congregations of the church in Rome; and they are therefore tokens of a date of composition earlier than that of Matthew and Luke. For it is not conceivable that such terms (some of which would so have jarred upon the ear of an educated Greek as almost to correspond to our "slang") should be substituted in later times for a more tasteful vocabulary; whereas it is easily conceivable, and *a priori* probable, that better Greek should, in the prosperous days of the church, be substituted for worse.

It is a natural characteristic of an unpractised reporter that he lays undue stress on a few vivid expressions and striking words, and that he reproduces or exaggerates anacolutha which, though not objectionable in a speech, are inconvenient in a book, because they tend to obscure or subordinate the subject matter. Many such words are inserted by Mark, and avoided by Matthew or Luke, or by both, *e.g.*, *σχιζομένους*, i. 10; *ἄγναφος*, ii. 21; *κωμοπόλεις*, i. 38; *ἄναλον*, ix. 50. For irregular constructions see iv. 28 (*πλήρης σῖτος*, the correct reading); xii. 40, *οἱ κατέσθοντες* (altered by Luke); v. 23, *ἵνα ἐπιθῇς*; note also the curious change of construction from *ἵνα* to the infinitive in iii. 15, as compared with iii. 14. The Latinisms of this Gospel are well known: see xv. 15, *τὸ ἱκανὸν ποιῆσαι*; vi. 35, *ὥρα πολλή*; vi. 27, *σπεκουλάτωρ*; xv. 39, *κεντυρίων*. The words *πραιτώριον* (xv. 16), *κῆνσος* (xii. 14), and *φραγελλοῦν* (xv. 15) Mark shares with Matthew. Other barbarisms are the use of *ὅταν* with the indicative, and the use of *ὅτι* to ask a question (ii. 16; ix. 11; ix. 28), both of which idioms are common in the *Acta Pilati*, and perhaps indicate Latin influence.

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[1] This is a quotation from Papias preserved by Eusebius (Kirchhofer, p. 123): "For he (Mark) took great care about one matter, viz., to omit nothing of all that (*μηδὲν ὧν*) he heard." If Papias spoke of our Mark, it would seem that this must refer rather to the words than to the incidents recorded in his very scanty Gospel. It seems to be an apology for the disproportion of the narrative. In writing the narrative just as he took it down in notes (from Peter's discourses) "Mark," says Papias, "committed no error," but simply acted as a faithful reporter. We do not, of course, commit ourselves to the truth of this statement; we merely point out that the hypothesis that Mark's Gospel is a collection of "notes," will explain some of the peculiarities of its style.

[2] Mark's custom of placing the Aramaic original side by side with the Greek translation is perhaps in part suggested by the Palestinian dialect of our Lord's time, in which (especially in certain phrases) Greek and Aramaic were blended together, as in the phrase "my Lord," מָרִי כִּירִי, which stands for מָרִי, *κύριε*. See Lightfoot, *Galat.*, p. 167, for this and other instances. But in Mark the reduplication for the most part is confined to passages expressive of strong emotion.

[3] Take, as an instance, the wounding of the high priest's servant by Peter. Here Mark (xiv. 47) merely records the wound; Matthew (xxvi. 52) adds the reproof addressed by Jesus to Peter; Luke (xxii. 50, 51) adds that it was the "right" ear, and that Jesus healed the man; lastly, the Fourth Gospel, while omitting the healing, retains the "right" ear, and adds that the servant's name was Malchus. In such a case it is impossible to feel certain that the simpler narrative of Mark may not have been modified by later accretions.

[4] Such arguments as that "Hippocrates used *ῥαφίς*" cannot count for anything against the general feeling of dislike for the word expressed by the dictum of Phrynichus, "*ἡ δὲ ῥαφὶς τί ἐστιν οὐκ ἄν τις γνοίη.*"

A still more cogent proof of the early date of Mark is that this Gospel contains many expressions which would be likely to be stumbling-blocks in the way of weak believers, so that they are omitted in the later Gospels, and would not have been tolerated except in a Gospel of extreme antiquity. For example, the strong expression (vi. 5, 6), "He *was not able* to do there any mighty work;" the statement (i. 32, 34) that *all* the sick were brought to Jesus, but that He healed only *many*, whereas Matthew (viii. 16) says that He healed *all*, and Luke (iv. 40) that He healed *each one* (ἑνὶ ἑκάστῳ); the attempt of his mother and brethren to lay hands on Him on the ground that He was insane (iii. 20–21); the imputation of an ambitious petition to James and John, instead of (as Matthew) to their mother (x. 35); the mention of the marvel of Pilate at the speedy death of Jesus, which might have been perverted to support those who denied that Jesus had really died upon the cross (xv. 44); the statement that Jesus only gave power to His apostles to cast out devils (iii. 15, correct text), and not (as Mat. x. 1) to heal diseases; the enumeration of the different stages by which Jesus, at least on one occasion, effected a cure, and the description of the, at first, only partial cure (viii. 24); the statement that the fig-tree, instead of being withered up "immediately" (as Matthew, παραχρῆμα, xxi. 19), was not observed to be withered till after the interval of a day; the bare statement (xvi. 4) that the women found the stone rolled away from the sepulchre (which might have been used to support the statements of those who maintained that the friends or enemies of Jesus had stolen His body), whereas Matthew (xxviii. 2) distinctly meets such an objection by asserting that an angel descended from heaven in the sight of the keepers and rolled away the stone;—these, and probably other expressions, indicate a very early date of composition, and a disposition to record facts as they came, without emphasis or subordination. Mark neither masses similar sayings or deeds, as Matthew does, nor supplies motives and occasions, as Luke does. It is most interesting to note that the words "law," "lawyer," which played so prominent a part in Matthew and Luke, are not to be found at all in Mark's narrative. His business is simply with the life of Christ. Again, whereas Matthew and (in a less degree) Luke are careful to point out that Jesus fulfilled the sayings of the prophets, Mark, on the other hand, though he recognizes in John the Baptist (i. 2) the messenger predicted by the prophets, sees in Jesus a Being too absorbing and interesting as a man to find much time for contemplation of Him as the mere fulfiller of prophecy. In a word, Mark writes of Jesus, not as the destroyer or fulfiller of the law, not as the Messiah predicted by the prophets, not as the refuge of the Gentiles, but rather as a man; subject to anger, and disappointment, and weariness; not knowing all things; not able to do all things; but endowed with strange powers of healing the souls and bodies of men; and carrying out a mysterious plan for the regeneration of the world, through a spirit of childlike obedience to God and brotherly love towards men; lastly, a man who assumed for Himself and for His disciples a power of forgiving sins, and who based all the success of His plans upon His predicted death and resurrection, to be followed by a second coming.

True, Mark's Gospel is disproportioned, inartistic, and uncouth—scarcely, indeed, to be called a book, but rather a collection of graphic anecdotes. Yet it has a unity derived from its naive simplicity and single-mindedness, in recording whatever it records as it was delivered from the earliest sources in its entirety; and possibly in that string of anecdotes the development of Christ's life and work may be traced with not less clearness than in the ampler and more artistic production of Luke.

The Additions and Peculiarities of Matthew.—The principal additions to the common tradition contributed by Matthew alone are the following:—

(1) i. 1–17, the genealogy of Jesus from David; (2) i. 18–25, the annunciation, and the dream of Joseph; (3) ii. 1–12, the adoration of the Magi; (4) ii. 13–23, the massacre of children in Bethlehem and the flight of the parents of Jesus to Egypt, together with their return to Nazareth; (5) iii. 13–17, the reluctance of John to baptize Jesus; (6) iv. 14–16, the fulfilment of the prophecy, "The people that sit in darkness," etc.; (7) v. 5–10, the six beatitudes on the sorrowing, the meek, the merciful, the pure in heart, the peace-makers, the persecuted; (8) v. 17–48, the new law is more exacting than the old law; (9) vi. 1–18, warnings against ostentation in almsgiving, prayer, and fasting; (10) vi. 34, "Sufficient for the day is the evil thereof;" (11) vii. 6, "Give not that which is holy to dogs," etc.; (12) vii. 13, 14, "Broad is the gate," etc.; (13) vii. 22, "In thy name have we cast out devils," etc.; (14) ix. 13 and xii. 7, the saying, "I will have mercy and not sacrifice;" (15) ix. 27–34, the cure of two blind men and of a deaf man;[1] (16) x. 5–8, "Go not into any city of the Samaritans," etc., instructions to the twelve; (17) x. 23, "But when they pursue you in this city, flee unto the other; for verily I say unto you, Ye shall not have gone over the cities of Israel until the Son of Man be come;" (18) x. 25, "The servant is not above his master," etc.; (19) xi. 28–30, "Come unto Me, all ye that are weary," etc.; (20) xii. 17–21, the prophecy of Isaiah, "Behold my servant," etc., is fulfilled in Jesus: (21) xii. 22, 23, the healing of one that was both dumb and blind; (22) xii. 33, "Either make the tree sound and the fruit sound, or," etc.; (23) xii. 36, 37, "Every idle word," etc.; (24) xii. 40, "As Jonas was in the whale's belly," etc.; (25) xiii. 14, 15, the fulfilment of a prophecy of Isaiah in the misunderstanding of Christ's teaching; (26) xiii. 24–30, the enemy and the tares; (27) xiii. 35, the fulfilment of prophecy in Christ's teaching by parables; (28) xiii. 36–43, the interpretation of the parable of the tares; (29) xiii. 44–50, "The kingdom of heaven is like (*a*) a treasure, (*b*) a merchant buying a pearl, (*c*) a net; (30) xiii. 51, 52, "Every disciple to bring forth things new and old," etc.; (31) xiv. 28–33, the attempt of Peter to walk upon the waves; (32) xv. 13, "Every plant that My heavenly Father hath not planted shall be rooted up," etc.; (33) xvi. 17–19, the blessing on Peter; (34) xvii. 24–27, the tribute money; (35) xviii. 3, 4, "If ye be not converted and become as little children, ye shall not enter," etc.; (36) xviii. 10, "Their angels do always behold," etc.; (37) xviii. 12–14, the parable of the hundred sheep (given by Luke in similar language); (38) xviii. 15–18, "Tell it to the church," etc., the course of procedure in case of quarrel; (39) xviii. 21, 22, the question of Peter, "How often shall my brother sin against me?" (40) xviii. 23–34, the parable of the unforgiving servant; (41) xix. 10–12, "There are some eunuchs," etc.; (42) xx. 1–15, the laborers in the vineyard; (43) xxi. 5, the fulfilment of the prophecy, "Behold thy King cometh," etc.; (44) xxi. 16, the fulfilment of the prophecy, "Out of the mouth of babes and sucklings," etc.; (45) xxi. 28–32, "I go" and "I go not;" (46) xxi. 43, "The kingdom of God shall be taken from you, and shall be given to a nation that bringeth forth the fruits thereof;" (47) xxii. 1–14, the parable of the despiteful and murderous guests (very dissimilar in Luke); (48) xxiii. 1–3, "The Scribes and Pharisees sit in Moses' seat," etc.; (49) xxiii. 7–12; *ib.*, 15–22, "Be not called Rabbi," etc., "He that sweareth by the altar," etc.; (50) xxv. 1–13, the parable of the ten virgins; (51) xxv. 14–28, the parable of the talents; (52) xxv. 31–46, the parable of the sheep and the goats; (53) xxvi. 51–54, "Put up thy sword," and "Thinkest thou not that I cannot now pray to My Father," etc.; (54) xxvii. 3–10, the fulfilment of the prophecy, "And they took the thirty pieces of silver," etc.; (55) xxvii. 19, "Have thou nothing to do with that just man," etc.; (56) xxvii. 24, 25, Pilate washing his hands; (57) xxvii. 52, 53, "And many bodies of them that slept arose," etc.; (58) xxvii. 62–66, the Jews seal the sepulchre; (59) xxviii. 2–5, the angel rolls the stone from the tomb of Jesus; (60) xxviii. 9–15, the women clasp the feet of the risen Jesus; the soldiers are bribed to say that the disciples stole away the body; (61) xxviii. 16–20, Jesus appears to the eleven disciples on a mountain in Galilee.

The preface (chaps. i. and ii.) reveals a part of the purpose of the whole Gospel, in tracing the genealogy of Jesus, not from David merely, who was under the law, but from Abraham, who was the receiver of the promise (Gal. iii. 16) and the father of the faithful (Gal. iii. 7). Such a genealogy is the fitting preface of a book which aims at exhibiting the law, not as trampled upon but as fulfilled and developed into a higher law of promise in which all the families of the world were to be blessed (Gen. xii. 3). But by this time also the church required some distinct affirmation concerning the divine origin of Jesus. The gap left in the opening of Mark's Gospel needed to be filled up. The mere earthly pedigree from Abraham was insufficient; nor did it suffice that Jesus should be declared to be spiritually the Son of God. It was necessary that the verity of the spiritual birth of Jesus from the Father should be embodied in a narrative so expressed as to be intelligible to all.

Additions peculiar to Matthew.

The differences between the prefaces of Matthew and Luke are obvious, and need no stress laid on them, except as illustrations of the freedom which, at this period, was allowed in the handling of the various introductions to the Gospel tradition. It is obvious, for example, that Luke regards Nazareth as the residence of Joseph and Mary from the first (i. 26; ii. 4), whereas Matthew seems to represent them as selecting Nazareth for their new home after the birth of Jesus and the return from Egypt, only because they were afraid to return to their old home in Judæa, thereby fulfilling an ancient prophecy (ii. 23). Throughout his preface, as throughout his version of the Triple Tradition, Matthew always bears in mind that Jesus came to fulfil the prophets as well as the law. The birth from a virgin (i. 25), the birth in Bethlehem (ii. 6), the return from Egypt (ii. 15), the massacre of the children in Bethlehem (ii. 18), and the residence in Nazareth (ii. 23) are all spoken of as the consequences of prophecies. It is scarcely fanciful, also, to see some reference to the infancy of Moses, and the slaughter of the Israelitish children by Pharaoh in the massacre of the children of Bethlehem by Herod.

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[1] Possibly these narratives may refer to events also described by Mark; but, as the language presents no similarity, they are placed here.

Passing next to Matthew's version of the Triple Tradition, we note first the prominence given to the law. Instead of giving a chronological account of our Lord's acts and sayings, Matthew prefers to collect a mass of doctrine into one continuous discourse, known from early times as the Sermon on the Mount. This discourse follows almost immediately (iv. 11; v. 1) on the commencement of his public life; and it contains the new law of the new kingdom. The Sermon on the Mount corresponds to the law given on Mount Sinai, and a thread of contrast runs through the former, comparing in each case that which had been said "of old time" with that which the New Lawgiver prescribed, and showing that in each case the new law, though more gentle, was also more stringent and more exacting than the old. "Depart from Me, ye workers of iniquity" (Lu. xiii. 27) is expressed by Matthew (vii. 23), "Depart from Me, ye that work lawlessness;" and this word "lawlessness" is found four times in Matthew, and not at all in the rest of the Gospels. Luke recognizes that no jot or tittle is to pass from the law till all be fulfilled; but nowhere in Luke shall we find the strong language which declares (Mat. v. 19) that he who breaks, or teaches others to break, one of the least of the commandments of the law shall be called least in the kingdom of God.

The genealogy traced from Abraham, and the stress laid on prophecy, as well as the prominence thus given to the law, all suggest that this book was primarily intended for Jewish readers; and this supposition is confirmed by the whole tenor of the Gospel. Matthew finds less space than Luke for the parables which point to the inclusion of the Gentiles, and more for those which point to the exclusion of the workers of lawlessness and of the unworthy Jews. He alone among the evangelists has the saying, "Many are called but few chosen;" and the distinction between the "called" (κλητοί) and "chosen" (ἐκλεκτοί) is the more remarkable, because Paul uses the two words almost indifferently, and Luke (though he too has the parable of the unworthy guests) has not ventured to use κλητοί in Matthew's disparaging signification. But Matthew, more than the rest of the evangelists, seems to move in evil days, and amid a race of backsliders, among dogs and swine who are unworthy of the pearls of truth, among the tares sown by the enemy, among fishermen who have to cast back again many of the fish caught in the net of the gospel; the broad way is ever in his mind, and the multitude of those that go thereby, and the guest without the wedding garment, and the foolish virgins, and the goats as well as the sheep, and those who even "cast out devils" in the name of the Lord, and yet are rejected by Him because they "work lawlessness." Where Luke speaks exultantly of "joy in heaven" over one repentant sinner, Matthew in more negative and sober phrases declares that it is not the will of the Father that one of the little ones should perish; and as a reason for not being distracted about the future it is alleged that "sufficient for the day is the evil thereof:" see above, (10), (11), (12), (13), (28), (29 *c*), (50), (52). It is far-fetched to suppose that these subjects are selected or amplified in antagonism to the doctrine of Paul. The condition of the Jews, their increasing hostility to the Christians, and the wavering or retrogression of many Jewish converts when the hostility became intensified shortly before and during the siege of Jerusalem,—this may well explain one side of Matthew's Gospel; and the other side (the condemnation of "lawlessness") might find an explanation in a reference to Hellenizing Jews, who (like some of the Corinthians) considered that the new law set them free from all restraint, and who, in casting aside every vestige of nationality, wished to cast aside morality as well. Viewed in the light of the approaching fall of Jerusalem, and the wavering or retrogression of great masses of the nation, the introduction into the Lord's Prayer of the words, "Deliver us from the evil," and the prediction (xxiv. 12) that "by reason of the multiplying of lawlessness the love of many shall wax cold," will seem not only appropriate, but typical of the character of the whole of the First Gospel.

Besides the fulfilments of prophecy mentioned in the preface, Matthew sees several others (6), (25), (43), (44), (54) which are not mentioned in the Triple Tradition, and these applications of prophecy sometimes contain obvious confusions. For example, Matthew sees in our Lord's entry into Jerusalem a fulfilment of the prophecy: "Thy king cometh . . . sitting upon an ass, and a colt the foal of an ass." The repetition seems to denote one animal, after the manner of Hebrew poetry, and only one is mentioned by Mark and Luke; but Matthew, applying prophecy more closely, speaks of two, and adds (xxi. 7) "they brought the ass and the foal and cast their clothes upon *them*, and he sat upon *them*." Again, in speaking of the "potter's field" (xxvii. 9), he quotes, as from Jeremiah, a prophecy that is really from Zechariah xi. 12 (the word translated "potter" is rendered by Ewald "treasury;" and [though Aquila has πλάστην] the LXX. has χωνευτήριον, "foundry," neither of which renderings will suit Matthew's application). Again, though Luke speaks of the "sign of Jonah," Matthew alone makes Jesus publicly declare that, as Jonah was three days and three nights in the belly of the whale (xii. 40), so he shall be three days and three nights in the heart of the earth; and such a declaration, exciting no questioning in the disciples, nor wonder in bystanders, appears in the highest degree improbable, and looks like a later application. It will be remembered that Matthew alone has the inaccurate statement that the murdered Zachariah was the son of Barachiah (xxiii. 35); and perhaps an inaccuracy resulting from a lapse of memory may explain, not only the use of the name of Jeremiah above, but also the quotation "He shall be called a Nazarene" (ii. 23), which is found in no existing book of prophecy. Similarly (perhaps) Mark, through lapse of memory on the part of those whose tradition he records, quotes (i. 2), as from Isaiah, according to the correct reading (the A. V. reads "prophets"), a prophecy composed of two passages, the first of which is from Malachi, and only the second from Isaiah. It must be remembered that, without the modern means for rapid reference, verification was a much harder task then than now, and much more trust was necessarily given to memory.

Few new miracles are introduced by Matthew into the body of his work (15), (21), (31), (34). Two of these consist of acts of healing; and two are connected with Peter, viz., Peter's partial success in walking upon the waves, and his (supposed) extraction of a stater from the mouth of a fish. But the words implying the latter miracle have possibly arisen from a misunderstanding; at all events they leave in the mind "a doubt whether, in this instance, some essential particular may not have been either omitted or left unexplained" (Farrar's *Life of Christ*, vol. ii. p. 46).

In its moral teaching this Gospel lays special stress upon the sin of religious ostentation and hypocrisy. In a strong passage (xii. 33) consistent undissembling wickedness is preferred to dissembled wickedness, and the Pharisees are described at greater length than in any of the other Gospels. Yet this Gospel does not always dwell upon the dark side of Christ's doctrine. It preserves also some of the Lord's most "comfortable" sayings: the blessings upon the meek and merciful; the saying that the angels of the little ones always behold the face of the Father; and above all that saying which is a gospel in itself, "Come unto Me, all ye that labor, and are heavy laden," etc. (xi. 28–30).

In speaking of the date of Matthew's Gospel, so far as it can be determined from internal evidence, we must remember that, if the work be composite, the fact that some of Matthew's additions are clearly late will not show that others may not be early. The saying, for example, that the disciples shall not have gone over the cities of Israel till the Son of Man shall have come (x. 23), seems to be an early and unaltered reminiscence of a saying of Jesus, which was not generally adopted in the tradition because of its recognized difficulty at a later date. It is possible that Matthew may consider the coming of the Son of Man fulfilled primarily in the transfiguration; for whereas in their prefaces to the transfiguration Mark and Luke write, "There are some standing here who shall not taste of death till they see the kingdom of God" (Mark adds "coming in power"), Matthew substitutes for "kingdom of God," etc., "the Son of Man coming in His kingdom." But, whatever may have been Matthew's theory, the difficulty of the utterance in Matt. x. 23 implies its early date. On the other hand, a decidedly late date seems implied in the expression "up to this day," which is twice found—once in the addition xxvii. 8 (the potter's field) and again in xxviii. 15 (the bribing of the guard by the chief priests). Yet these additions appear to be in the style of the writer both of the preface and the appendix, and of the other passages peculiar to Matthew.[1] It would follow that all these passages are of a late date, not added to the tradition till long after the death of Christ. The interval must have been long enough to allow, for example, the "potter's field"—and this argument holds whether the story of the potter's field (xxvii. 8) be historical or not—first, to acquire the name of the Field of Blood, and secondly, to retain that name for so long a period (nearly at least a generation) as to make it possible for a writer to speak of the acquisition of the name as a far distant fact, writing that the name is still borne, even "to this day." The same expression in xxviii. 15,—where it is said that the false charge against the disciples, of stealing the body of Jesus, is commonly reported "unto this day" by "the Jews,"—warrants the same inference; and this inference is corroborated by the remarkable use of "the Jews." The author of the Fourth Gospel, writing at a much later date, habitually speaks of "the Jews" as an alien race, quite separated from the Christians; but this is not in the manner of the synoptistic tradition.

The uncertainty in which Mark left the resurrection of Jesus would naturally seem to later writers to require to be removed; and accordingly we find that Matthew adds to the vision of angels (two instead of one) a manifestation of Jesus Himself. But the whole of this narrative (xxviii. 9–20), though apparently in Matthew's style (*cf.*, for example, the remarkable use of *οἱ δέ*, without the *οἱ μέν*, in the sense of "others," in xxviii. 17 with that in xxvi. 67), and though containing internal evidence of being composed long after the events narrated (xxviii. 15), is nevertheless strangely disjointed. Yet its very defects, its disconnectedness, incompleteness, and abruptness, indicate a date earlier than that of the more connected and completer narratives of the Third and Fourth Gospels. Matthew separates from Mark's narrative at the departure of the women from the tomb, having previously given an account (repeated by no other evangelist) of the resurrection from the dead of a great number of "saints," who "went into the holy city and appeared unto many." To Mark's simple statement that the women "found the stone rolled away" Matthew adds a graphic account of a glorious angel visibly descending from heaven, filling the keepers with fear, and rolling the stone away. Then, immediately after the women have departed with the angelic message, to bid the disciples to go to Galilee, Jesus suddenly appears to them. They clasp His feet, while He repeats over again the message that the disciples must go to Galilee there to behold Him. Without any further mention of the place of meeting, the disciples are said to have gone to "*the* mountain, where Jesus made agreement (*ἐτάξατο*) with them (to meet them)." To avoid this dislocation, there has been suggested the desperate remedy (Weiss, *Matthäusevangelium*, p, 582) of rendering *ἐτάξατο*, "laid down the law," with reference to the Sermon on the Mount; but the probable solution is that Matthew here extracts and separates from its context some ancient tradition which is obscured through want of its framework.[2] Again Matthew tells us that, upon this mountain, only the eleven were present, and that while some of them worshipped, others "doubted." This statement is of value as evidence that it was acknowledged, even so late as the compilation of Matthew's Gospel, that some at least of the manifestations of Jesus were of such a nature that, while they brought immediate conviction to some beholders, they did not at once convince others, even of His nearest disciples; in other words, the manifestation of Jesus depended upon other considerations than the mere physical sense of sight. But, on the other hand, the statement seems quite inconsistent with the supposition that in previous manifestations in or near Jerusalem Jesus had been recognized and worshipped by all the eleven. The last words of the Gospel represent Jesus as commissioning His disciples to go into all nations, preaching His gospel, and baptizing in the name of the Father, the Son, and the Holy Ghost. The thought contained in these words furnishes a suitable termination to the Gospel; but there is every probability that we have not here the exact words of Jesus Himself. Not to speak of the introduction of the later baptismal formulary, "in the name of the Father, the Son, and the Holy Ghost," the rest of the vocabulary is not found in the words of Jesus as recorded in the Triple Tradition, but is peculiar to Matthew. For example, (1) the word *μαθητεύειν* (xxviii. 19) is used three times by Matthew, and nowhere else in the New Testament, except once in the Acts; (2) the expression *συντελείας τοῦ αἰῶνος* (xxviii. 20) is found five times in Matthew, and nowhere else in the New Testament, except once in the Epistle to the Hebrews; and (3) the word *τηρεῖν* (xxviii. 20), used by Matthew six times, is used once only by Mark, and not at all by Luke.

It is noteworthy that Matthew makes no express mention of the ascension of Jesus. But it is possible that he considers this final manifestation on the mountain-top to have terminated with the ascension; for Matthew, describing the farewell of Jesus, appears to have in his mind the picture, contemplated also by Daniel, of the Son of Man endowed with all power and seated on the clouds of heaven. Compare Daniel vii. 14, "*ἐδόθη αὐτῷ ἐξουσία*," with Matthew xxviii. 18, "*ἐδόθη μοι πᾶσα ἐξουσία*." And this perhaps may explain the twice repeated saying of Matthew, that some of the disciples should see the Son of Man coming. The manifestation of Jesus upon the mountain in Galilee, commissioning His disciples to go forth to make disciples of all the world, and claiming all kingdoms for Himself, might well seem a fulfilment of these two prophecies (x. 23; xvi. 28), as well as a fitting close to the book of the Gospel.

Additions peculiar to Luke.

Additions and Peculiarities of Luke.—The principal passages peculiar to Luke are;—

(1) i. 1–4, the dedication to Theophilus; (2) i. 5–25, the vision of Zacharias; (3) i. 26–38, the annunciation; (4) i. 39–45, the meeting of Elisabeth and Mary; (5) i. 46–56, the song of Mary; (6) i. 57–80, the naming of John and the song of Zacharias; (7) ii. 1–7, the journey of Mary to Bethlehem; (8) ii. 8–20, the vision of the shepherds; (9) ii. 21–35, the song of Simeon; (10) ii. 36–40, the prophetess Anna; (11) ii. 41–52, the child Jesus found in the temple; (12) iii. 1, the precise date of the commencement of the public life of Jesus; (13) iii. 5–16 (except vers. 8 and 9), the teaching of John the Baptist; (14) iii. 18–20, Herod imprisons John; (15) iii. 23–38, the genealogy of Jesus from Adam; (16) iv. 13, the devil departs from Jesus "for a season;" (17) iv. 14–30, Jesus preaches at Nazareth; (18) v. 1–11, the miraculous draught of fish and the call of Simon; (19) v. 17, preface to the healing of the paralytic; (20) v. 39, "No one having drunk old wine desireth new," etc.; (21) vi. 12–13, preface to the choice of the apostles; (22) vi. 24–26, "Woe unto you that are rich," etc.; (23) vi. 32–35, "Love your enemies," etc. (in language peculiar to Luke); (24) vii. 1–10, the healing of the centurion's servant (in language peculiar to Luke); (25) vii. 11–17, the raising of the widow's son at Nain; (26) vii. 21,

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[1] Want of space renders it impossible to state the grounds on which it seems probable that Matthew consists only of (1) the Triple Tradition; (2) extracts from a book or tradition of the words of the Lord from which Luke also borrowed; and (3) an introduction, framework, and appendix, all added by one hand; though possibly the introduction and appendix, being borrowed, the former from an Aramaic source, the latter from a Latin source, may show differences of idiom not wholly concealed by the overlying style of the author who works up the materials. A similar use of the particles *δέ* and *καί* and of participles, runs throughout almost all the non-traditional narrative parts of Matthew; and the rhythm of the sentences is very similar. But the linguistic evidence has not as yet been so selected, classified, and concentrated as to obtain any certain results. And until this is done, inferences drawn from isolated phenomena are likely to be very misleading. For example, it has been inferred (Weiss, *Matthäusevangelium*, p. 502) that the use of the form Ἱερουσαλήμ once only in Matthew (xxiii. 37, in a passage almost identical with Lu. xiii. 34, whereas Matthew uses Ἱεροσόλυμα eleven times) proves that Matthew borrowed the passage in which it occurs from an Aramaic source. Now it is true that other reasons make the hypothesis of an Aramaic source for the identical passages in Matthew and Luke extremely probable; but this use of Ἱερουσαλήμ is quite insufficient proof. For a comparison of Paul's use of Ἱεροσόλυμα (Gal. i. 17, 18; ii. 1) and Ἱερουσαλήμ (Gal. iv. 25, 26) will show that the same author might use the one form geographically and the other in a higher style, theologically or rhetorically. And this may possibly be held to explain the use of Ἱερουσαλήμ by Matthew in the highly rhetorical passage in which alone it is found.

[2] In a somewhat similar manner the author of the Second Epistle of Peter speaks of "*the* holy mount" (2 Pet. i. 18), assuming that his readers would understand the definite reference to the mountain of the transfiguration.

22, the acts of healing wrought before John's disciples; (27) vii. 36–50, the sinful woman and the parable of the two debtors; (28) viii. 1–3, the names of the women who accompanied Jesus; (29) ix. 51–56, James and John wish to call down fire on the Samaritans; (30) ix. 61, 62, "No one having put his hand to the plough," etc.; (31) x. 1, the appointment of the seventy; (32) x. 17–20, "I beheld Satan as lightning," etc.; (33) x. 25–37, the good Samaritan; (34) x. 38–42, Martha and Mary; (35) xi. 1, "Teach us to pray," etc.; (36) xi. 6–8, the friend persuaded by importunity; (37) xii. 13–21, the rich fool; (38) xi. 21, 22, "When the strong man armed," etc.; (39) xi. 27, 28, "Blessed is the womb that bare Thee," etc.; (40) xii. 32, 33, "Fear not, little flock," etc.; (41) xii. 35–38, "Let your loins be girded about," etc.; (42) xii. 47, 48, "But that servant that knew not his lord's will," etc.; (43) xii. 49, 50, "I came to send fire on earth," etc.; (44) xii. 54–57, "When ye see a cloud rising," etc.; (45) xiii. 1–9, the Galileans slain by Pilate, and the parable of the fig-tree; (46) xiii. 10–17, the healing of the woman bound by Satan; (47) xiii. 23–27, "Are there few that be saved?" and the answer; (48) xiii. 31–34, "Go tell that fox," etc.; (49) xiv. 1–6, the healing of the dropsical man on the sabbath; (50) xiv. 7–11, "Sit not down in the highest room," etc.; (51) xiv. 12–14, "When thou makest a dinner," etc.; (52) xiv. 15–24, the discourteous guests; (53) xiv. 28–33, "Which of you intending to build a tower," etc.; (54) xv. 1–10, the lost sheep (different in Matthew), and the lost piece of silver; (55) xv. 11–32, the prodigal son; (56) xvi. 1–12, the unjust steward; (57) xvi. 14–31, Dives and Lazarus, with preface; (58) xvii. 7–10, the master must be served before the servant; (59) xvii. 11–19, the grateful Samaritan; (60) xvii. 20–22, "The kingdom of God cometh not with observation," etc.; (61) xvii. 28–30, "It shall be as in the days of Lot," etc.; (62) xviii. 1–8, the unjust judge; (63) xviii. 9–14, the Pharisee and the publican; (64) xix. 1–10, Zacchæus; (65) xix. 11–27, the parable of the pounds (different in Matthew); (66) xix. 39–44, "If thou hadst known even thou," etc.; (67) xx. 18, "Whosoever shall fall upon that stone shall be broken,"[1] etc.; (68) xxi. 18, "There shall not an hair of your head perish;" (69) xxi. 23–26, "There shall be great distress in the land," etc.; (70) xxi. 28, "And when these things begin to come to pass, then look up," etc.; (71) xxi. 34–38, "But take heed to yourselves lest at any time your hearts be overcharged with surfeiting," etc.; (72) xxii. 14–16, with parts of 17 and 19, "With desire have I desired to eat this passover with you," etc.; (73) xxii. 31–34, "Simon, Simon, behold Satan hath desired to have you," etc.; (74) xxii. 35–38, "When I sent you without purse," etc.; (75)[2] xxii. 43, 44, the angel strengthening Jesus; (76) xxii. 48, 49, "Betrayest thou the Son of Man with a kiss?" (77) xxii. 51, the healing of the wound of the high priest's servant; (78) xxiii. 5–12, Jesus is sent by Pilate to Herod; (79) xxiii. 13–15, Pilate proposes to release Jesus; (80) xxiii. 27–31, "Daughters of Jerusalem, weep not for Me," etc.; (81) xxiii. 39–43, the penitent thief; (82) xxiii. 48, 49, the crowd beat their breasts and return; (83)[3] xxiv. 12, Peter sees the linen clothes in the open tomb; (84) xxiv. 13–35, the walk to Emmaus; (85) xxiv. 36–49, Jesus appears and eats in the presence of His disciples; (86) xxiv. 50–53, Jesus parts from the disciples near Bethany,[4] and they return to the temple.

Before speaking in detail of the passages peculiar to Luke, it will be convenient to consider his avowed purpose in writing, and some peculiarities of his style. The dedication to Theophilus, a name which is now believed by many to be merely typical of every reader who is so far "loved of God" as to be admitted into the church of Christ, states that the author purposes to write an account "in order," and implies that many previous[5] "attempts" (*ἐπεχείρησαν*, a word implying impotence; *cf.* Acts ix. 2, 9; xix. 13) at similar compilations had not been "in order;" further it informs us that the object of the treatise was not to tell the reader anything that was new, but rather to give him an ampler knowledge of the certainty of those things which were then and always had been fully believed in the church, even as they had been handed down by those who had been from the beginning eye-witnesses and ministers of the word. Without going so far as to affirm that the word handed down (*παρέδοσαν*) excludes written tradition (Westcott's *Introduction*, 186, 203), it is at least remarkable that Luke distinguishes between the "eyewitnesses" and those whose attempts he disapproved,—saying that the latter attempted to draw up a "connected narrative," whereas the former merely "handed down" the facts. This amounts almost to a denial on the part of Luke that any "eyewitness" (that is to say, apostle) had up to that time written any narrative (so far as Luke knew) of the life of Christ. It implies also that the words and deeds of the Lord had been recorded by many without arrangement, and that the author purposed to arrange them. The literary and artistic purpose of the author appears in words and phrases, as well as in the conceptions. Writing perhaps principally for readers to whom the Greek of the original tradition would be in many respects distasteful, he substitutes more classical words for many that are used by Matthew and Mark in the Triple Tradition (see above, p. 708). Even the use of "sea" to denote the Lake of Gennesareth, is objectionable to him, and he always substitutes "lake." The Latinism *κοδράντης* for farthing (Mat. v. 26; Mk. xii. 42) is altered or omitted by Luke. He prefers *πορεύομαι* to *ὑπάγω*. Versed as he is, and as his readers would be, in the metamorphoses of the heathen stories, he shrinks from applying the word "metamorphosed" (Mat. xvii. 2; Mk. ix. 2) to the transfiguration of Jesus, and substitutes (ix. 29) "became different." He dislikes repetitions also, as much as he dislikes low-class words: compare v. 32, 33; vi. 10; viii. 21, 15, with the corresponding passages in Matthew and Mark; and note especially, in the cure of the palsied man (Mat. ix.; Mk. ii.; Lu. v.) how Luke not only avoids the word *κράββατος*, for "bed" (noted by Phrynichus as objectionable, Lobeck, p. 62), but also, to avoid repetition, uses three substitutes in succession,—(v. 18) *κλίνης*, (v. 19 and 24) *κλινιδίῳ*, (v. 25) *ἐφ' ᾧ* (or *ὃ*) *κατέκειτο*, where Mark is content to use the objectionable *κράββατος* four times. When writing in his own style he is fond of long and sonorous words, such as *διάδος* for *δός* (Mat. xix. 21; Mk. x. 21; Lu. xviii. 22), *διαμερίζομαι*, *διαγογγύζειν*, and the compounds of *διά* generally; compare also his use of *περιποιοῦμαι* (xvii. 33, correct text), and of *ζωογονεῖν* (*ib.*) for *σώζειν*.

The style of Luke.

The question of Luke's style is specially important because the striking differences between certain portions of his Gospel which are all, though in very different styles, found in his Gospel alone (occurring neither in the Triple Tradition, nor in the parts which Luke has in common with Matthew or in common with Mark), might naturally induce even a careful student to believe that they are composed by different authors. For example, take as a criterion the use of *καί* and *δέ*. In classical Greek, and indeed in almost every Greek except the ultra-Hebraic, the particle *δέ* is of constant occurrence. The fact that it does not occur more than six or seven times in the whole of the Apocalypse, and not at all in the first book of the Maccabees till chap. iii. 36, would naturally lead us readily to believe that the former was written by a Jew who knew little of Greek literature, and that Jerome was right in saying that the latter is a translation from a Hebrew original. Applying this test to Luke, we find that in the 80 verses of Luke's first chapter, it occurs 16 times, while in the 19 verses of x. 25–42, it occurs 16 times; or in other words, *δέ* is (proportionately) used more than four times as often in the ninth chapter as in the first. This suggests the inference that Luke's introduction has an Aramaic origin. But if we turn to the Acts we find that in the first chapter, containing 26 verses (or 19 verses of narrative and 7 of a speech), *δέ* occurs only twice; whereas in the ninth chapter, which contains 43 verses, *δέ* occurs 35 times. Yet an Aramaic origin has not been thought, by any consensus of competent authorities, necessary or probable foi the first chapter in the Acts.

Although, therefore, it is possible that the first two chapters of Luke may be a direct translation from an Aramaic original, yet there is an alternative. The alternative is that Luke, a man of letters and skilled in composition, consciously or unconsciously adapted his style to the subject, feeling that a different style was required on the one hand by the Magnificat and the Nunc Dimittis, and on the other hand by the graceful domestic narrative of the contrast between the sisters Martha and Mary.

This will be made all the more probable if it can be shown that Luke had studied and imitated the LXX., and in particular the Greek Apocrypha. Words not used (or seldom) by Matthew and Mark, but by Luke and the Apocryphal writers, are ἐπίβλεψον, ἀποσπασθέντων, ἐπιβάλλει in the sense of "belonging," ἐπισιτισμός, the use of ὕψιστος for God, στιγμή, ἀντιβάλλειν, εὔθετος, περισπᾶσθαι, καιρὸς ἐπισκοπῆς, δοχή, and λυσιτελεῖ. But far more striking than mere words (for Matthew and Mark might be shown to have some peculiar words in common with the Apocrypha) are the sentences in the Apocrypha which seem to have suggested similar sentences in Luke. For example, compare Luke's story of the rich fool (xii. 19) with the following passage from Sirach (xi. 18): "There is one that gathereth wealth from his overheed and pinching; and this is the lot of his reward. In the hour when he sayeth, I have found rest, and now let me eat of my good things, even then he knoweth not what season shall pass away, and he shall leave these things unto others and shall perish." Again, in the parable of the unjust judge, there is a striking similarity between the words (xviii. 8), "Though he bear long with them (μακροθυμεῖ), I tell you He will avenge them speedily," and (Sirach xxii. 22), "And He will surely not delay; nor will He bear long (μακροθυμήσει) with them;" so also between, (i. 42) "Blessed art thou among women," and (Judith, xiii. 17) "Blessed art thou, O daughter, by the Most High God, above all the women that are in the earth;" and between (vi. 35) "Love ye your enemies . . . and ye shall be the children of the Highest," and (Sirach iv. 10), "Be as a father unto the fatherless . . . and thou shalt be as the son of the Highest." Occasional similarities of thought and even of words are found between Matthew and Mark and the LXX. Apocrypha; but it cannot be said of either of them, as it can of the Third Gospel, that it is saturated with the LXX. diction. In many cases there is an allusive use of LXX. words. For example, Luke (xxiii. 51), telling us that Joseph of Arimathæa had not "consented to" the wicked decision of the Pharisees against Jesus, uses a word not elsewhere used in the whole of the New Testament. Why? Because the word is used by the LXX. (Exod. xxiii. 1) in a passage expressly prohibiting combinations for false judgment: "Thou shalt not *consent with* (συγκαταθήσῃ) the unjust to become an unjust witness; thou shalt not be with the stronger side to do ill; thou shalt not add thyself with the multitude to shut out judgment." Again, when Luke (xxiii. 49), telling how the "acquaintances" of Jesus stood at a distance from the cross, used the word "γνωστοί"—not elsewhere found in the synoptists,—there can be little doubt that he has in his mind the passage from the LXX. (Ps. lxxvii. 9), "Thou hast put mine acquaintances (γνωστούς) far from me." Compare also the use of ἐγκαθέτους, only found once in Luke (xx. 20), with the use of the word in the LXX. (twice only) Job xix. 12; xxxi. 9. See also a similarity implied between the aged Abraham and Sarah on the one hand, and Zacharias and Elizabeth on the other, in the similarity between "προβεβηκότες ἡμερῶν (Gen. xvii. 11), and προβεβηκότες ἐν ταῖς ἡμέραις" (Lu. i. 7).

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[1] But possibly this passage is also found in Matt. xxi. 44.

[2] The genuineness of this passage is doubtful.

[3] The genuineness of this passage is doubtful.

[4] The clause describing the ascension is omitted by Tischendorf.

[5] It is very doubtful whether the aorist tense (*ἐπεχείρησαν*) necessarily implies (Westcott, *Gospels*, p. 186) that "St. Luke speaks of the 'attempts' as of something which had no influence at the present . . . (*attempted*, not *have attempted*)." In the New Testament the proper distinction between the aorist and perfect cannot always be maintained as it can in classical Greek. For example (Mk. xiv. 9), our A. V. rightly renders *ἐποίησεν*, "she *hath done* what she could:" and it would seem absurd to say that the aorist *ἐποίησεν* represented an action "which had no influence at the present," in the face of the following words, "Throughout the whole world this also that she *hath done* (*ὃ ἐποίησεν*) shall be spoken of for a memorial of her."

Our conclusion must be (1) that as Luke has modified the Triple Tradition, and the words of the Lord common to himself and Matthew, by alterations of words and phrases, so and much more has he modified other traditions or documents which he has introduced into his work; and (2) that those portions of the part of the Gospel peculiar to himself which have a more archaic and Judaic rhythm and vocabulary than the rest may be either translations from Aramaic documents, or imitations, conscious or unconscious, of the books of the LXX.,—natural adaptations of the style to the subject, like the language of Shakespeare's *Julius Cæsar* as compared with the less simple and dignified language in his English plays of the same date. It is probable, however, that when the evidence is more thoroughly classified than it has hitherto been, it may at least demonstrate the existence of different documents in Luke, whether translations or not.

Impossible though it is here even to summarize the evidence, we may give the reader a conception of the nature of it. Attention has been called above to the use of the form ὁ Κύριος, "the Lord," in narration, as being an indication of late authorship. But this form occurs several times in the body of Luke's Gospel: namely, in the passages containing the raising of the widow's son at Nain (vii. 13); the appointment of the seventy (x. 1); the rebuke of the Pharisees (xi. 39); the preface to the parable of the faithful and just steward (xii. 42); the healing of the daughter of Abraham bound by Satan (xiii. 15); the parable of the sycamore tree (xvii. 5, 6); the parable of the unjust judge (xviii. 6); the story of Zacchæus (xix. 8); warning to Simon Peter (xxii. 31); Christ's look (xxii. 61); and the verse where it is said that they found not the body of the Lord Jesus (xxiv. 3). Many of the above passages certainly show signs of translation; and when we remember that the Gospel of the Hebrews (see below, p. 727) always uses the form ὁ Κύριος, and never ὁ Ἰησοῦς, we see herein a confirmation of the theory that these passages in Luke are translations from Aramaic. Another testing word is Ἱερουσαλήμ. Luke uses Ἱερουσαλήμ about twenty-six times, Ἱεροσόλυμα only three times (ii. 22; xix. 28; xxiii. 7). It has been shown above that the latter form is sometimes used geographically by writers who use the former rhetorically or historically; but it is certainly remarkable that in ii. 22 and 41 the two forms should be used, apparently in the same sense, ἀνήγαγον αὐτὸν εἰς Ἱεροσόλυμα and ἐπορεύοντο . . . εἰς Ἱερουσαλήμ. Many other test words might be mentioned, the converging evidence of which, added to the internal evidence of thought (and perhaps corroborated by the evidence of special forms, *e. g.*, ἦλθαν for ἦλθον), may possibly hereafter enable future critics to distinguish with certainty between the different strata of Luke's narrative. But no certainty is possible in the present condition of the evidence. There has been abundant labor but insufficient classification of evidence, and no attempt at all to represent it in a concentrated form.

Peculiarities of Luke's Gospel.

Passing now to the consideration of Luke's additional subject matter, and reserving the supernatural element to the last, we will speak first of the doctrine. The key-note is struck in the song of Zacharias, and repeated in the first sermon of Jesus in Nazareth. The object of the messenger of Jesus is (i. 77) "to give us knowledge of salvation" by "the remission of sins," by reason of "the tender mercy of our God, whereby the dayspring from on high hath visited us to give light to them that sit in darkness;" and the object of Jesus Himself (iv. 18) is "to preach the gospel to the poor," to "heal the broken-hearted, to preach deliverance to the captives, and recovering of sight to the blind." All through the Gospel (or at least the parts peculiar to Luke) there appears to a greater degree than in the First or Second Gospel the contrast between light and darkness, God and Satan, sin and remission of sins, culminating in the triumph of forgiveness and mercy; so that in the very last words of Jesus to His disciples (xxiv. 47) the proclamation of "repentance and remission of sins" is made the prospect of the future gospel to all nations.

The law of Moses appears at first sight inconsistently magnified, almost in an Ebionitic spirit, throughout the first two introductory chapters of the Gospel, and afterwards put aside. But there is no inconsistency. Paul himself says that the Saviour placed Himself at His birth "under the law," and hence it is that Luke, with an almost anxious elaboration, details the exact fulfilments of the law not only by the parents of Jesus, but also by those of His messenger. Hence also it is that in a single chapter of the introduction the word "law" occurs more often than in all the rest of the Gospel put together. For when Jesus attained to manhood, He was no longer under the bondage of the old law, which had now attained its fulfilment in the new law of the remission of sins through love. Yet the law is not trampled on, but only superseded by development; it was only "until John;" yet not "one tittle" of it can fail (xvi. 16, 17).[1] True to its principle of contrast, this book gives Satan a prominent position. When Satan departs from Jesus, he departs only "for a time" (iv. 13); Satan causes diseases and binds a daughter of Abraham;[2] Satan is beheld by Jesus in a vision cast down from heaven; he enters into Judas (xxii. 3, not mentioned by Matthew or Mark); he demands the Twelve that he may "sift" them; see above (16), (32), (46), (73). But this need not denote (as is thought by Keim) an Ebionitic source; the same recognition of the ἐξουσία τοῦ σκότους appears in the Acts and the Epistles to the Ephesians and Colossians, which no one suspects of Ebionitic tendencies (Lu. xxii. 53; Acts xxvi. 18; Eph. ii. 2; vi. 12; Col. i. 13). Something more than the principle of contrast, may, however, be required to explain the sharp demarcation between rich and poor. We do not find in Luke that qualification of the epithet "poor" which Matthew (v. 3) inserts, "the poor in spirit." He enforces the hampering disadvantages of wealth, pronouncing a woe upon them that are rich; gently rebukes the "cumbered" Martha; exhorts the rich to entertain the poor; and dooms the rich fool to a sudden and disappointing death, while Dives is consigned to unalterable torment,—(21), (34), (46), (51), (57). But if this seems to savor of Ebionitic thought, let it be remembered that the principle of contrast is even more systematically applied to illustrate the power of the genuine Pauline faith in the parables of forgiveness. As Lazarus is contrasted with Dives, and the grateful Samaritan with the ungrateful Jewish lepers, and the merciful Samaritan with the heartless priest and Levite, and even the trivial anxieties of Martha with the simple devotion of Mary,—so in the stories of forgiveness, the publican finds his foil in the Pharisee who prays by his side; the woman "which was a sinner," and who "loved much," contrasts with Simon, the churlish host, who loved little; the prodigal younger son with the envious elder son; and the penitent thief on the right with the impenitent thief on the left. All these stories, as well as the tale of Zacchæus, and the lost piece of silver, and the lost sheep (peculiar to Luke in language, though the same subject is found in Matthew), magnify the power of forgiveness, and repentance, and faith, for the most part "without works"—contrasting the instantaneous and complete victories of emotional faith with the inferior results of a long life of ordinary and prudent respectability,—(27), (54), (55), (81), (66), (64).

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[1] Compare the strong language of Luke xvi. 16, and the contrast there between the "law" and the "kingdom," with the similar but much weaker language in Matt. xi. 12, 13, where the contrast is almost lost.

[2] Note that Luke alone in the description of the cure of Simon's mother-in-law (iv. 39) tells us that Jesus rebuked the fever.

The universality of the Gospel is more marked in Luke than in Matthew or Mark. The seventy missionaries appear to be emblematic of the preaching of the gospel to the seventy (or seventy-two, see Westcott's *Introduction*, p. 374) nations of the earth. The preference of the Gentiles to the Jews would seem to be indicated at the very outset of the public life of Jesus in the sermon at Nazareth (iv. 16–30), if we could accept this as chronologically and historically accurate. Besides the statement of Jesus in the Triple Tradition, that his kinsmen were those that heard the word of God and did it (Luke prefers this expression to that of Matthew and Mark, "doing the will of God"), Luke gives us another assurance that God's special blessing is reserved, not for the mother of the Saviour, but for those who do the word of God. The inclusiveness of the author breaks down the barrier between Jesus and the Samaritans; the sons of Zebedee are rebuked for desiring to call down fire on a Samaritan village; a just Samaritan shames both priest and Levite; and a grateful Samaritan puts nine Jewish lepers to the blush,—see (31), (17), (39), (29), (33), (59).

In connection with this, the gentler and more inclusive side of the gospel teaching, it may be mentioned that Luke lays especial stress on the part played by women alike in discerning the providence of God, in ministering to Jesus, and in eliciting some of his most helpful utterances. The songs of Mary and of Elisabeth, and the testimony of the prophetess Anna, are found nowhere but in the Third Gospel; in Luke, for the first time, the mother of the Lord begins to assume a wider province,—she it is, and not Joseph, that ponders in her heart the words of her divine Son, and her sufferings are made the subject of inspired prophecy (ii. 35). Luke alone thinks it worth while to record at some length the names of those women who accompanied Jesus and contributed to His support; he alone knows of the devoted faith of Mary and the domestic anxieties of Martha; he alone records the cure of the afflicted "daughter of Abraham," the truth-eliciting exclamation of the woman who invoked a blessing upon the womb that bare Him, the story of the woman who "loved much," and the parable of the woman rejoicing over the lost piece of silver. Luke alone holds up the fate of Lot's wife as a warning; nor do we find in any other Gospel the touching utterance of Jesus to the weeping "daughters of Jerusalem." The other synoptists concur with Luke in pronouncing a blessing on the man who gives up father or mother or lands or houses for Christ's sake, and the sense of fitness has induced the scribes of several MSS. to insert in Matthew and Mark the word "wife" as well as "mother;" but it has no legitimate place except in the version of Luke. It is true indeed that Luke, so far from giving to women the prominent part assigned to them by Matthew and the interpolated Mark, and even by the Fourth Gospel, in attesting the resurrection of Jesus, carefully places their evidence in the background; but the evidence of impressionable witnesses might naturally be subordinated by a writer (perhaps a physician too) who was collecting the traditions of the church into an historical narrative. In any case, it is noteworthy that the word "woman" occurs in Luke almost as many times as in Matthew and Mark put together.

Probably the most perplexing part of Luke's doctrine is found in the parables of the unjust steward, the unjust judge, and the friend persuaded by importunity. In the last two of these the argument appears to be—"If an unjust or indolent man can be goaded by importunity into granting requests, much more will assiduous prayer prevail with the Father in heaven;" in the first, "If the fraudulent show forethought in providing for their earthly future, much more should the children of light show forethought for their eternal future." Although it is quite possible that our Lord drew a contrast (with something of irony) between the single-mindedness of earthly ambition and the scattered energies of those whose aim is righteousness, yet it is difficult to believe that He uttered these parables in their present shape, or that they are entirely free from misunderstanding. The last two of these three parables (as they stand) seem at variance with his teaching in prayer, which bids us remember that the Father knoweth what things we need before we ask them; and the right moral to be drawn from the unjust judge would seem to be, "Although the unjust judge may be won by importunity, do not suppose that importunity can prevail with the just Judge." It is to be observed, however, that the language and style of these parables (differing from that of the Triple Tradition) make it somewhat improbable that we have here in Luke's narrative the exact words of Jesus; see (36), (56), (62). As regards the great day and the coming of the Lord, Luke appears to distinguish (more than Matthew and Mark) between the ultimate coming and the fall of Jerusalem, which was to precede it. As Luke distributes the discourses which Matthew connects with the twelve into two parts—one connected with the twelve and the other with the seventy—so he distributes the discourse on the coming (which Matthew reports as one continuous discourse uttered at Jerusalem) into two parts—one uttered at Jerusalem, and dealing principally with the fall of Jerusalem (xxi. 6–38), the other uttered on the way to Jerusalem, and expressed in more general terms (xvii. 20–37). As a preparation for the coming, Luke lays stress on constancy and directness of purpose. No man who puts his hand on the plough must look back (30); better not to begin the tower than leave the tower unfinished (53); remember Lot's wife (61). The coming is spoken of as possible at any moment—suddenly and without observation (60); and the disciples are exhorted to wait as servants for their master, with their loins girded (41 and 42), avoiding surfeit and drunkenness (71). When the master or king returns, ignorant disobedience will be less severely punished than the disobedience of knowledge (42); and those who have not increased the "mina" or pound intrusted to them, will be less severely punished than the rebels (65), who will be slain.

Luke (like Matthew and Mark) predicts a time of trouble; but he sees somewhat clearly, beyond it, the dawn which is to precede the rise of the kingdom. Destruction falls, not by chance, but on all that do not repent (45); all must strive to enter the strait gate (47), for not those that were first called shall enter in (52). Much more clearly than in Matthew and in Mark is the future fall of Jerusalem described, as the result of a *siege* and capture; and the slaughter of the citizens, the scattering of the nation, and trampling down of the city are mentioned, with details for which we vainly look in the first two Gospels (59). It is not concealed that the disciples have much tribulation in store, and that they must use all prudence to protect themselves (74). But a term is set for all these troubles; Luke (omitting the remarkable saying of Matthew and Mark that the Son Himself knoweth not "the hour") declares that the trampling down of Jerusalem will be only till "the times of the Gentiles are fulfilled." Then will come a time of "distress," not, however, now for Israel but for the Gentiles (69); and amidst convulsions of nature the Son of Man will come. In the hope of this coming, the disciples are to lift up their heads (70), remembering that not a hair of their heads will be injured (68). Certainly the comparatively cheerful tone of the discourse on the coming, combined with the joyful and triumphant tone of the first two chapters of Luke's Gospel, indicates an author writing at a time when the fall of Jerusalem was an accepted fact, and the establishment of a new and spiritual Jerusalem recognized as a sufficient consolation—a time when the church, not yet troubled by systematic persecution or by serious desertion (Keim, *Jesus of Nazara*, Engl. ed., vol. i. p. 96), was still sanguinely looking forward to the moment when the times of the Gentiles should be fulfilled, and the Son of Man should suddenly come.

The supernatural narratives peculiar to Luke, and found in the main body of his treatise, are the miraculous draught of fishes, the raising of the widow's son at Nain, the healing of the woman bound by Satan, the cure of the dropsical man, and the appearance of the angel strengthening Jesus—(18), (25), (46), (49), (75). The first two suggest to many minds a symbolical interpretation, and raise the question whether they (and possibly some of the other miracles) may be emblematical rather than historical. This question cannot suitably be discussed in these pages; but one or two observations may be made. That Jesus wrought instantantaneous cures cannot be contradicted, being proved by the whole texture of the Triple Tradition, as well as by the indirect testimony of Paul. That He also had the power of raising the dead no Jew could well doubt or dispute. Elijah had raised a child from the dead; still more notably Elisha, even when dead himself; some (interpreting the prophet literally) said that Ezekiel (Ez. xxxvii. 7) had done the same. But whatever the inferior prophets had done He who was at once *the* Prophet and Messiah could not fail to do. Still less could heathen converts suppose that Jesus was inferior in power to Æsculapius. It was therefore certain that, whether the traditions and books of the church contained or omitted any record of a raising from the dead, the church would believe from the first that Jesus possessed and employed this power. Different readers will give different weight to the considerations for and against the authenticity of Luke's narrative of the raising of the widow's son. Many will be so far influenced by the extreme beauty of the story (and perhaps by the fact that the custom of early burial among the Jews might reduce this, like the case of Jairus's daughter, to the level of natural though marvellous events) as to believe that in it we have, not legend, but history; but no one who can weigh evidence at all will maintain that the evidence for this miracle is equal to the evidence for the raising of Jairus's daughter. Luke's other principal miracle, the draught of fishes, is also considered by many to have arisen from metaphor misunderstood. It is connected by Luke with the calling of Simon Peter, an incident mentioned both by Matthew and by Mark; yet neither Matthew nor Mark describes or gives the slightest hint of any such miracle in connection with the calling of Peter. In the next place, the metaphor describing the apostles as fishermen and converts as fish, borrowed from Jeremiah perhaps (xvi. 16), is applied by our Lord both to the apostles, as "fishers of men," and to the preaching of the gospel, which he describes as a "net" catching all sorts of fish, bad and good. As the sea in the Old Testament is regarded as the type of "sin," everything favored the addition and development of this metaphor. Accordingly Philo (*Creation*) describes fishes as typical of the lowest kind of unenlightened existence; and Clement of Alexandria addresses a hymn to Christ, as the fisher of men catching fishes with the bait of eternal life from the hateful wave of the sea of vices (*The Instructor*, iii. 12). It is of course possible that the developed symbolism which we find in Clement may have been entirely the effect, and in no degree the cause, of the narrative in Luke v. 6; and in any case the full discussion of this question would require more space than the limits of this article allow.

The introductory chapters of Luke's Gospel.

Passing now from the main body of Luke's Gospel, we come to the introduction, which name we may give to the first two chapters, describing the birth and childhood of Jesus, and the birth of His forerunner John, the son of Zacharias. The doctrine of the miraculous incarnation, although distinctly stated in Matthew's Gospel, nevertheless required further confirmation. This doctrine appears to have been spoken of from the earliest time, in language which might give rise to different conclusions according as it was interpreted literally or metaphorically. For example, in the Apocalypse, "the Man Child who was to rule over all nations with a rod of iron" is said to have been born of a woman who was "clothed with the sun, and the moon under her feet, and upon her head a crown of twelve stars," who, after her son had been "caught up into heaven," fled "into the wilderness where she hath a place prepared of God" (Rev. xii. 1–6). It seems certain that the writer represents by the woman, not the virgin Mary, but the Church—the Spiritual Israel; and in later times the letter of the Church of Lyons (Euseb., *H. E.*, v. 1) speaks of the "Virgin Mother" as having her children restored to her from the dead (meaning that the church received back, as martyrs, those who had first recanted and then renounced their recantation). Justin Martyr also protests that, even though he should not be able to prove the pre-existence of Jesus, and even though it should appear that He was born man of men, yet it would still be true that He is Christ; "for," adds he, in his dialogue with Trypho (chap. xlviii.; or, ed. Morell, p. 267), "there are some, O my friends, of our race,[1] who confess Him to be Christ, but who declare that He is man of men, to whom I do not assent: nor would very many that have formed the same opinions as I have say as they say, because we have been commanded by Christ Himself not to follow the teachings of men, but the proclamations made by the blessed prophets, and taught by Him." The expression "not very many" (*οὐ πλεῖστοι*) indicates that (*a*) even in Justin's time (150 A. D.) a large though not very large number of Christians in Samaria or Judæa believed that Christ was the son of Joseph, and that (*b*) a principal part of the evidence for the contrary belief was based upon "the proclamations of the prophets." On the other side, what germs of wild and fanciful doctrine were in the air may be inferred from the Gospel of the Hebrews, which will not allow that Jesus had even a human mother, but speaks of His mother as being the Holy Spirit (Kirchhofer, p. 451, and *cf.* p. 454). In opposition to these divergent but heterodox beliefs, it became increasingly necessary to maintain the doctrine that Jesus was at once a man, born of a human mother, and divine, born of the heavenly Father; and this needed to be reaffirmed now, during the prosperity of the church, in a somewhat less apologetic tone than characterized the narrative of Matthew.

When we speak of Luke's "supplying the deficiencies of Matthew," we must not be supposed to mean that Luke had before him, or even knew the existence of, Matthew's Gospel. It has been shown above that he probably knew of no apostolic written narrative (see p. 717 above). Though Matthew's was probably written some years before Luke's Gospel, very many years might elapse before a treatise used in one church or province might be recognized as authoritative beyond its original boundaries. But by "supplying the deficiencies" we mean that the conscience and faith of the church required in Luke's time some further and more vivid embodiment of the spiritual truth involved in the incarnation than was contained in the unsupplemented narrative of Matthew.

For example, it was not a sufficient argument against the Jewish slanderers who asserted that Jesus was born of adultery, to say that Joseph, when purposing to put Mary away, was warned by an angel in a dream to give up his purpose. Something more positive, and in a higher tone, not a dream, but an angelic visitation, was needed to confirm the divine origin of the Son of God. Moreover, in order to set forth still more emphatically the subordination of John the Baptist to the Lord, it was needed that the church should know that the prophet (who himself also had his own birth heralded by angels) was from the first acknowledged by his parents as the mere forerunner and messenger of Him that was to come, to whom, even in his mother's womb, the inferior prophet did obeisance. Further, when Jesus was born, it was not enough that wise and learned men from the East should come to worship Him. It was necessary to show that the poor and simple toilers of the earth, typified by night-watching shepherds, were also privileged to behold His glory, and were the first to hear with the ear of faith the divine message of the birth of the Redeemer.

The testimony offered to the divine Son of David by Zacharias, who represents the priestly tribe of Levi, and by Elisabeth, who was one of the daughters of Aaron,[2] and the blessing of Simeon, and of Anna who is said to have been of the distant tribe of Asher,—all this emblematic homage from Israel to its Redeemer would be inadequately replaced by Matthew's brief story of the flight into Egypt; and, although refusing to feed a frivolous curiosity with frivolous legends on the childhood of Jesus, the church would naturally cherish the story which told how the youthful Redeemer, when missed by Mary and Joseph, was found in His Father's house. A narrative of this kind, not vulgar nor colloquial, and yet not too refined or scholastic, but framed both in language and in thought on the model of the best Greek Apocrypha, setting forth in the sacred vocabulary of the LXX. the earliest Christian psalms and hymns that had been committed to writing, would be justly felt by all the churches to tend to edification, and would soon find a place in every assembly for Christian worship.

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[1] Another reading *ὑμετέρου* would make Justin refer to Jewish Christians; but the inference would remain unaffected.

[2] The importance attached to the co-operation of Levi with the "Lion of the tribe of Judah" is clearly seen in the very early (before 135 A. D.) apocryphal book entitled *The Testaments of the Twelve Patriarchs* (Sinker, p. 104), in which "Christ is spoken of as coming forth from the two tribes of Judah and Levi, as typical of His twofold office of King and Priest." The symbolism of Origen, as regards Zacharias and Elizabeth is far more fanciful; he sees (*In Evang Joann.*, ii. 27) in the meanings of Elizabeth ("the oath of my God") and Zacharias ("memory") a reference to the birth of John ("the gift of God"): "*ἐκ τῆς περὶ θεοῦ Μνήμης κατὰ τὸν τοῦ Θεοῦ ἡμῶν Ὅρκον τὸν περὶ τοὺς πατέρας*" (Luke i. 73).

But the resurrection, even more than the incarnation, required amplifications. If Matthew had left gaps in his introduction, still more serious were the deficiencies in his appendix to the traditional gospel. Although Matthew had added something to the mere suggestions of a resurrection contributed by Mark, he had not added enough. More proof was required, tangible proof, if possible. The women, it is true (according to the narrative of Mat. xxviii. 9), had held Jesus by the feet, but the disciples themselves were not recorded to have done so; and, besides, the increasing reverence of the church shrank from the thought that the body of the risen Saviour had been actually touched (Jo. xx. 17), even though He might have offered himself to the touch of His disciples. As far therefore as the evidence went, it was open to the Jewish sceptic to call the manifestations of the Lord delusions, or at best visions, and to apply to them the words of the angel (Tobit xii. 19): "All those days I did but make myself visible unto you, *and did neither eat nor drink;* but ye beheld a vision." Against so formidable an objection, no proof could better commend itself to a close student of the LXX. (such as Luke assuredly was) than a narrative describing how Jesus ate in the presence of His disciples (xxiv. 43). Again, whereas the conclusion of Matthew's narrative leaves Jesus (except by inference) still on earth, Luke omitting the apologetic details which had now become unnecessary, or even liable to perversion (*e. g.*, the Jewish slander that the Lord's body had been stolen from the sepulchre, and the fact that some of the eleven disciples "doubted" when they saw the Lord, apparently for the last time, upon the mountain), describes how Jesus was not parted from His disciples till He had produced complete conviction in all of them, and had opened their minds to understand the scriptures.

Still, even with these important additions, the appendix of Luke seemed to some, and perhaps to Luke himself, incomplete; and, accordingly, either Luke himself, or some early editor or very early scribes, inserted in the appendix several further additions:—(1) that Peter saw the grave-clothes of Jesus lying in the open tomb (xxiv. 12);[1] (2) that Jesus proved His identity to His disciples by showing them His hands and His feet; (3) that He fed not only on the emblematic "fish" but also on the "honeycomb" (xxiv. 42); and lastly, (4) that He ascended into heaven (xxiv. 51). Perhaps the same hand added, in the account of the agony at Gethsemane, the description of the angel from heaven who appeared strengthening Jesus, and of drops as it were of blood falling from Him to the earth. It is by no means improbable that Luke himself added these passages in a later edition of his own work, as authoritative traditions which had subsequently become known to him; and two or three of them, in somewhat different shapes, will present themselves to us subsequently in the Fourth Gospel.[2]

The language of the original tradition.

Language of the Original Tradition.—It is probable that the Jews, and more especially those in Galilee, were (like the Welsh in the present day) bilingual; and the question has therefore been raised whether our Lord, in His teaching, spoke Greek or Aramaic. If He spoke Greek, then the Aramaic words *Talitha cumi* and *Ephphatha* (Mk. v. 41; vii. 34) must be supposed to be specially addressed to the young and the illiterate, who would best understand the national dialect. But the names Cephas, Boanerges, given by our Lord to His Galilean disciples, and the use of Aramaic in His own prayer ("*Abba*, Father"), and in His last utterance (as recorded by Mat. xxvii. 46; Mk. xv. 34), indicate that both for Himself and for His disciples Aramaic and not Greek was the natural tongue. Although therefore it cannot be denied that Greek, even in Jerusalem (see Acts xvii. 2, indicating that Greek would have been understood, though they preferred "Hebrew"), was generally intelligible, yet the scanty evidence derivable from our Lord's words is that He habitually used Aramaic.

The testimony of Josephus tends in the same direction. He, though a man of education, composed certain books first in his own tongue (pref. to *Wars*, 1). He also tells us that he found it a laborious task to render the history of his country in Greek, "an alien and strange language" (pref. to *Antiqu.*, 2). It is to be presumed that he wrote in Aramaic partly for his countrymen in Judæa; but he adds that it was also for the sake of "Parthians, Babylonians, and remotest Arabians, and those of our nation beyond Euphrates, and the Adiabeni" (pref. to *Wars*, 2). Making every allowance for exaggeration, we are justified in drawing from the fact that Josephus thought it worth while to compose books first in Aramaic the inference that a large number of readers in the East would be more likely to read Aramaic than Greek.[3]

But it has been thought that the use of the LXX. in our Lord's quotations from the Old Testament shows that He spoke Greek. The answer is—(1) Even if all the quotations in the synoptists from the Old Testament exactly agreed with the LXX., the agreement would by no means prove that our Lord used the LXX.; for, in translating Hebrew into Greek, the translator might naturally translate the Hebrew quotations from the Old Testament into the corresponding LXX. version, to which his readers were accustomed. This he might do, even though the LXX. did not quite accurately represent the Hebrew; just as, in translating into English a Latin book, with quotations from the Vulgate, we should naturally use our English version, without considering whether the English exactly represented the Latin. (2) But, in the second place, there is scarcely a single quotation[4] in the Gospels from the Old Testament that exactly agrees with the LXX. when the LXX. differs from the Hebrew; and many of the quotations differ slightly both from the Hebrew and from the LXX., and even from the same quotations as elsewhere occurring in the New Testament. And this is just what we might expect. A Hellenist, translating a Hebrew document into Greek (in times when reference to books was far more cumbrous, and trust to memory far more common, than with us) would be likely to be guided principally by his memory of the LXX., but partly by the Hebrew before him. Hence would result translations slightly varying both from the Hebrew and from the LXX., and from other translations made by contemporaneous writers. This argument is, of course, unaffected whether the translation was originally made in a document or, as is more probable, in an oral tradition.

Some confirmation of this hypothesis is derived from the fact that, although the first book of Maccabees was without doubt originally written in Hebrew, yet the quotations in it from Scripture are not translations from the Hebrew version. On the contrary, if the quotation in 1 Mac. vii. 17 from Ps. lxxviii. (lxxix.) 2, 3, be compared with the latter passage in the LXX., it will be seen at once that the former, though not identical with the latter (nor with the Hebrew), could not have been written but by a writer familiar with the LXX. version; compare also 1 Mac. ix. 23 with the LXX. version of Ps. xci. (xcii.) 8. A similar inference would seem to be justified by the statement (De Wette, quoted by Roberts, *Discussions on the Gospels*, p.

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[1] It is most improbable that this passage has been interpolated in Luke from the Fourth Gospel (xx. 4–7); for the passage in the Fourth Gospel is fuller than in Luke, and the tendency of copyists is rather to amplify than to curtail. Besides, there are traces that Luke and John are both different versions of the same tradition, differently understood.

[2] Unless these additions were made by some authoritative hand, it is not easy to see why they should have been adopted by so many of the best MSS.; no such additions are found in the appendix of Matthew. Again, unless they are additions (not forming a part of the first edition of the Gospel), it is hard to see why any of the best MSS. should omit them, since they would recommend themselves to all readers and copyists.

[3] The statement of Josephus (*Contra Apion.*, i. 9), that "he alone understood (*μόνος αὐτὸς συνίην*)" the information brought to the Romans by deserters from Jerusalem during the siege, must be regarded as a piece of bombast. For is it credible that a Roman army before a besieged city should have had with it no other interpreter besides one recently captured prisoner? Nevertheless, this exaggeration may be taken as an indication that the lower classes in Jerusalem could not, as a rule, speak Greek; for Josephus assumes this, as a matter of course. Greek, of course, would have been perfectly intelligible to any educated Roman if the deserters had been able to speak it.

[4] An exact illustration may be derived from the Latin translation, by Rufinus, of the *Clementine Recognitions*, in which (Sanday, *Gospels*, p. 161) "the quotations from the gospels have evidently been assimilated to the canonical text which Rufinus himself used."

50) that Josephus uses the LXX. more than the Hebrew text.

The hypothesis of translation.

Mistranslation of an Aramaic original may possibly explain in part some of the confusions in the common tradition noted above (p. 704). It cannot of course be denied that *some* of these confusions imply a confusion of Greek, not Hebrew, tradition (*e. g.*, ἰσάγγελοι, Lu. xx. 36; ὡς ἀγγέλοι, Mat. xxii. 30; Mk. xii. 25); but some of the changes of construction (*e. g.*, πᾶσα ἡ περίχωρος ἐξεπορεύετο, Mat. iii. 5 and Lu. iii. 3, ἦλθεν εἰς πᾶσαν τὴν περίχωρον, Mk. i. 5) are more easily explicable on the hypothesis of translation. Some of the changes of words are also explicable thus, as may be illustrated by the Latin version. Commenting on the text, "Domine, ne in *ira* tua arguas me, nec in *furore* tuo corripias me," Augustine (Ziegler, p. 10) says that in some codices of the Latin translations "ira" stands first, and "furor" second, in others "furor" first and "ira" second. Compare with this Mat. v. 40, τῷ θέλοντι λαβεῖν χιτῶνα ἄφες αὐτῷ τὸ ἱμάτιον, and Lu. vi. 29, τοῦ αἴροντός σου τὸ ἱμάτιον μὴ κωλύσῃς τὸν χιτῶνα, where the phenomena are precisely the same; and note that Mat. (xxvii. 65) has ἱμάτια, where Mk. (xiv. 63) has χιτῶνας. Of somewhat the same type (perhaps) are the passages Mat. vii. 16, ἀπὸ ἀκανθῶν σταφυλήν, and Lu. vi. 44, ἐκ βάτου σταφυλήν.

In the translations from Greek into the early Latin versions of the New Testament, one very common difference is (besides divergent rendering of single words) that one version uses participles where the other uses finite verbs, or relative pronouns where the other uses co-ordinate conjunctions.[1] These same slight differences are found in several sayings of our Lord where they happen to be twice recorded by the same evangelist. Compare (*a*) Lu. viii. 18, ὃς γὰρ ἂν ἔχῃ, and Lu. xix. 26, πάντι τῷ ἔχοντι (see also Mat. xiii. 12; xxv. 29); (*b*) Lu. viii. 17, οὐ γάρ ἐστιν κρυπτὸν ὃ οὐ φανερὸν γενήσεται, and Lu. xii. 2, οὐδὲν δε συγκεκαλυμμένον ἐστιν ὃ οὐκ ἀποκαλυφθήσεται (see also Mat. x. 26); (*c*) Mat. x. 39, ὁ εὑρὼν τὴν ψυχὴν αὐτοῦ ἀπολέσει αὐτὴν, καὶ ὁ ἀπολέσας τὴν ψυχὴν αὐτοῦ ἕνεκεν ἐμοῦ εὑρήσει αὐτήν, and Mat. xvi. 25, ὃς γὰρ ἐὰν θέλῃ τὴ ψυχὴν αὐτοῦ σῶσαι ἀπολέσει αὐτὴν, ὃς δ' ἀν ἀπολέσῃ τὴν ψυχὴν αὐτοῦ ἕνεκεν ἐμοῦ εὑρήσει αὐτήν (and *cf.* Lu. ix. 24; xvii. 25); (*d*) Mat. v. 32, πᾶς ὁ ἀπολύων τὴν γυναῖκα αὐτοῦ, etc., and Mat. xix. 9, ὃς ἂν ἀπολύσῃ, etc. (*e*) In the same two passages there appears to be a confusion between "causeth to commit adultery" and "committeth adultery,"—Mat. v. 32, παρεκτὸς λόγου πορνείας, ποιεῖ αὐτὴν μοιχευθῆναι, and Mat. xix. 9, μὴ ἐπὶ πορνείᾳ . . . μοιχᾶται; (*f*) Mat. v. 32, ὃς ἐὰν ἀπολελυμένην γαμήσῃ, and Mat. xix. 9, ὁ ἀπολελυμένην γαμήσας. These passages, so far as they go, would indicate that the compilers of the First and Third Gospels did not themselves translate from Aramaic originals; for if they had themselves been the translators, it would seem that they would have adopted a uniform rendering in translating the same or very similar words. Limited though the evidence is, it goes to prove that the compilers incorporated in their treatises Greek translations, not all made by themselves, from Aramaic originals.

The phenomena of the ante-Jerome versions of the New Testament deserve careful consideration in discussing the possible origin of our Greek synoptic tradition from an Aramaic original. In a well-known passage, Jerome (Ziegler, *Die Lateinischen Bibelübersetzungen vor Hieronymus*, p. 12) complains that there were as many texts as copies of the Latin versions ("tot sunt enim exemplaria pœne quot codices"), and the occasionally great variety may be illustrated by comparing an extract from the Codex Bobbiensis (*Jahrbücher d. Literatur* Vienna, 1847, *ad fin.*) with the Vulgate version of Acts xxvii. 20, 21:—

BOBBIENSIS.	VULGATE.
Neque sole neque stellis *apparentibus per* multos *dies* et hieme et *tempestate* minimia [*sic*] perseverante, *jam* amputabatur *spes omnis* liberandi nos. *Et cum* jam diù sine cibo essent, *tunc stans Paulus in medio* ipsorum ait: *Opor*tuerat *quidem* vos obediri credentes mihi non navigare de *Creta* et *lucrari hanc injuriam* et detrimentum.	*Neque* autem *sole neque* sideribus *apparentibus per* plures *dies*et *tempestate* non exigua imminente, *jam* ablata erat *spes omnis* salutis nostræ. *Et cum* multa jejunatio fuisset, *tunc stans Paulus in medio* eorum dixit: *Oporte*bat *quidem*, o viri, audito me, non tollere a *Creta*, *lucr*ique facere *injuriam hanc* et jacturam.

It will be seen at once that there is some similarity between the thread common to these two Latin versions and the thread common to many passages in Matthew, Mark, and Luke; though the resemblance between any two of the three synoptists would generally exceed the resemblance of the two passages quoted above. In most cases, however, the ante-Jerome versions (as represented by the Codex Corbeiensis, Brixianus, Vercellensis, and Veronensis) agree much more closely together, even more closely than any two of the synoptists agree together, and a portion more closely than the three synoptists agree. On the whole, taking into consideration the greater influence of differentiating causes in the earliest times of the church than in the times when the ante-Jerome versions were composed, we may fairly conclude that if in these later times so great a variety could occur in the process of translation from Greek, the greater variety found in the common tradition, as given by the three synoptists, might well be partly explained in the same way, as originating in part from varieties of translation from Hebrew. But then the questions arise—(*a*) Were the ante-Jerome versions independent translations from the Greek text? (*b*) Or were they divergent corruptions of one original Latin translation from the Greek text? (*c*) Or were they partly independent, but partly modified by some oral tradition or "ecclesiastical use," which diminished the divergence? On these questions there is not at present a complete agreement. Wiseman maintained that the second (*b*) answer was the right one; but in a recent work (quoted above) Ziegler (p. 123) maintains, with great probability, that the third (*c*) is correct—viz., that the oral catechising and preaching in the Latin churches modified and assimilated translations otherwise independent. It is extremely probable that the same hypothesis of combined causes—(1) translations from Aramaic documents, (2) influence of oral Greek tradition—may explain much of the agreement and variation in the passages common to the three synoptists.

The difference between the Triple Tradition of Matthew, Mark, and Luke, and the Double Tradition of Matthew and Luke will, at this stage, occur to us as an important feature in our evidence. The widely different phenomena of the Double and the Triple Traditions suggest different origins for the two traditions. Many of the passages common to Matthew and Luke agree together far more closely than even the Latin versions of the Greek Gospels. It would seem to follow that in such cases Matthew and Luke used one and the same Greek document—a translation of some Aramaic original—which document had not undergone much modification by oral tradition before passing into the several treatises of Matthew and Luke. On the other hand, the more varying language of the Triple Tradition, together with the additions and omissions of the three writers, suggests (*a*) independent translations of an Aramaic original; (*b*) occasional resemblances suggested by the general "usus ecclesiasticus;" (*c*) divergences created by the local "usus ecclesiasticus," or by the individual style of the editor or editors.

Date of synoptic Gospels.

Date of the Synoptic Writers.—The composite nature of the synoptic Gospels makes it necessary to distinguish carefully between the date of the compilation of each collective treatise and the date of the composition of the several parts of which that treatise may be composed. The original tradition has been shown to have existed before any of the three synoptics; some common document of the words of the Lord has been shown to have probably existed before Matthew's or Luke's narrative; other documents or traditions might also possibly be shown to exist embedded in each of the synoptists, and the date of each of these parts would be earlier than the date of the whole. Therefore, even if the date of Matthew, or Mark, or Luke could be exactly determined, it would by no means determine the date of the traditions which they contain. It is even possible that a later Gospel may retain in some cases an earlier version of the common tradition of the words of the Lord, as we have seen in the case of Luke's version of the Lord's Prayer (see p. 710 above).

There is no internal evidence for exactly determining the date of any one of the synoptics. The supposed references in Mark to the death of James, the capture of Jerusalem, or any special earthquakes which might determine the date (Renan's *Évangiles*, p. 123), are so shadowy as scarcely to deserve consideration. The reference to the death of Zachariah the son of Baruch, shortly before the capture of Jerusalem (Joseph. *B. J.*, iv. 5, 4), supposed to be found in Matt. xxiii. 35, is still more improbable. Still the marked difference between the detailed prediction (in Luke xxi. 18–25) of the fall of the city and the scattering of the people, and the more general predictions in corresponding passages in Matthew and Mark, indicates that Luke's description is modified by reminiscences of the siege of Jerusalem; while Matthew's and Mark's accounts are not thus, or at all events not equally, modified. It is an almost certain inference that Luke compiled after 70 A. D. As regards Matthew and Mark inferences cannot be drawn with equal certainty;

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[1] Compare the Codex Corbeiensis and Brixianus (Migne, *Patrologiæ Curs. Compl.*, vol. xii. p. 147); of which (1) the former has (Mat. ii. 7) "Tunc Herodes, clam *vocatis* Magis diligenter *didicit* ab eis tempus stellæ *quæ* apparuit eis; et *mittens* illos in Bethleem, *dixit* '*Ite et interrogate*,'" etc.; while the latter has (2) "Tunc Herodes *occulte vocans* Magos diligenter exquisivit ab eis tempus *quando* apparuit eis stella, et *misit* illos in Bethleem, *dicens* '*Euntes requirite*,'" etc.

for of course a compiler may compile at a late date, and yet preserve traditions in their earliest shape; but it is at least a reasonable inference that the compilers of the First and Second Gospels wrote before Luke; and there is a balance of probability in favor of the supposition that they wrote before the fall of Jerusalem.

Coming to more general evidence, we find (see p. 702) that (1) Mark, at least in many passages, includes the original tradition from which both Matthew and Luke borrowed; (2) his language, less polished than that of Matthew and Luke, appears more natural for an earlier Gospel in the first and rudest age of the church; (3) Mark's version of the tradition contains many expressions which might naturally be considered "stumbling-blocks," and which, in fact, were rejected or not inserted in the other Gospels; (4) the omission of all account of the manifestations of Jesus after the resurrection indicates a very early date; and though it may be said that this omission arises from the fact that the Second Gospel was accidentally left incomplete, yet this answer will not account for the omission of the genealogies, and of all account of the birth and infancy of Jesus; (5) the interpolated appendix describing the resurrection of Jesus, quoted as it is by Irenæus, shows that even in the time of Irenæus (170 A. D.) the Gospel had been long enough in use to admit of widespread interpolations. All these facts lead to the inference that Mark was compiled earlier than any of the other Gospels, and probably some time before 70 A. D. It is almost impossible to fix any date (worth stating) after which the compilation must have taken place. Those who accept as literally true Mark's accounts of the feeding of the four thousand and five thousand, the walking on the waves, and the exorcism of the Gadarene, may naturally carry back his history to the first years of the Galilean church; and even those who interpret these accounts symbolically are ready to admit that a very short space of time is often quite sufficient, by misunderstanding and accretion, to erect supernatural narratives on a basis of natural and symbolic story. But any approximation to a date *after* which the Gospel was compiled must be deferred till we consider the external evidence.

The narrative of Matthew does not leave us quite so uncertain. The mention of "the Jews," which is so frequent in the Fourth Gospel, is justly regarded as a proof that the author was writing in times when the Christian church was regarded as definitely and antagonistically separated from the Jewish nation. In the synoptists it is the "Pharisees," not the "Jews," who are in conflict with Jesus. But in his account of the resurrection Matthew (xxviii. 15) uses the word in this antagonistic sense. Further, he twice (xxvii. 8; xxviii. 15) uses the expression "even to this day," of events occurring shortly before or after the death of Jesus,—thereby showing that a long interval had occurred between the death of Jesus and the compilation of the narrative. The tone of the Gospel, as compared with Luke, indicates a period when the Jews still existed as a nation, and when the abrogation of the law and the destruction of the temple were not yet accepted as recognized facts; but the number of parables upon the end of the world and the judgment, the tendency to dwell on exclusion rather than inclusion, on the "many" that are shut out rather than on the "few" that are chosen, and the atmosphere of gloom generally characterizing the Gospel, point, perhaps, to the crisis immediately preceding the siege of Jerusalem. The additions concerning the birth and incarnation may seem to imply a later date; but when we reflect how natural it was that in very early times the church should attach importance to these subjects, the wonder will be, not that these narratives were written so soon, but that they were deferred to so late a period as forty years after our Lord's death. It is also extremely remarkable—and a mark of early date as compared with Luke—that even in this developed form of the Gospel the accounts of manifestation of our Lord after His resurrection should be so scanty, doubtful, and vague.

In Luke the signs of later date abound:—(1) the pre-existence and implied failure of many "attempts" to set forth continuous narratives of the things "surely believed;" (2) the mention of the "tradition" of the eye-witnesses and ministers of the word as past, not as present (παρέδοσαν) (i. 2); (3) the dedication of the Gospel to a man of rank (fictitious or otherwise), who is supposed to have been "catechised" in Christian truth; (4) the attempt at literary style and at improvement of the "usus ecclesiasticus" of the common tradition; (5) the composition of something like the commencement of a Christian hymnology; (6) the development of the genealogy and the higher tone of the narrative of the incarnation; (7) the insertion of many passages mentioning our Lord as ὁ κύριος, not in address, but in narrative; (8) the distinction, more sharply drawn, between the fall of Jerusalem and the final coming; (9) the detailed prediction of the fall of Jerusalem, implying reminiscences of its fulfilment; (10) the very great development of the manifestations of Jesus after the resurrection. The inference from all this evidence would be that Luke was not written till about 80 A. D. at earliest. If it could be further demonstrated that Luke used any Greek Apocryphal book (Judith, for example), and if it could be shown that the book in question was written after a certain date (Renan suggests 80 A. D. for the date of the book of Judith), it might be necessary to place Luke much later; but no such demonstration has been hitherto produced.

External Evidence.

The earliest quotations from the Gospels.

The composite nature of the synoptic Gospels will affect the inferences we shall draw from early quotations of passages found in them, where the authors of the Gospels are not expressly mentioned. If, for example, we find in Justin a passage (quoted as a saying of the Lord) which is found both in Matthew and Luke, Justin may indeed have quoted it from Matthew or from Luke; but it is also possible that he may have quoted it neither from Matthew nor from Luke, but either (*a*) from the common source whence Matthew and Luke derived the passage, or (*b*) from some other book or tradition, which, like Matthew and Luke, included the passage in its collection or compilation. The same applies to a quotation from the Triple Tradition. It may be quoted from Matthew or from Mark or from Luke; but it is also possible that it may be drawn from none of these, but from the common tradition itself, or from some other treatise based on the Triple Tradition.

Taking the evidence chronologically, we come first to the testimony of Paul, who, in the First Epistle to the Corinthians, says (1 Cor. xi. 23), "I received from the Lord that which also I delivered to you:" and then follows a description of the institution of the Lord's Supper, differing materially from Matthew and Mark, and agreeing in the main with Luke, except that Paul repeats twice the command, "Do this in remembrance of Me." It would seem unreasonable and scarcely reverent to suppose that a special revelation revealed to Paul the exact words of the institution: but comparing the passage with Gal. i. 9, 12, we see that Paul merely says here about this part of his teaching what in Gal. i. 9. 12 he says about the whole of it, viz., that he received it from the Lord and not from man. From Ananias, or from other elders of the church, he may have received the words of oral tradition of the church; but for the meaning and spiritual force of it, and the application of each part of it to the work of redemption, he was indebted, not to the elders of the church in Damascus, but to the revelations given to him in the solitude of Arabia. The words of Paul, therefore, do not exclude (and the facts render probable) the use of oral tradition in this passage. This being so, it may seem remarkable that Paul follows the tradition contained in the latest of the three Gospels. It can hardly be that Luke has here preserved the earliest tradition. The insertion of "new" before "testament" (not inserted in the correct text of Matthew and Mark), and the ampler narrative of Luke indicate a later, not an earlier, shape of the tradition. The word "testament" appears to have been used by our Lord in the ordinary sense of "will" and "testament," indicating that in that funeral feast He was *bequeathing* Himself to His disciples for ever.[1] The insertion of "new," by a sort of play upon the double meaning of the word "testament," introduces the sense of "covenant," and therewith a contrast between the old and the new covenants. But this suggestive thought (highly characteristic of Paul) seems more likely to have been added to the original in process of explanation, than to have been dropped by Matthew and Mark through neglect, or discarded owing to difficulty. The probable solution therefore would seem to be that Luke has embodied, not the earliest tradition, but the later Pauline shape of the tradition. We have here therefore not Paul supporting the tradition of Luke, but Luke (in all probability) borrowing from Paul.[1] The only other passage in which Paul (in the Acts) quotes a saying of Jesus contains (Acts xx. 35) words not found in any of our Gospels, "It is more blessed to give than to receive."

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[1] Similarly it is used in the Epistle to the Hebrews (ix. 17), διαθήκη γὰρ ἐπὶ νεκροῖς βεβαία· ἐπεί μήποτε ἰσχύει ὅτε ζῇ ὁ διαθέμενος. This use of the word is also found in the title of the early apocryphal work, *The Testaments of the Twelve Patriarchs.* It is said by Mr. Sinker, in his edition of that work (p. 32), that probably, by the time of the composition of the *Testaments* (*i. e.*, before 135 A.D.), the word διαθήκη itself [דְּיָתִיקִי] had been taken into Hebrew in the sense of "will" (Buxtorf, *Lex. Rabb.* s. v.). It would seem to follow that long before that date the word διαθήκη was in regular use, in Hebraic Greek, to render the meaning "will" or "testament," although of course it also represents (and very much more frequently, owing to the more frequent repetition of the thought in the New Testament) the meaning "covenant."

The Second Epistle of Peter (2 Pet. i. 17) contains a reference (apparently) to the transfiguration, of which the writer speaks as an eye-witness. But this testimony, most important if genuine, is almost certainly spurious. The mention of the mount of transfiguration as "the Holy Mount," and of Paul's epistles as "scriptures," would in itself suggest a late date; and Canon Westcott (*Gospels*, p. 175) justly says that "the comparative elaborateness of the description (of the transfiguration) seems to offer an instructive contrast to the simplicity of the earlier Gospel." External evidence is also against the genuineness of this epistle. Up to the times of Clement of Alexandria "no trace has been found" of its existence (Westcott, *Canon*, p. 349); and neither Origen nor Eusebius accepts it as canonical. To obtain a complete idea of the judgment of the church upon the canon, we must combine (Westcott, *Canon*, p. 264) the two canons of the East and West; by doing this "we obtain, *with one exception*, a perfect New Testament without the admixture of any foreign element." That "exception" is the Second Epistle of Peter. The only importance to be attached therefore to the testimony of an epistle thus rejected by the general consent of the early church is that which attaches itself to an early literary fabrication composed so early as to have found a place in our canon. Such a composition (mentioning Paul's letters as "scriptures") cannot have been written before the beginning of the second century; yet we find that, even at that date, the common tradition is quoted most inexactly. The voice from heaven, as given by the author of the spurious epistle, is, Ὁ υἱός μου ὁ ἀγαπητός μου οὗτός ἐστιν εἰς ὃν ἐγὼ εὐδόκησα· But in Matthew (xvii. 5) it is οὗτός ἐστιν ὁ υἱός μου ὁ ἀγαπητός ἐν ᾧ εὐδόκησα· ἀκούετε αὐτοῦ. Mark and Luke differ still more from the Epistle, for they both omit εὐδόκησα. The inaccuracy is the more serious because, in describing the baptism of Jesus, Matthew (iii. 17) speaks of a voice from heaven which almost exactly agrees with the words in the Epistle, omitting the words ἀκούετε αὐτοῦ. In these circumstances it is impossible to say that the author of this spurious Epistle had Matthew before him. Much more probably he was quoting from memory, or from some document differing from any of our synoptic Gospels.

Clement. The next witness is Clement of Rome, whose Epistle to the Corinthians, probably written in or soon after 95 A. D. (Lightfoot's *Clement of Rome*, Appendix, p. 267), contains three passages which may indicate a use of our Gospels. (1) In chap. xiii. he blends together (Sanday, *The Gospels in the Second Century*, p. 921) passages common to Matthew (v. 7; vi. 14; vii. 12; vii. 2), Mark (iv. 24; xi. 25), and Luke (vi. 36, 37, 31, 38, 37) in a terse, antithetical, and uniform style, inserting the words, Ὡς χρηστεύεσθε οὕτως χρηστευθήσεται ὑμῖν. Dr. Lightfoot has pointed out that the looseness of this quotation does not exceed the looseness with which (chap. 12) the same author quotes the narrative of Rahab, and therefore it is quite possible that here, as there, Clement may be simply quoting from memory with no other documents than Matthew and Luke in his mind; but to many the "roundness, compactness, and balance of style" which Dr. Sanday notices in the quotation will make it probable that Clement was quoting, not perhaps from any other document (for else how is it that no trace remains of a documentary version of the word of the Lord so "rounded and compact" in style, and used 95 A. D. by so eminent a man as Clement of Rome in writing to the church of Corinth?), but with some tradition in his memory (which had perhaps served the purpose of preachers, teachers, and catechists in the Roman Church), blending and condensing the versions of Matthew and Luke into a form adapted for the oral instruction of converts. (2) In another passage (chap. xxvi.) Clement combines Mat. xviii. 6 (Mk. ix. 42; Lu. xvii. 1, 2) and Mat. xxvi. 24 (Mk. xiv. 21; Lu. xxii. 22) in a manner which suggests quoting from memory. (3) A third passage (Sanday, p. 70) contains a quotation from Isaiah (xxix. 13) differing from the Hebrew and from the similar LXX. (which is, ἐγγίζει μοι ὁ λαὸς οὗτος ἐν τῷ στόματι αὐτοῦ, καὶ ἐν τοῖς χείλεσιν αὐτῶν τιμῶσίν με, ἡ δὲ καρδία αὐτῶν πόῤῥω ἀπέχει ἀπ' ἐμοῦ), and substituting a condensed and antithetical form, οὗτος ὁ λαὸς τοῖς χείλεσίν με τιμᾷ, ἡ δὲ καρδία αὐτῶν πόῤῥω ἀπέστιν ἀπ' ἐμοῦ, which is also found in Mat. xv. 8 and Mk. vii. 6 (except that they read ἀπέχει for ἀπέστιν). The inference has been drawn that Clement is quoting from our Gospels. But this is not the only passage where quotations from the Old Testament in the New appear to have been influenced by an "ecclesiastical use," arising in some cases from a desire to make the application closer (compare Jo. xix. 37 with the LXX. version of Zech. xii. 10, and note that this version is exactly quoted by Justin, and allusively by the author of the Apocalypse, i. 7), in part from abridgment or other causes (compare Mat. iii. 3; Mk. i. 3; Lu. iii. 4 with Isa. xl. 3). Therefore, even though the citation in Clement exactly coincided with the citation in Mark and Matthew, it would not follow that Clement cited it from them: and as the quotation is not identical, the probability is that it is quoted by Clement, with a slight alteration, from memory of "ecclesiastical use." There is also in chap. ii. ("more gladly giving than receiving") an allusion to the saying of Jesus mentioned in Acts xx. 35. Our conclusion is—(*a*) that Clement of Rome, about 95 A. D., is proved to have a knowledge of the several scattered sentences in our common tradition which he quotes as "words of the Lord," but very loosely and freely; (*b*) that his quotation of the Old Testament appears on one occasion to be influenced by Christian "ecclesiastical use;" (*c*) that he uses (but whether as a quotation or not we have no means of determining) some words not found in our Gospels, which words are attributed to Jesus by the author of the Acts of the Apostles.

Ignatius. Early in the second century we for the first time meet with a quotation from the addition to the common tradition which are peculiar to Matthew. The Curetonian or shorter version of the epistles of Ignatius (107 or 115 A. D.) uses Mat. x. 16 almost *verbatim*, and possibly refers (Sanday, p. 79) to the star of Matthew (chap. ii.). The Vossian or longer version of the Ignatian epistles (which may be accepted as testimony for about 150 A. D.) contains, besides an ample and somewhat exaggerated reference to the star in Mat. ii., three or four (Westcott, *Canon*, p. 60) short but striking phrases peculiar to Matthew. But none of these passages have marks of quotation, the words of Matthew being in each case embedded in the writer's own words. It is remarkable that the only words of the Lord expressly quoted by Ignatius are words not found in any of our synoptic writers: "And when He came to those about (πηρί) Peter, he said to them, Take, handle Me, and see that I am not a bodiless demon." These words, although they have some likeness (the word ψηλαφήσατε is in both) to Luke xxiv. 39, are expressly said by Eusebius to be derived from some source unknown to him, and by Jerome to be derived from a Gospel which he had translated (from Hebrew), and which was read in his time by the Nazarenes (Kirchhofer, p. 449); and, according to Origen, the passage occurred in the teaching of Peter. It is, of course, impossible for us, upon this evidence, to determine whether Ignatius quoted from the Nazarene gospel, or from the teaching of Peter, or from some other document or tradition embodied before or after in both those documents. Our conclusion is that, by the middle of the second century, the writer of the Vossian version of the Ignatian epistles was familiar with the Gospel of Matthew, but that he also used other sources (not known to us) when quoting the words of the Lord in support of the material resurrection of Jesus.

Barnabas. In the Epistles of Barnabas (100–125 A. D.) is found (chap. iv.) the first apparent reference (if we except the reference in 2 Pet. iii. 16) to any passage of the New Testament as "written:" "Let us beware lest we be found, as it is written, many called, but few chosen," words almost exactly found in Mat. xxii. 14 alone (probably interpolated in Mat. xx. 16). There is also an allusive quotation of the words in Mat. ix. 13; Mk. ii. 17; Lu. v. 32: "I came not to call the righteous, but sinners." The only words expressly assigned to Jesus (chap. vii.) are not found in our Gospels: "Even so, saith He," they that would see Me and touch My kingdom, must take Me, through persecution and suffering." It is most unfortunate that the inexactness of the verifiable quotations in this epistle prevents us from laying much stress upon the author's statement as to the source of those which are unverifiable. For example, in chap. xvi., the author has, "The scripture saith, And it shall come to pass in the last days, that the Lord will deliver up the sheep of his pasture, and their sheepfold and tower to destruction. And it so happened as the Lord had spoken." But we know of no "scripture" containing these words: and the probability is that the author was quoting from memory and erroneously, as when (chap. v.) he combines Isa. iii. 9 and Wisdom ii. 12, as follows: "The *prophet* speaks against Israel, Woe to their soul because they have counselled an evil counsel against themselves, saying, Let us bind the Just One, because He is displeasing to us." Our conclusion is that, if Barnabas is deceived by his memory in attributing one passage to "writing" or "scripture," he may be deceived about another, and that we consequently cannot feel sure that he is quoting Mat. xxii. 14 from a document and not from memory of oral tradition. But (*a*) that the author was acquainted with passages found in Matthew is certain; and (*b*) it is also certain and noteworthy that the only words of the Lord quoted by him are quoted from sources not known to us.

Polycarp. Polycarp (born about 69 A. D., died 155 or 156) quotes (chap. ii.) sentences from the Sermon on the Mount, similar to those quoted by Clement above, with the preface, "remembering those things which the

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[1] If the similarity between Luke xxii. 20 and 1 Cor. xi. 25 arises from an interpolation in the former, in that case the negative conclusion remains the same, that we have not here Paul supporting the tradition of Luke.

Lord said (while) teaching, Judge not," etc. The quotation, like Clement's, is antithetical and compressed, but neither in order nor in words agrees so far with Clement's as to make it in the least degree probable that Polycarp and Clement are quoting from a written version differing from our synoptics. There is also a quotation from Mat. xxvi. 41 and Mk. xiv. 38, and a reference to Mat. vi. 13, "Asking the all-beholding God not to lead us into temptation: even as the Lord said, The spirit indeed is willing, but the flesh is weak." Two other coincidences (chap. v. and vi.) seem to refer to Mat. xx. 28; Mat. ix. 35; Mat. vi. 12, 14; Lu. xi. 4. There are no supposed allusions to apocryphal writings in Polycarp (Westcott, *Canon*, p. 61). It will be seen from what has been said above that there is nothing remarkable in the great variations with which the "Sermon on the Mount" was taught and quoted among the Christians in the first century. Like the "Lord's Prayer," it has not a literary but a practical interest; and being much used in many different churches from the earliest times, it may naturally have assumed many different shapes serviceable for catechists and preachers. This consideration (and the possibilities of variation arising from translation) may easily account for the variation between Clement and Polycarp, without necessitating or justifying, even as a working hypothesis, the supposition that Clement or Polycarp, in quoting the "Sermon on the Mount," quoted from other documents than our existing Gospels.

Shepherd of Hermas.

The "Shepherd" of Hermas, written about 135–140 A. D., "contains no distinct traces of any writing of Old or New Testament" (Sanday, *Gospels*). This is worth bearing in mind, as a warning that the nature of the subject will greatly affect the number of quotations from the scriptures in any early books. The allegorical nature of the "Shepherd," intended more as a stimulating tale than as a polemical or hortatory discourse, dispenses with scriptural illustrations; and in the same way Justin, in his *Second Apology*, refrains from quoting the scriptures, while in his other works he multiplies quotations or references. In appealing to the heathen, Justin "quotes the scriptures only when he must speak of things beyond the range of common history, preferring elsewhere to appeal to external documents such as the enrolment of Quirinus and the Acts of Pilate" (Westcott, *Canon*, p. 110).

Papias.

Papias, who wrote about 130–140 A,D., composed five books, entitled "Exposition (ἐξηγήσεως) of the Oracles[1] of the Lord." It is (apparently) in an introduction to this work that he speaks (Euseb., iii. 39) of traditions gathered from different sources: "But I will not shrink from placing along with my interpretations (ἑρμηνείαις) as many (traditions) as at any time I learned well, and well stored up in memory from the elders." The noun "interpretations" (ἑρμηνείαις) may receive some light from Papias's own use of the words ἑρμηνευτής and ἑρμηνεύω, as quoted in the same chapter of Eusebius. "Mark," he says, "was the interpreter of Peter (ἑρμηνευτὴς Πέτρου γενόμενος):"[2] again, "Matthew wrote his scriptures (λόγια) in Hebrew, and each man interpreted them (ἡρμήνευσε) as he best could." So Eusebius himself in the preceding chapter tells us that some believe Clement to have "interpreted" (ἑρμηνεῦσαι) Paul's (Hebrew) Epistle to the Hebrews into Greek. Our conclusion would be that the word ἑρμηνείαι may here mean something more than mere "commentary;" it may imply that he, as others had done, wrote an interpretation of the "Logia," accompanied by comments and by supplementary traditions. At all events he does not speak of any one Greek "interpretation" of Matthew as being as yet paramount and authoritative, so as to exclude the necessity of further "interpretations." Of Mark he speaks (in the person of "the elder") almost apologetically, implying that his narrative had been censured for its incompleteness and unpolished style; and he defends it by quoting a tradition from "the elder" (apparently John the elder) thus:—"Mark, having become Peter's interpreter, wrote down accurately all that he remembered—not, however, in order—both the words and deeds of Christ. For he neither heard the Lord nor attached himself to Him, but later on, as I said, attached himself to Peter; who used to adapt his lessons to the needs of the occasion, but not as though he were composing a connected treatise of the discourses (λόγων, v. r. λογίων) of the Lord: so that Mark committed no error in writing down some matters just as he remembered them (ἀπεμνημόνευσε). For one object was in his thoughts (ἑνὸς γὰρ ἐποιεῖτο πρόνοιαν)—to make no omissions and no false statements in what he heard."

Much of this exactly applies to our Mark. If we desire to know what is meant by Mark's not writing "in order," we have only to turn to Luke, who made it his object to write "in order," and whose arrangement, chronologically as well as artistically, differs from Mark. It is true that we may be disposed to think Mark's "order" not inferior to Luke's; but the fact is indisputable that Luke attempted to write "in order," and that his "order" differs considerably from that of Mark, who manifests no purpose except the desire to put down what he knew as he remembered it. It has been shown above (see p. 713) that Mark's Gospel is rather a collection of anecdotes than a connected narrative; and of such a collection it would be natural to say that it was not written as an orderly narrative. To the single evidence of Papias, derived from an unknown elder, not much importance can be attached; and it is very doubtful whether the most searching investigations will ever determine with certainty the name of the author or authors of any one of the synoptic Gospels. But at all events it is only reasonable to admit that the hypothesis of "notes" taken from oral discourses, and serving as the groundwork for the Second Gospel, would explain many of its phenomena. If these oral discourses embodied the early common Greek tradition, it would be easy to see how the First and Third Gospels came to resemble the Second Gospel, although all three Gospels are mutually independent. As regards the First Gospel, it has been shown above that internal evidence is against the theory of a very early authorship; and we must add that it exhibits no signs that the portion before the call of Matthew was written from hearsay, and that after the call of Matthew by an eye-witness. But there seems the following strong argument in favor of the tradition of Papias as to the authorship of Matthew: if there was no basis for it, if it was a mere fiction or guess, why not select, as the author, some more distinguished apostle, Peter, John, or James? This argument is neutralized by the following consideration. The apostles (Acts iv. 13) were known in the earliest days to have been unlearned and ignorant men; and although the Holy Spirit gave them power to speak and teach, it was less natural that they should be inspired with power to write and to compose connected treatises. But Matthew being a publican, and necessarily ready with his pen, might naturally be supposed in the post-apostolic generation to be a skilful writer; so that if an early tradition with general apostolic authority was committed to writing, the church would naturally select Matthew the publican and ready writer as the special author of it. Nevertheless, the testimony of Papias is important as attesting the belief (1) in a Hebrew origin for the Logia or the Gospel scriptures, and (2) in an early multiplicity of "interpretations."

The apologetic tone in which Papias introduces the traditions, which he "will not shrink from placing along with the interpretations" of the scriptures, indicates that the written scriptures were gradually subordinating tradition. He nowhere expresses an opinion that the Logia are unauthoritative, but he implies that they require "interpretation," and adds (almost as though it were an idiosyncrasy) that *he* set a great store on supplementary tradition from the sources nearest to the truth,—not only taking pleasure in those who taught the commandments that came from the Lord (who was) the very truth (*i. e.*, the disciples of the Lord), but also questioning any who had "attached themselves to the elders," whom he used to examine closely on the utterances of Andrew, Peter, Philip, Thomas, James, John, Matthew, or any other of the disciples of the Lord, and on the sayings of Aristion and the elder John, the disciples of the Lord.[3]

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[1] No one word in English will exactly express the word λόγια, which was used both before and after Papias, to mean not merely "sayings" but "Scriptures."—Lightfoot, *Contemporary Review*, Oct., 1875.

[2] *Cf.* also Clem. Alex., *Strom.*, vii. 17, 106, where certain heretics appeal to Glaucias τὸν Πέτρου ἑρμηνέα; and Jerome suggests as an explanation of the difference in style between the First and Second Epistle of Peter that the apostle used different *interpreters* (Kirchhofer, p. 276). The point for consideration is, not whether the statements of Papias are correct, but what Papias meant when he spoke of Mark as ἑρμηνευτής, and of himself as writing ἑρμηνείαι.

[3] Eus., *H. E.*, iii. 39: Οὐκ ὀκνήσω δέ σοι καὶ ὅσα ποτὲ πάρα τῶν πρεσβυτέρων καλῶς ἔμαθον καὶ καλῶς ἐμνημόνευσα, συντάξαι ταῖς ἑρμηνείαις, διαβεβαιούμενος περὶ αὐτῶν ἀλήθειαν· οὐ γαρ τοῖς τὰ πολλὰ λέγουσιν ἔχαιρον, ὥσπερ οἱ πολλοί, ἀλλὰ τοῖς τἀληθῆ διδάσκουσιν, οὐδὲ τοῖς τὰς ἀλλοτρίας ἐντολὰς μνημονεύουσιν. ἀλλὰ τοῖς τὰς παρὰ τοῦ κυρίου τῇ πίστει δεδομένας καὶ ἀπ' αὐτῆς παραγιγνομένας τῆς ἀληθείας. εἰ δέ που καὶ παρηκολουθηκώς τις τοῖς πρεσβυτέροις ἔλθοι, τοὺς τῶν πρεσβυτέρων ἀνέκρινον λόγους· τί Ἀνδρέας ἢ τί Πέτρος εἶπεν ἢ τί Φίλιππος ἢ τί Θωμᾶς ἢ Ἰάκωβος ἢ τί Ἰωάννης ἢ Ματθαῖος ἢ τις ἕτερος τῶν τοῦ κυρίου μαθητῶν, ἅ τε Ἀριστίων καὶ ὁ πρεσβύτερος Ἰωάννης οἱ τοῦ κυρίου μαθηταὶ λέγουσι. It is maintained by able scholars (from whom dissent can be expressed only with great diffidence) that the λέγουσι indicates that Aristion and John the elder were living, while the εἶπεν indicates that Andrew, Peter, John the apostle, Matthew, and all the rest of the apostles were dead at the time "when Papias began his investigations" (Westcott, *Canon*, p. 69). Now, John the apostle is supposed to have died at a very advanced age, about 98 A. D., and Papias (Lightfoot, *Contemporary Review*. May, 1875) to have been born about 60–70 A. D., and to have written (Westcott, *ut sup.*) about 140 150 A. D. We have therefore to suppose on this hypothesis *a*) that Papias did not "begin his investigations" till he was twenty-eight or thirty-eight years old (*i. e.*, not till seven or seventeen years after he had attained to manhood), although the apostle John was living all that time in his immediate neighborhood; (*b*) that two personal disciples of Jesus outlived the aged apostle John for a period long enough to enable Papias to conduct a systematic investigation into their traditions during their lifetime. "Improbable" is too mild a word for such a hypothesis. It seems very much more probable that λέγουσιν is simply the graphic present used for variety. Papias desires to make a distinction between the *dicta* of the apostles and the less authoritative utterances of Aristion and John the elder, who were not apostles. For this purpose he not only (1) mentions them separately, but also (2) varies the construction, changing τί into ἅ τε, and (3)

It must be added that Papias, besides recording the raising of a dead man by Philip, and the drinking of poison without injury by Justus surnamed Barsabas, is said by Eusebius to have narrated several "strange parables and teachings of the Saviour," and other fabulous matters, originating from a literal understanding of figurative expressions. He also published "a story about a woman accused in the presence of the Lord for many sins, which is contained in the Gospel according to the Hebrews" (Euseb., *ib.*). It has been demonstrated by Dr. Lightfoot that Eusebius, in treating of the disputed and undisputed writings of the earliest times, adopted one course for the former and another for the latter. (1) As to the disputed books, the *antilegomena*, he pledged himself to "record when any ancient writer employs any book belonging to their class;" but (2) as regards the undisputed canonical books, he only professes to mention them, "when such a writer has something to tell about them" (τίνα περὶ τῶν ἐνδιαθήκων εἴρηται) *Contemporary Review*, Jan. 1875. We are not therefore to infer from the silence of Eusebius that Papias did not know or quote the Gospels of Luke and John, but only that he said nothing about them; which of course might arise from either of two causes, either because he did not know of their existence, or because, knowing their existence, he "had nothing to say about them." What bearing this may have on the authorship of the Fourth Gospel we shall see hereafter. But, so far, we see written scriptures still (1) supplanted by oral tradition; (2) freely criticised as inadequate; and (3) accompanied by memoirs of various interpretations from some Hebrew original; though rapidly emerging, if they have not already emerged, to authoritative definiteness.

One fact is of the highest importance. We have seen that Papias was of a curious disposition, discontented with the written records before him, and anxious to supplement them by traditions. He was also, according to Eusebius, a man of no great judgment, fond of recording wonders, and, by his own account, fond of recording novelties. If therefore there had been any other non-canonical Gospel at that time, rivalling our present Gospels, and known to Papias, it seems probable, if not certain, that he would have used such a book; and, if he had done so, Eusebius could not (in the execution of his plan) have failed to mention such a use: but Eusebius makes no mention of the use of any non-canonical gospel by Papias. Even in the narrative of the sinful woman mentioned above, which was found in the Gospel according to the Hebrews, Eusebius expressly avoids saying that he derived the narrative from that Gospel. He merely says that Papias "has published a narrative which is contained in the Gospel according to the Hebrews" (it is probably the narrative interpolated in Jo. viii. 1–11); whereas, almost in the same sentence, he says that Papias "has used testimonies from the First Epistle of John." This negative evidence from the silence of Papias is strongly in favor of our Gospels.

Justin Martyr.

In the works of Justin Martyr (who is supposed to have written his *Apologies* and *Dialogue with Trypho*, 145–147 A. D.; so Hort, quoted by Westcott, *Canon*, p. 98) we find definite and abundant mention of written documents containing the facts of the Gospel narratives, but no assigned names of authors. The Gospel is by him considered as a whole, sometimes called εὐαγγέλια, sometimes εὐαγγέλιον, but frequently τὰ ἀπομνημονεύματα τῶν ἀποστόλων, and once (when he is referring to Mark's Gospel) τὰ ἀπομνημονεύματα Πέτρου. Bearing in mind Xenophon's well-known ἀπομνημονεύματα Σωκράτους, from which title "the word had already been borrowed by several writers" (Westcott, *Canon*, 108), we might naturally infer that the memoirs were not written by the apostles, but about the apostles or rather about their teaching; and this view is confirmed by what Papias says (above) about Mark, that he ἀπεμνημόνευσε, "recorded from memory," the teaching of Peter.[1] This probably was originally the meaning of the title as applied to our Gospels; but it seems to have been understood differently by Justin, as though it meant "written by the apostles." For in describing the descent of the Holy Spirit on Jesus at His baptism, he uses the words, "The *apostles* wrote." It might indeed be said that he has in his mind Matthew and John, for John also records this; but St. John's Gospel is not once quoted in the whole of his works, and it is inconceivable that, in this latent fashion, he should have referred once to a writing as apostolic, which elsewhere he never quotes. It seems more likely that Justin considered that the ἀπομνημονεύματα Πέτρου were written by Peter, so that the first two Gospels at all events were written by apostles; or else that he considered the First Gospel not to have been written by one apostle, but to have been a joint apostolic production. Elsewhere, in describing the agony of the Lord (Lu. xxii. 44), a passage peculiar to Luke, he seems to have been struck with the inapplicability of his favorite title to a work written by one who was only a follower of the apostles; and instead of his usual formula, he here substitutes "The memoirs which I assert to have been written by the apostles, and by those who attached themselves to them;" but even this more precise description would only hold good of the three Gospels used by Justin, on the supposition that the "Memoirs of Peter" were written not by Mark but by Peter. The subject is important, as showing by what easy stages a work written by a pupil may be supposed (even in the face of direct evidence to the contrary) to be written by the teacher.

For a full discussion of Justin's quotations from the Gospels the reader is referred to Westcott, *On the Canon of the New Testament*, pp. 95–175, and Sanday, *The Gospels in the Second Century*, pp. 88–137. Here it must suffice to state a few general conclusions deduced from an examination of his use of the Old and New Testament.

We must bear in mind then (1) that Justin is writing polemically, and that (especially in his dialogue with the Jew Trypho) a main object with him is to show that "the prophets are fulfilled in Jesus;" to the proof from prophecy he attaches more importance than to any other. (2) He is a most inexact quoter; and though he quotes long passages from the Old Testament accurately, shorter passages are quoted from memory inexactly, while Messianic passages, even when long, are modified (sometimes with a closer return to the Hebrew original) by Christian use and adaptation to Christ. (3) He often inserts words and notions of his own in the passages quoted from the Old Testament: for example, he says that Moses, in order to heal the children of Israel from the plague of serpents, "took brass and made an image of a cross and set this in the holy tabernacle, and said to the people, Should you look on this image and believe on it, ye shall be saved" (*Canon*, p. 124). (4) He ascribes texts to wrong authors, and quotes the same text in various shapes, not only in different books, but even in the same book and at short intervals (*Ib.* 127). This being the case, we shall naturally be prepared, in approaching the New Testament quotations of Justin, to find many inaccuracies, and some alterations of fact; especially where a slight alteration can render some Old Testament prophecy more applicable to the New Testament narrative.

Reviewing the quotations from the apostolic fathers given above, we shall expect to find in Justin also a great number of the words of the Lord and incidents in the life of Jesus quoted from tradition, which are not found in our Gospels. Clement, we find, has two passages roughly quoted from our Gospels; and one traditional saying quoted in Acts xx. 35. Ignatius (Vossian) uses phrases or sentences from Matthew four times allusively, but quotes a "word of the Lord" found in no Gospel. The author of the Epistle of Barnabas quotes Matthew once, and a non-canonical word of the Lord once. Polycarp is the first apostolic father, who, while four or five times quoting or alluding to sayings in our Gospels, quotes no non-canonical passages. Papias "published" a narrative contained in the Gospel according to the Hebrews. If then, in the small modi-

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εἶπε into λέγει. A hundred instances might be given from the Gospel of St. John alone, where εἶπε and λέγει are used indifferently and alternately for the mere purpose of variety; see John iv. 9, 10, 11, 13, 15, 17 (*bis*), and the whole of the Gospel *passim*. And for the use of λέγει in a dependent sentence following an imperf. indic., compare Plato, *Apol.* 21 B, ἠπόρουν τί ποτε λέγει, "I was in doubt as to what (the oracle) meant." It is true that Eusebius, though he denies Irenæus's assertion that Papias was a hearer of John the apostle, maintained that Papias heard John the elder. But he appears to have no evidence for this statement except the sentence just quoted, and the fact that Papias set down certain traditions of John the elder, mentioning him by name. His words are: "'Αριστίωνος δὲ καὶ τοῦ πρεσβυτέρου 'Ιωάννου αὐτήκοον ἑαυτόν φησὶ γενέσθαι. 'Ονομαστὶ γοῦν πολλάκις αὐτῶν μνημονεύσας ἐν τοῖς αὐτοῦ συγγράμμασι τίθησιν αὐτῶν παραδόσεις. This is quite insufficient in face of the great difficulties in such a supposition. The only tradition of an elder quoted by Eusebius from Papias with any words of preface begins thus: "The elder said this also." Such a preface is quite consistent with the supposition that Papias had heard the tradition, not from the elder himself, but from one who had attached himself to the elder (παρηκολουθηκὼς τῷ πρεσβυτέρῳ); and the above-quoted sentence of Papias itself better suits such a supposition, for the "cross-examining of those who had attached themselves to the elders" naturally applies to *all* the names that follow, and more especially to John, since he is expressly included in the class of "elders." "I used to cross-examine any that came in my way who had attached themselves to the elders (asking them), what said Andrew, . . . and about the sayings of Aristion and John the elder;" surely the natural inference is that Aristion and John are included in the "elders." If this be so, every difficulty vanishes. Papias, though placed before Polycarp by Eusebius, may have been naturally so placed because he died before the aged Polycarp, so that his work fell in a period preceding Polycarp; but he may have been born about the same time or later, say 80 A. D. In that case the last of the apostles would have passed away before Papias was nineteen; and when Papias began his investigations he would necessarily have to rely on the pupils of the elders, since the elders themselves, whether apostles, as Andrew and Peter, or mere elders, as Aristion and John, had all passed away. If, however, it should appear after all that Papias did hear John the elder, it follows that, when Irenæus described Papias as "the hearer of John," he either (1) meant John the elder, or (2) confused John the elder with John the apostle. In either case most important consequences might follow, bearing upon the authorship of the Fourth Gospel. For it follows that, if here, then on other occasions, when speaking of the authorship of the Fourth Gospel, Irenæus either (1) may have meant John the elder where we at present suppose him to mean John the apostle, or (2) may have confused John the elder with John the apostle.

[1] Clement of Alexandria (Eus., *H. E.*, vi. 14) expressly says that Peter had no part in the composition, and did not even encourage it. There seems to have been an early and not unnatural tendency to depreciate the Second Gospel.

cum of quotation hitherto given, so large a proportion (say a fourth) is non-canonical, how much more non-canonical matter might we naturally expect to find in Justin, who in two works quotes our Gospels 67 times (Sanday, p. 116), and occasionally in long continuous passages? We shall also expect to find in Justin many misquotations of our Gospels, arising from interpolations and corruptions of the text, for "the worst corruptions to which the New Testament has ever been subjected originated within a hundred years after it was composed" (Scrivener, quoted by Sanday, p. 135). A generation after Justin, Irenæus will be found quoting the interpolated appendix of Mark, which the general consent of scholars now recognizes to be spurious; and it has been pointed out that the differences of Justin from the ordinary text are little more than the differences of Codex D from the same text.

Bearing these considerations in mind, we ought to be surprised not at the large, but at the small amount of extraneous matter which Justin has introduced into the Gospel narrative, and at the comparative accuracy with which he has quoted the Gospels. Treating of the variations of quotation, Dr. Westcott has shown that, even where Justin's misquotations are found in other authors, the resemblances are of such a kind as to be easily derivable from some common tradition, or from some early but now obsolete text (*Canon*, pp. 148–156). The extraneous matter may readily be explained as arising either from sense of an omission or from the morbid desire to find in each incident of the life of Christ the fulfilment of some prophecy in the Old Testament. If, for example, (1) he speaks of the voice from heaven at the baptism as being, "Thou art My Son, this day have I begotten Thee;" this is explained (apart from the various reading in D, which no doubt arose from the same motive) by a desire to see in the voice a repetition of Ps. ii. 7. (2) If a fire is said to have been kindled in the Jordan at the Lord's baptism, was it not natural that He who came to baptize others with the higher baptism of fire, as well as that of water, should Himself receive the highest baptism; or that the act which was already technically known as φωτισμός, "enlightenment," should be accompanied (in the case of the Lord of Light) by that symbol which was specially characteristic of the divine presence? (3) If Mark recorded that Jesus was a "carpenter" (a fact not then suppressed by the various reading in Mk. vi. 3, owing to such sneers as those of Celsus, Origen, *Cont. Cels.*, v. 34), was it not fitting that the Carpenter, who bade men lay hand on the plough, and take His yoke on them, should have "wrought, when among men, ploughs and yokes"? (4) If he speaks of the Magi as having come "from Arabia," had it not been prophesied, Ps. lxxi. (lxxii.) 10, that "the kings of the Arabians shall bring gifts"? (5) If the foal of the ass on which our Lord entered Jerusalem was said by Justin to have been "bound to a vine," must it not needs have been so, seeing that it was said of Judah (Gen. xlix. 11) that "he bound his foal unto the vine"? (6) Lastly since Isaiah predicted (xxxiii. 16 in LXX.) that "he shall dwell in a high cave of a strong rock," was it not necessary that the Messiah should not only be born in Bethlehem, but also "in a cave"?

In all these additions there is absolutely nothing to make probable, or even suggest (even though the "fire" at the baptism of Jesus is mentioned in an apocryphal Gospel) that Justin used any other written Gospel than those known to us. These thoughts and others like them were floating in the atmosphere of every Christian church in those days. They were the results naturally developed from that habit of appeal to prophecy which has produced, even in our own canonical Gospels, not inconsiderable effects; and there is nothing in Justin's additions that is not capable of being explained from the same method (developed a little further) as that by which we may explain Matthew's addition about the potter's field, and possibly some of the other passages peculiar to the First and Third Gospels. Nor does the omission of the names Matthew, Mark, and Luke, by Justin, throw any doubt upon the supposition that he used the Gospels called by those names. It is quite possible that the names were given to these Gospels long after their composition. The very title, "The Gospel *according to* Matthew," etc. (not *of*, or *by*, Matthew), indicates that, even at the time when the titles were assigned, the compilers were regarded rather as editors of an old and received tradition than as authors of a new book. It is therefore quite possible that Justin (who mentions John by name as the author of the Apocalypse) may have used the first three Gospels, and yet have been ignorant of the names under which they are now current.

Three most important facts remain to be mentioned. (*a*) Justin tells us that in his days, the memoirs of the apostles were read with the books of the prophets in the service of the church. This public reading of the memoirs must have given, if not a complete security, at least a considerable guarantee against material alterations. The fact that the new traditions were now placed on a level with the ancient and venerable writings or scriptures of the Old Testament was a still more effectual barrier against change. (*b*) Although Justin mentions sayings of our Lord and events in His life not found in our Gospels, yet "he never does so when he proposes to quote the apostolic memoirs" (Westcott, *Canon*, p. 157). (*c*) In describing the fire kindled in the Jordan and the voice from heaven, he not only does not quote the memoirs, but, by implication, distinguishes these statements from other statements immediately following, which are quoted from the memoirs (*Canon*, pp. 158–159).[1]

To conclude, we find that, although Justin knew and used traditions, yet (1) he set a special value on certain writings, which were publicly read in the churches: (2) he believed these to have been written by apostles, or the immediate disciples of apostles, and he repeatedly quotes them under this title; (3) though he does not lay stress on miracles (for miracles would be assumed by the Jew Trypho accustomed to the miracles of Moses and Elisha, and they would be rather harmful than helpful to his cause in the eyes of educated Greeks and Romans), nor on the longer lessons involved in Christ's parables, yet he covers the greater part of our Gospel history, and much of our Lord's teaching through maxims; this he does to such an extent that it is possible (Sanday, pp. 91–98) to reconstruct from his quotations a fairly connected narrative of the incarnation, birth, teaching, crucifixion, resurrection, and ascension of the Lord; (4) the whole of this narrative (with the exception of the few unimportant incidents mentioned above, and one or two traditional sayings of Jesus) is found in Matthew, or Mark, or Luke, or in all three; and there is also a reference to an incident recorded by Mark alone: (5) he never, as from these memoirs, quotes any words, or alleges any incidents not found in our Matthew, Mark, or Luke; (6) he never quotes any rival Gospel, nor alleges any words or facts which make it probable he used a rival Gospel; (7) such non-canonical sayings and facts as he mentions are readily explicable as the results of lapse of memory, general looseness and inaccuracy, extending to the use of the Old as well as the New Testament, and the desire to adapt the facts of the new scriptures to the prophecies of the old. Our conclusion is that the memoirs of the apostles which include so much that is contained in our first three Gospels, and which were continuously read in the services of the church from the time of Justin downwards, cannot have passed into oblivion a few years afterwards, so as to have given place to rival Gospels not known to Justin. They must be identical with the Gospels, to some or all of which testimony is successively borne by Marcion (140 A. D.) in spite of his arbitrary and entirely uncritical excisions; by the heretical Clementine Homilies (160 A. D.?) in spite of occasional use of apocryphal sources; by the Muratorian fragment (170 A. D.); by Athenagoras and Ptolemæus, and the churches of Vienne and Lyons (177 A. D.); till the century closes with the affirmation of Irenæus, who not only uses three synoptical Gospels with the Fourth so fully as to leave no doubt of the identity of his Gospels with ours, but also is so convinced of the essential necessity that there should be four and only four Gospels, that he discerns in the quadriform nature of the cherubim a type of the pre-ordained quadriform nature of the records of the life of Christ.[2]

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[1] Perhaps we may also lay some stress on the fact that, in the seven passages in which Justin uses the phrase, "it is written," as applied to the memoirs, he almost always agrees *verbatim* with Matthew or with Luke (*Canon*, p. 130).

The Gospel of the Hebrews.

[2] As a good deal of stress has been laid upon the apocryphal Gospel of the Hebrews, from which (according to the testimony of Jerome, Kirchhofer, p. 449) Ignatius quoted, it may be well to show that this was later than our Gospels. (1) We have seen above (p. 718) that in the common tradition Ἰησοῦς is habitually employed, and that the use of ὁ Κύριος, "the Lord," in narrative is a sure sign of later origin; but "the Lord" is habitually used in the narrative of the Gospel of the Hebrews (see Kirchhofer, pp. 450, 453, 454). (2) It softens moral difficulties: (*a*) in the story of the rich young man, the Lord says to him, "Behold, many of the brethren, sons of Abraham, are covered with dung and dying for hunger, and thy house is full with many good things, and naught goeth forth at all from thee to them," thereby blunting the point of the young man's rejection; (*b*) after the words "If thy brother shall sin against thee" (*cf.* Matt. xviii. 22), Jesus adds, in the Gospel of the Hebrews, "in word, and if he shall make thee amends" (*Ib.* p. 454) (*in verbo et satis tibi fecerit*); (*c*) the error in Mat. xxiii. 35, "son of Barachiah," is corrected into "filium Jojadæ," Jerome (*Ib.* p. 455). (3) It increases the marvellous element: (*a*) at the baptism of Jesus, "It came to pass when the Lord was come up from the water, the whole fountain of the Holy Spirit came down and rested upon Him, and said to Him, O My Son, in all the prophets I was awaiting Thee, that Thou mightest come, and that I might find rest in Thee; for Thou art My rest, Thou art My first-born Son, who reignest for ever" (*Ib.* p. 454), (*b*) hence the Holy Spirit is called the Mother of the Lord, and it is said by the Lord, "But now My Mother, the Holy Spirit, took Me by one of My hairs, and carried Me away to the Mount Tabor" (*Ib.* p. 451); (*c*) after His resurrection, it is added that the Lord ordered a table and bread to be brought, and caused His brother James to break his fast, when James had sworn not to eat bread till he had seen the Lord; in this story James is called "James the Just," a title which in itself is a mark of late composition.

To this note we may add that Celsus, towards the end of the second century, speaks of "the writings of the disciples of Jesus" (*Ib.* p. 330) as the source of his information, and mentions nothing (so far as we know) of any importance that is not found in our Gospels. It is true that Origen (*Cont. Cels.*, ii. 74), in answer to Celsus's boast that he had crushed the Christians with facts taken from their own writings, replies, "But we showed (above) that there has been a great deal of nonsensical blundering, contrary (παρά) to the writings of our

Summary of the external evidence.

In the foregoing remarks attention has been mainly directed to definite evidence, whether external or internal. Limits of space, as well as other considerations, prevent the discussion of that more indefinite evidence which might perhaps be called indirect external evidence and which would treat of the influences amid which the Gospels grew up and by which they were likely to be moulded. For such a discussion it would be necessary that we should place ourselves in the position of a disciple in some early congregation of Jewish or Gentile Christians, and endeavor to realize the influence exerted upon the Christian records—(1) by prophecy; (2) by heathen religions; (3) by Eastern metaphor acting upon Western literalism; (4) by the ritual and language of the Lord's Supper; (5) by the universal predilection for the marvellous; (6) by the fall of Jerusalem. The results thus obtained would be in a great measure conjectural; but, compared step by step with the results deduced above, they would enable the reader to feel additional confidence in conclusions supported by the double confirmation of indirect as well as direct evidence. The best work in English bearing on this subject is probably the translation of Keim's *Jesus of Nazara* (London, 1876–79); and there is also much valuable information in the Appendices to Canon Farrar's *Life of Christ.*

THE FOURTH GOSPEL.

Authorship.

Early evidence of authorship.

Evidence from earliest Tradition.—Before considering the subject matter of this Gospel, it will be well to consider the evidence, direct and indirect, bearing on the authorship. The author is not mentioned in the Gospel by name, but only as "the disciple whom Jesus loved" (xxi. 24, 20), "which also leaned on his breast," and to whom Jesus commended His mother from the cross (xix. 26; xiii. 23). The first writer who mentions John as the author in connection with a passage quoted from our Fourth Gospel is said to be Theophilus, who wrote towards the close of the second century (170–180 A. D.). The Muratorian fragment (170 A. D.) speaks of the apostle as the author of a Gospel, but does not quote from it. But Theophilus quotes Jo. i. 1, as written by John, one of those "inspired by the Spirit" (πνευματοφόρων).[1] It is a natural inference that Theophilus (at so late a date), using the name thus without further definition, meant by "John," the "John" best known to his readers, *i. e.*, John, the son of Zebedee, the apostle. But there is unusually strong evidence to show that John the apostle wrote the Apocalypse, so strong that we may assume the apostolic authorship of that book with more confidence than the authorship of any other book in the New Testament, except some of Paul's epistles. The question therefore arises, how far does the style of the Gospel, which was said by Theophilus (170–180 A. D.) to have been written by John (presumably the apostle), agree with the style of the Apocalypse, which we have so good reason for believing to have been written by the apostle John? If we assume John to have been four or five years younger than his Master, he would be, according to the commonly received date (68 A. D.) of the Apocalypse, about sixty-seven or sixty-eight years of age when he wrote that work. By that age (one would suppose) an author's style would, if ever, have reached its maturity. Even if he were ten years younger than Jesus, so that he was only a little over sixty years of age, yet his style would not be capable of a complete transformation. But when the Gospel is compared with the Apocalypse, instead of similarity, we find an almost complete contrast.[2] The vocabulary, the forms, the idioms, the rhythm, the thought—all is different. That the Apocalypse and the Fourth Gospel should have been written by the same author would be, we will not say impossible, but one of the most marvellous literary phenomena ever authenticated. The change in Shakespeare's style, or in the style of Burke, cannot be compared with this; for those changes can be in part explained by the transition from youth to maturity or old age. Here we have to explain how a writer could completely change language, style, and thought, after the age of sixty or sixty-seven years. It is possible, but *a priori* highly improbable.

It has indeed been suggested that this change of language may be explained by the lapse of more than thirty years, during which the author was living in the midst of a Gentile population. This assumes that the Apocalypse was written in 68 A. D., before John had resided in Ephesus, and that he wrote the Gospel at the age of ninety-eight. But (1) the minute knowledge of the Seven Churches (Rev. i. ii. iii.) makes it probable that the writer had resided for some time in their neighborhood; (2) the composition of such a work as the Fourth Gospel at the age of ninety-eight is in itself unlikely; (3) it is by no means certain that the Apocalypse was written in 68 A. D., and not rather in 78 A. D., simultaneously with the fourth Sibylline Book (and the later the date of the Apocalypse the shorter the interval between it and the Fourth Gospel, and the more improbable becomes the theory of the change of style). An hypothesis based upon three hypotheses, themselves not proved or improbable, requires much evidence before it can be accepted.

There is yet another difficulty in the way of believing that John the apostle is the author: the words of Jesus in the Fourth Gospel (1) differ altogether in style and rhythm from the synoptic tradition of the words of the Lord, and (2) do not differ at all from the author's own remarks and observations. So great is the similarity between the words of the writer and the words which are assigned by him either to our Lord or to John the Baptist that Dr. Westcott, commenting on Jo. iii. 10–21, 27–36, says (*Introduction to the Gospels*, p. 292), "It is impossible not to feel that the evangelist is in fact commenting on and explaining the testimony which he records. The comments *seem to begin* respectively at verses 16 and 31." The words italicised (not by Dr. Westcott) require little comment. It is obvious that a biographer, who so mixes the words of his characters with observations of his own that a most careful and scholarlike commentator is unable to feel sure where the words of the characters end and the observations of the author "seem to begin," cannot be supposed to be exactly recording, scarcely even to be attempting to record with exactness, the words of the characters themselves. Yet it seems impossible that the "disciple whom Jesus loved" should either remember his Master's words so ill, or else deliberately transmute them into entirely different language of his own. A work of this kind, notwithstanding the presence of historical elements, seems rather to deserve to be called a poem, or a drama, than a biography; and accordingly the same careful commentator who is quoted above declares that "the spirit of parallelism, the instinctive perception of symmetry in thought and expression, which is the essential and informing spirit of Hebrew poetry, runs through the whole record" (*Introd. to the Gospel of St. John*). Such a work does not seem likely to have proceeded from one of the sons of Zebedee, a fisherman of the lake district of Galilee, not indeed a poor man, but still not a man of letters nor of any great literary culture.

The hypothesis of joint authorship or revision.

"The earliest account of the origins of the Gospel is already legendary" (Westcott, *Introduction to the Gospels*, p. 255), as given in the fragment of Muratori (A. D. 170). It is there said that, being requested by his fellow-disciples and bishops to write, John desired them to fast for three days, and then to relate to one another what revelation each

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Gospels," etc.; but if we refer to what has gone before, we find that Origen is referring (1) to Celsus's unfair inaccuracy, *e. g.*, in saying that Jesus was betrayed, not by one disciple, but by His disciples; (2) to such blunders as the confusion of "Chaldeans" with "Magi;" (3) to his ignorance of the number of the disciples, etc. There is therefore every reason to believe—for if Celsus had attacked any apocryphal narratives as representing the faith of Christ, Origen could not have failed to take advantage of the triumphant rejoinder which such a mistake would have afforded him—that an assailant of Christianity, writing before the end of the second century, knew of no writings of the disciples of Christ upon which he could base any effective attacks against their religion, except our four Gospels.

[1] Such at least is the statement of Kirchhofer (p. 153), and it has been reproduced in modern books. But part of the period of Irenæus might precede part of the period of Theophilus; and Irenæus quotes John's Gospel (xx. 31) as from "John the disciple of the Lord," in a passage of his work *Against Heresies* (III. xvi. 5, or ed. Grabe, iii. 18), a passage omitted by Kirchhofer.

[2] It is not necessary, however, to deny that the Gospel exhibits traces of the Apocalyptic doctrine and thought. On the contrary, the impression left by a comparison of the two is, that the Gospel exhibits an attempt to refine and spiritualize some of the more material and concrete expressions of the Apocalypse. From this point of view, we may say that "the Gospel is the spiritual interpretation of the Apocalypse. . . . The active and manifold religious thought of Ephesus furnished the intellectual assistance which was needed to exhibit Christianity as the absolute and historical religion in contrast with Judaism and heathenism" (Westcott, *Introd. to St. John*).

had received either for or against the project. The same night it was revealed to Andrew, one of the apostles, that "while all called (the past) to mind (or while all revised, —'cunctis recognoscentibus'), John should write everything *in his own name.*" Legendary though this account may be, it curiously agrees with a passage in the Gospel itself which implies that others besides the author were "revising," or otherwise assisting in, the work: "This is the disciple which testifieth of these things and wrote these things: and we know that his testimony is true" (xxi. 24). Yet immediately afterwards—in a sentence which, though omitted by Tischendorf, is supported by the MSS. almost without exception—the singular number is resumed: "I suppose that the world could not contain the books that should be written." This passage certainly seems to indicate some kind of joint authorship or revision, or at all events a desire to convey the impression of joint authorship or revision, such as the Muratorian fragment describes. The theory of joint authorship or revision is confirmed by evidence derivable from the 1st Epistle of John, which is justly regarded (Lightfoot, *Contemp. Rev.*, 1875) as a kind of postscript to the Gospel. It begins (like the Gospel, and unlike the Apocalypse, as also unlike the 2d and 3d Epistles of John) without mention of the author's name, and in the plural number: "That which was from the beginning, which we have heard, which we have seen with our eyes, which we have looked upon, and our hands have handled, declare we unto you, that ye also may have fellowship with us." Yet at the conclusion of the first chapter, as though it were to be understood that the whole was written "in the name of John" ("suo nomine," as the Muratorian fragment has it), the singular number is used, "these things write I unto you" (1 Jo. ii. 1, 7, 12, 13, 14, 21; v. 16).[1] So far therefore as we have gone, the evidence is very decidedly against the supposition that John the apostle was the sole author of the Fourth Gospel. He may have written it (1) through an amanuensis or disciple, who translated his language (and possibly his thoughts also) in the process of expressing them (just as Paul is said by some to have written the Epistle to the Hebrews in Hebrew, and to have had it freely rendered by one of his followers);[2] or (2) it may have been an attempt on the part of a leading teacher of the Johannine school at Ephesus to reproduce the spirit of their Master's teaching after He had been taken from them by death, an attempt of one of the Ephesian elders to reproduce John once again in their church, surrounded by Andrew and Philip and Aristion and the rest of the disciples of the Lord, the former proclaiming and all the rest assenting to "that which they had heard, that which they had seen with their eyes."[3] If during the latter years of his life John was infirm and bedridden, obliged to preach and teach by deputy,[4] it is obvious that the "teaching of John" during the last eight years of his life, when the old man was now past ninety years of age, might be very different in language, and even somewhat different in thought and substance, from the teaching of the apostle himself; and a spiritual doctrine, taught in the Ephesian church, and based upon three or four traditions affirmed by the aged apostle, such as the tradition of blood and water, might, even in the lifetime of the apostle, become known, within a limited district, as the Gospel according to the apostle John. How different, in language if not in substance, may be a pupil's record of a master's teaching may be perceived from Plato's and Xenophon's records of the teaching of Socrates. But in any case, whatever may be the authorship of the book, it must be admitted to be, so far as we have gone, in the highest degree improbable that John the apostle wrote the Fourth Gospel with his own hand at the age of ninety or nearly a hundred, in the same way in which he wrote the Apocalypse at the age of sixty or seventy or eighty.

Evidence from quotations. Papias.

Evidence from Quotations.—But we pass now to the evidence of the early fathers. Theophilus and Irenæus are the first to quote John by name, but earlier writers, who do not mention his name, quote words contained in the Fourth Gospel. We will take Papias first. He tells us (see above, p. 725) that he used to inquire about the *dicta* of Andrew, Peter, Philip, Thomas, James, John, Matthew, or any other disciples of the Lord, and also about the sayings of Aristion and the elder John, the disciples of the Lord. The order of names is remarkable, and it has been most ingeniously inferred (Lightfoot, *Contemp. Rev.*, Oct., 1875) that John is placed, out of his order of precedence, along with Matthew, because the last two had left written Gospels; moreover the order of the first three, "Andrew, Peter, Philip," quite unlike the synoptic order, is the order in Jo. i. 40–43, which suggests that Papias was aware at all events of the story of the calling of the apostles contained in the first chapter of the Fourth Gospel. We are also told by Eusebius that Papias "used testimonies" from the 1st Epistle of John. This is, of course, no proof that Papias quoted the Epistle with John's name (for quotations of New Testament documents with the name of the author are not common in the earliest writings of the church); but it may be inferred that he regarded the 1st Epistle of John as an authoritative document; and the Epistle is so closely connected with the Gospel that, if the apostle John is proved to be the author of the one, it must follow that he is the author of the other also. But it is important to note that Papias recognized two Johns, both of whom were "disciples of the Lord;" and Eusebius tells us that Papias quoted certain traditions of the non-apostolic John, distinguishing him as "the elder,"—"the elder used to say," etc. Now Irenæus—who speaks highly of Papias, describing him (wrongly) as a "hearer of John" (the apostle),—quotes Papias as one of "the elders who saw John the disciple of the Lord," and who remembered how he (John) had repeated to them certain teachings of the Lord Jesus, to the effect that "the days will come in which vines shall grow, having each 10,000 branches, and in each branch 10,000 twigs, and in each twig 10,000 shoots, and in every shoot 10,000 clusters, and in every cluster 10,000 grapes, and every grape when pressed will give 25 measures of wine. And when any one of the saints shall lay hold of a cluster, another shall cry out, 'I am a better cluster, take me; bless the Lord through me,'" etc. (*Apostolic Fathers*, Clark's trans. p. 443). The question therefore arises, Which John is here meant? It seems certain from the context that Irenæus meant *the* famous John, the apostle: yet he calls him nothing but "disciple," and the tradition imputed to John (though not out of accord perhaps with the imagery of the Apocalypse) is quite unlike anything that we find in the Gospel or 1st Epistle called by John's name. On the other hand, a passage of the Fourth Gospel (xiv. 2) is quoted by Irenæus (*Adv. Hær.*, V. xxxvi. 2) in connection, not with John the apostle, but with "elders," and possibly as part of the doctrine communicated to Papias by the "elders" ("the context makes it at least highly probable that the passage was quoted from Papias's 'Exposition,'" Westcott, *Introd. to the Gospel of St. John*). But, if this be so, *i. e.*, if a passage of the Fourth Gospel was communicated to Papias, not necessarily by John the apostle, but by "elders," then it follows that among the "elders" who communicated it to him may have been John the "elder." Although this is, in great measure, conjectural, yet, even as a possibility, it becomes deserving of attention, when placed in juxtaposition with the certainty mentioned above; (1) it is *possible* that a saying in the Fourth Gospel was communicated to Papias, not by John the apostle but by John the elder; (2) it is *certain* that the only passage quoted from Papias as coming from John (the apostle) is not to be found in the Fourth Gospel and in no way resembles the style or thought of the Fourth Gospel. Again, the 2d and 3d Epistles of John, which have the name of the author inserted, are written, not in the name of John the apostle, but in the name of "the elder," and they were so doubtfully regarded (perhaps on that account) by the church that Eusebius places them among the "impeached (ἀντιλεγόμενα) writings," while Origen speaks of them as only possibly genuine, and Jerome attributes them not to John the apostle but to John the elder. Yet Irenæus quotes this 2d "impeached" Epistle, not as the work of

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[1] Of course the "we," whereby the writer identifies himself with his readers (ii. 3 and *passim*), is quite different from the "we" mentioned above.

[2] The statement that Papias "wrote out the Gospel at the dictation of John," quoted by Westcott (*Canon*, p. 76) from an argument prefixed to an MS. of the 9th century, is probably worthless, except as indicating an opinion much earlier than the MS., that John did not himself write the Gospel.

[3] That a similar attempt was made to reproduce, as it were, the authority of Peter by a writer in the 2d century, we have seen above (p. 724) in the account of the Second Epistle of Peter. But the circumstances and prolonged infirmities of the apostle John might make such an attempt far more successful and a far more accurate representation of spiritual truth.

[4] Jerome, *Comm. in Ep. ad Gal.*, vi. 10, quoted in Westcott's *Introd. to St. John.*

John the elder, but (twice) as the work of "John the disciple of the Lord." Evidently there is here, if not confusion, at least a danger of confusion, and one cause of confusion can be immediately indicated. Papias tells us that both John the apostle and John the elder were "disciples of the Lord." Now, for some reason or other, Irenæus, though he quotes Matthew as "the apostle" (*Adv. Hær.*, III. ix. 1) and a speech of Peter as spoken by "the apostle" (*Ib.* xii. 1), appears not to quote the Fourth Gospel except as written by John "the disciple of the Lord," or simply "John" (*Ib.* xi. 1, 2, 3, 7). It cannot indeed be assumed that Irenæus is here (unconsciously) referring to John the elder, and not to John the apostle. On the contrary, the more probable explanation is, that John the apostle was himself called by preference John "the disciple of the Lord," as being "the disciple whom Jesus loved."[1] Nevertheless it remains an unfortunate fact that Irenæus and Theophilus, who are the first to quote John by name, give us no means of ascertaining whether they refer to John the apostle or John the elder, both of whom are described by Papias as being "disciples of the Lord." In this state of confusion we are naturally led to suspect that possibly the two Johns mentioned by Papias (neither of whom, as we have shown above, was probably known to Papias himself) may have really been one; and this suspicion is confirmed by the testimony of Jerome, who informs us that though two tombs were shown in his time at Ephesus, one as the tomb of John the apostle, and the other as the tomb of John the elder, yet some considered the two persons to be identical; "nonnulli putant duas memorias ejusdem Joannis evangelistæ esse" (Jerome, quoted by Kirchhofer, p. 159). We have not evidence to prove this theory, but neither have we evidence to disprove it; and we must therefore leave the question who was the author of the Fourth Gospel (so far as the evidence of Papias and Irenæus can help us) unanswered and unanswerable. Indeed it cannot be denied that the probability is that Papias did not know of its existence as an authoritative Gospel written by the son of Zebedee. For, had he known it, would he have had "nothing to say" about its origin, about the contrast between it and the Apocalypse, about the difference between it and the synoptic narrative, and about the interesting account of its composition given in the Muratorian fragment and therefore current before 170 A. D.? That Papias should have "nothing to say" about Luke's Gospel is intelligible, because the dedication to Theophilus speaks for itself; but why he should describe the origin of the First and Second Gospels and pass over the Fourth, where there was so much to describe, and where a joint-authorship was not only suggested by tradition but also by internal evidence (John xxi. 24), is by no means easy to explain. In the face of this silence we cannot attach much value to the evidence in Papias for the apostolic authorship, derived from the association of John with Matthew in the list of the apostles. Against that evidence, too, such as it is, must be set the fact that the only tradition detailed by Irenæus as coming through Papias from John the disciple of the Lord is one quite unlike the tone of the Fourth Gospel. The latter negative at least neutralizes the first positive; and the scale is thus left unaltered, pressed heavily downwards against the apostolic authorship by the discrepancy of style (when the Gospel is compared with the Apocalypse) and by the external and internal evidence of joint authorship.

Evidence has been drawn from the epistle of Barnabas, the "Shepherd" of Hermas, the Ignatian letters, the epistle of Polycarp to the Philippians, the works of Justin, and the Clementine Homilies, to show that the authors of these writings used the Fourth Gospel (Westcott, *Canon passim;* Sanday, *Gospels in the Second Century*, 273–298); and no candid mind can resist the proof that some of them knew and were influenced by the thoughts of the Fourth Gospel, while some even used its language. But it is by no means certain, indeed it is improbable, that they knew of it as a Gospel; and it is still more improbable that they recognized it as a Gospel written by "the disciple whom Jesus loved." Else, how comes it that Justin quotes Matthew about fifty times and the Fourth Gospel once, or not at all?

Moreover, the apparent quotations of the Fourth Gospel in the apostolic fathers show not so much the use of a document from the first, as rather the influence of the common atmosphere of the Asian churches, the floating tradition of the Ephesian school, gradually merging into a definite document. Barnabas, for example, speaks of "water," with a certain mystery, associating it with the "cross;" as also Justin seems to do, mentioning the cross and baptism in consecutive chapters (lx. lxi.) of his *First Apology.* But the Clementine Homilies, amplifying the mysterious efficacy of water, as being the origin of all things, and the direct recipient of the impulses of the Spirit (ch. xxiv.), give a loose quotation of Jo. iii. 5, which seems adapted for the Clementine context by being blended with the baptismal formulary previously mentioned by the writer in xxviii. 19: "For thus the prophet has sworn to us, saying, Verily I say to you, Unless ye be regenerated by living water into the name of Father, Son, and Holy Spirit, ye shall not enter the kingdom of heaven." It can scarcely be an accident that this same passage is the only passage from the Fourth Gospel quoted in the whole of the works of Justin Martyr. Moreover, in Justin also, as in the Clementine Homilies, it is not so much the Gospel as rather the substance of the Gospel that is given; and this, too, in a shape not so developed as that which appears in the Fourth Gospel.

Justin Martyr.

It is worth while to sketch the growth of this passage, for the process is a typical one, and will illustrate many other theological developments. The doctrine of the new birth first appears (but only in its germ) in the synoptic Gospels: "Except ye be converted, and become as little children, ye shall not enter the kingdom of heaven" (Mat. xviii. 3: *cf.* Mk. x. 15; Lu. xviii. 17). But Jesus clearly did not mean that his disciples were to become like little children by becoming ignorant, foolish, or helpless; but only that they must trust the Father in heaven, as earthly children trust their earthly parents; in other words, that they must become children of the heavenly Father, and therefore be born again with a heavenly birth. It was therefore a legitimate development of Christ's teaching to remind Christians (1 Pet. i. 3, 23) that they had been "begotten or born again" (ἀναγεννᾶν); and Paul describes his converts as "begotten" (γεννᾶν) by himself in Christ spiritually, distinguishing such a birth from the "birth according to the flesh" (Gal. iv. 23, 29). It was inevitable that the Christians should early associate this spiritual birth with the rite of purification or baptism, with which they would naturally (as John had done) introduce their converts into the church. But further, as soon as the need of this spiritual "begetting" became a part of the teaching of the church, it would have to be protected against the literalism of misrepresenting enemies and of dull unspiritual friends. Jews and Gentiles would argue, "But it is impossible for a man who has once been born to enter a second time into his mother's womb." This argumentative objection would therefore be naturally placed (in the minds of the teachers and catechists of the first century) side by side with the doctrine of Christ. One teacher, treating the subject dramatically, might put the objection into the mouth of an objector in the shape of dialogue; another might state the answer to the objection in his own person. With this explanation we shall at once understand that Justin, though appearing (in the course of an argument upon baptism) to quote the Fourth Gospel once only (whereas he quotes Matthew fifty times), is not really quoting it, but only the floating tradition of the Ephesian elders, when he writes as follows:—

Justin, *Apol. I.*, lxi.	John iii. 3–5.
"For Christ said, Except ye be born again (ἀναγεννᾶν, Peter's word, 1 Pet. i. 3, 23), verily ye shall not enter into the kingdom of heaven. Now, that it is impossible for those who have once been born to re-enter the wombs of those that bare them is evident to all." [Here the quotation terminates, without making any reference to water.]	"Jesus answered and said unto him, Verily, verily, I say unto thee, except a man (γεννηθῇ ἄνωθεν) be born again (or from above) he cannot see the kingdom of God. Nicodemus saith unto Him, How can a man be born when he is old? Can he enter the second time into his mother's womb, and be born? Jesus answered, Verily, verily, I say unto thee, Except a man be born of water and the Spirit, he cannot enter into the kingdom of God."[2]

Note here the inexplicable omission—on the hypothesis that it is an omission. We must bear in mind that in the preceding extract Justin is arguing for baptism by *water*. How obvious then to quote the words of Christ himself, "Except a man be born of *water* and the Spirit," etc. But Justin does no such thing. He gives as a reason for water-baptism the intention that men may not remain "the children of necessity and ignorance," which reason, he says, we have learned from the apostles. He also quotes, suitably enough, the saying of Isaiah, "Wash you, make you clean." Lastly, he quotes a saying of Christ, and omits from it (supposing that he has the Fourth Gospel before him) the very words which tell with greatest force for him, and which indeed make all further argument unnecessary! It is possible, but most improbable, that Justin should quote Matthew fifty times, and a Gospel which he knew to be written by the beloved disciple of the Lord only once; but it is more than improbable—it is inconceivable—that, in this single quotation, he should not only quote inaccurately, but omit the very words that were best adapted to support his argument.

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[1] Compare *Fragments*, iii., "John the disciple of the Lord and the other apostles with whom he was conversant." Hippolytus doubles the title (*Christ and Antichrist*, ch. 36), "Tell me, blessed John, apostle and disciple of the Lord." In speaking of the author of the Apocalypse, Irenæus (*Adv. Hær.*, IV. xx. 11) describes him not only as the "disciple of the Lord," but also as the disciple "upon whom Jesus had leaned at supper."

[2] The argument is not affected even though we adopt in John iii. 3 the reading ἀναγεννηθῇ, which is unquestionably proved by the Latin renderings to have been a very early reading. Whichever be the reading, Justin's omission—as an omission—remains inexplicable.

The probability is that Justin's quotation represents one stage, and the Fourth Gospel another stage, of the Christian doctrine of the new birth, and that the Ephesian "usus ecclesiasticus" had not yet come to his knowledge, or, if it had, had not yet superseded the less developed tradition. The stages may be classified as follows: (1) Synoptists, "Except ye become as little children;" (2) Justin, "Except ye be born again;" (3) a third stage is implied in 1 Pet. i. 3, 23, and iii. 21, and it would run thus, "Except a man be born of the Spirit as well as water" (a protest against the Essenistic overvaluing of ablutions, see also *Sibylline Books*, iv. 164–174); (4) the inevitable transition hence was to the form in the Fourth Gospel, "Except a man be born of water and of the Spirit." Here the authority of the Ephesian apostolic school arrested the development, which would else have issued in (5) the Clementine stage, "Except ye be regenerated by living water into the name of Father, Son, and the Holy Spirit, ye shall not enter the kingdom of heaven." If (6) "living" had subsequently been omitted, the development would have been completed in a sixth and last stage.

Ignatius.

Take another case of the apparent use of the Fourth Gospel by Ignatius. "I desire bread of God, heavenly bread, bread of life, which is the flesh of Jesus Christ, . . . and I desire drink of God, His blood, which is love imperishable, and ever-abiding life" (*Ep. to the Romans*, ch. vii.). Now here it is true that we have a thought peculiar to the Fourth Gospel. Paul speaks of the "blood" always as sacrificial, the "blood of sprinkling;" and indeed to a Jewish mind, taught to "abstain from blood," the thought of drinking "blood" would be at first extremely repulsive, even as a spiritual metaphor. It is very unlike anything in the Apocalypse, where blood is never "drunk," except by the scarlet woman and the murderers of the saints. But it is an image that must have suggested itself to the church as soon as the Gentiles, unfettered by Jewish associations, began to be imbued with eucharistic thought. Indeed, after the first repugnance had worn away, Jewish thought itself—even Pauline thought, and much more the thought of Jewish Christians trained in the school of Philo—would hasten the adoption of the eucharistic metaphor. For was not the blood "the life," according to Moses? And was not a Christian taught to believe, with Paul, that his individual life was merged and "hid" in Christ's life? Again, it would soon be felt that to speak merely of feeding on Christ's flesh was to present the New Testament in an unsymmetrical and almost maimed aspect. Moses had not only fed his people upon bread from the sky (the manna), but had also given them water to drink from the rock. What had the church to show against this symmetrical display of Mosaic power? It was not enough to say (with Paul) that that same "rock" was really Christ: it was necessary to show that the rock still supplied the faithful with divine drink. And for this purpose, what was more appropriate than the cup of the Lord's blood? Regarded in this way, the metaphor would commend itself speedily even to the Jewish mind. Nay, to the cultivated Alexandrian Jew, it would at once commend itself, as we may perceive from the works of Philo, who uses words so strikingly similar to Christian thought that they might almost seem, to a hasty reader, to have (of themselves) originated the eucharistic miracle of Cana. "Who can pour over the happy soul (which proffers its own reason as the most sacred cup) the holy goblet of true joy, except the cup-bearer of God, the Master of the Feast, the Word?" (*On Dreams*, ii. 38). When such thought as this was floating in the atmosphere of Ephesus and Alexandria, it is impossible to draw from the vague resemblance of the Ignatian passage quoted above any inference that Ignatius was quoting, or even referring to, the Fourth Gospel.

Polycarp.

Nor can we infer any quotation of documents from the fact that Polycarp (*Ep. to Philip*, ch. vii.) mentions Antichrist in language somewhat similar to 1 Jo. iv. 2, 3. "Every one that doth not confess that Jesus Christ hath come in the flesh," writes Polycarp, "is Antichrist; and whoso doth not confess the mystery of the cross is of the devil." The thought indeed is manifestly similar, and the language so far similar as to show that both Polycarp and the author of the epistle lived amid identical traditions of Christian teaching. But the epistle itself testifies that the name "Antichrist," so far from being invented by the author of the epistle, was already current in the church: "Little children, ye have heard that Antichrist shall come." If, therefore, it was a fact that already in Asia there had arisen a sect denying that Christ had come "in the flesh," and that the Ephesian circle of apostles first, and the Ephesian school of elders afterwards, had denounced such a belief as being of Satan and of Antichrist, and if this was taught to the Ephesian catechumens, and preached in the Ephesian pulpits, in a form sanctioned by authoritative teaching and by repeated use, what more is wanting to explain the similarity between the Epistle of John and that of Polycarp?

Justin Martyr.

Again, it is said that Justin (*Dial*, ch. 88) imitates John (i. 23) in putting the words "The voice of one crying," etc., into the mouth of John the Baptist, instead of placing them as an evangelical comment (as the synoptists do) on the appearance of the Baptist (Mat. iii. 3; Mk. i. 3; Lu. iii. 4). But this inference is unsound, as can be shown by analogy; for Mark uses also as an evangelical comment (i. 2), "I send My messenger before thy face;" but Matthew and Luke place it in the mouth of our Lord (Mat. xi. 10; Lu. vii. 27); and therefore, according to the reasoning above, we must infer that Luke had copied Matthew, or Matthew had copied Luke, in taking the evangelical comment, and inserting it in a discourse of Jesus! How fallacious would be such a deduction! How much more reasonable to suppose that—in accordance with the inevitable tendency thus to take prophecy, as it were, out of the framework, and insert it in the picture—Matthew and Luke have independently adopted a tradition later than Mark, which transposed Mark's evangelistic application of prophecy, and inserted it in the words of the Lord! But if this is the more probable solution in the case of Matthew and Luke, why not also in the case of Justin and John, the circumstances being precisely the same?

But it has been urged that, although Justin cannot be shown to have quoted the Fourth Gospel, yet his acquaintance with the Valentinians (*Dial.* 35)—"who freely used the Fourth Gospel" (Iren. *Adv. Hær.*, I. viii. 5)—"shows that the Fourth Gospel could not have been unknown to him" (Westcott, *Introd. to Gospel of St. John*). Justin's words are these: "There are, and there were, many who, coming forward in the name of Jesus, taught both to speak and act blasphemous things, with whom we have nothing in common, since we know them to be atheists. Some are called Marcians, and some Valentinians, and some Basilidians, and some Saturnilians, and others by other names." Now this mere mention of the Valentinians as one of a number of abhorred sects, with whom the writer has nothing in common, scarcely seems to prove any minute acquaintance on the part of Justin with the opinions or books in use among the Valentinians. But even if it be proved, what is the consequence? Surely this, that Justin, knowing the Fourth Gospel to be freely used by a sect which he stigmatizes by name, altogether abstained from using it himself. Irenæus, who uses the Fourth Gospel, accuses the Valentinians of misusing it; Justin, who does not use the Gospel, brings no such accusation. The natural inference is (if any inference at all is to be drawn from such slight premises) that either he did not know of the existence of the Gospel or of its misuse, or that he knew of its existence and use but did not recognize its authority.

Two more instances must conclude the list. It is found that both Justin and John alter the quotations of Zech. xii. 10 from the LXX. version (*ἐπιβλέψονται πρὸς μὲ ἀνθ' ὧν κατωρχήσαντο*) into *ὄψονται εἰς ὃν ἐξεκέντησαν*: "They shall look on Him whom they pierced;" and the Apocalypse (i. 7) also contains the same word in "they also which pierced Him." But this, as we have seen above, especially as it involves a return to the Hebrew text, is perfectly explicable on the same grounds as those which explain prophecies similarly quoted by the synoptists—viz., a common "ecclesiastical use." Still less can anything but floating tradition be inferred from such an allusion as is contained in Polycarp's Epistle to the Philadelphians: "The Spirit, coming from God, is not to be deceived; for it knoweth whence it cometh, and whither it goeth." Here, though the words *οἶδεν πόθεν ἔρχεται καὶ ποῦ ὑπάγει* (*ὑπάγει* is a word specially disliked by Luke in his Gospel, and not used by Paul), being identical here and in John iii., do certainly, as Dr. Sanday points out (*Gospels*, p. 275), imply "an association of ideas," yet, as the same writer remarks, the thought is different. Polycarp says, "The Spirit knoweth whence it cometh;" John says, "We know not whence the Spirit cometh." This indicates that Polycarp is vaguely alluding to oral and traditional doctrines current in his province (familiar, perhaps, but by no means as yet authoritative), rather than quoting from a Gospel known to be written by one of the foremost of the apostles, the "beloved disciple of the Lord."[1]

The Logos of Justin and Philo.

But it is urged (1) that Justin has the doctrine of the Christian, as distinguished from the Alexandrian, Logos; (2) that he could not have had originality enough to develop this himself, and therefore (3) he must have borrowed this method of thought from the Fourth Gospel. And the following expressions are quoted: "Jesus Christ is, in the proper sense (ἰδίως), the only Son begotten of God, being His Word (λόγος), and First-born, and Power (Πρωτότοκος καὶ Δύναμις);" "But His Son, who alone is rightly (κυρίως) called Son, who before all created things was with Him and begotten of Him as His Word, when in the beginning He created and ordered all things through Him," etc.; "Now, next in order to the Father and Lord of all, the first Power (who indeed may also be called Son) is the Word, concerning whom we shall relate, in what follows, how being made flesh (σαρκοποιηθείς) He became man;" "The Word of God is His Son" (*Apol. I.*, xxiii., xxxii., lxiii.; *Apol. II.*, x., quoted by Sanday, *Gospels*, p. 284; see also Lightfoot's *Colossians*, i. 15).

But it can be shown (1) that all these thoughts were suggested, and many of these expressions actually used, by Philo in Alexandria (40 A. D.), about a hundred years before Justin wrote; (2) that the personification of the Wisdom of God (and Logos means Wisdom as well as Word) in the books of Proverbs and Wisdom rendered it necessary for orthodox Christians, who accepted these books, to identify this personified Wisdom with Christ; (3) that the generally recognized Messianic reference of Ps. lxxxix. 27, ἐγὼ πρωτότοκον θήσομαι αὐτόν, leading to the comment, "I will make King Messiah a First-born," resulted in a recognition of "the First-born" (ὁ Πρωτότοκος, בְּכוֹר) used absolutely, as a title of the Messiah (Lightfoot, *Col.* i. 15); (4) that those elements of the Alexandrian theory of the Logos which are inconsistent with the Christian theory furnish no proof at all that the Christian theory was independent of the Alexandrian. It was inevitable that, when the Christians borrowed, they would adopt what was consistent, and discard what was inconsistent, with the belief in the incarnation of Christ.

There is abundant evidence to prove these propositions. Even before Paul wrote the Epistle to the Colossians, and *a fortiori* before the composition of the Fourth Gospel, that instinct which compels men to set the First Cause of all at a distance from matter had impelled Alexandrian Judaism to adopt the belief that the supreme God did not Himself directly and immediately create the world, or manifest Himself to mankind, but indirectly and mediately, through some medium or mediator. The simplest and subtlest metaphor to express this mediateness was Word—more especially in the Greek language, where Word (Λόγος) might mean reason as well as speech, the word in the thought as well as the word in the sound. Man manifests himself through deeds as well as words; but for the Supreme (with whom to speak is to do) the only necessary manifestation was the Word, the Logos. Dr. Lightfoot has shown (Col. i. 16) that Philo sometimes regards the Logos as a merely passive instrument, so that he allows himself to use the simple instrumental dative (ᾧ) to describe the relation of the Word to the Creator (ᾧ καί τὸν κόσμον εἰργάζετο), "which mode of speaking is not found in the New Testament;" and elsewhere Philo, even where he uses the prepositional construction (δι' οὗ), expressly likens the world to a house, the Supreme to the builder, and the Logos to the ὄργανον or tool (*Of Cain and his Birth*, ch. xxxv.). Moreover, as a city, while as yet only existing in the conception of the architect, may be said to *be* the reason of the architect, so the world (regarded as perceptible only to the intellect) is said to *be* the Logos or reason of God busying itself in the work of creation (*The World*, vi.). Philo also describes the Logos as "the archetypal model, the idea of ideas." These passages undoubtedly indicate a great gulf between the Christian and Alexandrian Logos. But other passages abound, which Christians could adopt unchanged, applying them to the incarnate Christ; in particular, the passage quoted above (*On Dreams*, ii. 38), where the Word of God is described as "the cup-bearer of God;" and here follow words which would be fraught with eucharistic meaning for a Christian—"the Master of the feast . . . not differing from the draught itself." Again, the Word is said (*Who is the Heir*, ch. xxxix.) to divide in equal portions among all that are to use it the heavenly food of the soul which Moses calls manna: and the Word is expressly said to be a Person in the following passage (*Questions and Solutions*, 62)—*Question:* "Why is it that He speaks as if of some other god, saying, He made man after the image of God, and not that He made him after His own image?" *Solution:* "Very appropriately and without any falsehood was this oracular sentence uttered by God; for no mortal thing could have been formed on the similitude of the supreme Father of the universe, but only after the pattern of the Second Deity, who is the Word of the Supreme Being." Even where Philo describes the Word as the instrument of creation, he speaks of it or Him as "the image (εἰκών) of God" (*On Monarchy*, ii. 5): "The Image of God is the Word by whom all the world was framed (ἐδημιουργεῖτο)." Further, the Word is frequently called by Philo the "First-begotten (πρωτόγονον) Son" and "Eldest Son." The prophecy of Zechariah (vi. 12, according to the LXX.) "Behold a man, the East is his name," which is twice applied by Justin (*Dialogue*, cvi. and cxxi.) to Jesus the Son of God, was applied with curious similarity and difference a hundred years before by Philo, who, although he finds it inappropriate for "a man compounded of body and soul," sees in it a singular appropriateness to "that incorporeal Being who in no respect differs from a divine image . . . For the Father of the Universe has caused Him to spring up as the Eldest Son" (*On the Confusion*, etc., 24).[2] Many of the very expressions which are sometimes used to show that the Logos of the Alexandrians was impersonal are found applied to God in the Old Testament, or to Christ in the New. For example, if Philo calls the world the "garment" of the Logos, the Psalmist also (Ps. civ. 2), appealing to the Lord his God, says, "Thou coverest Thyself with light as with a garment;" or if the Logos is described by Philo as the "bond" which holds the world together, so also does Paul describe Christ as the Being in whom "all things cohere" (τὰ πάντα συνέστηκεν, Col. i. 17). Nay, further, he attributes to the Logos that function of "reproving" or "convincing" (ἐλέγχειν) which is so strikingly assigned in the Fourth Gospel to the Spirit of the ascended Christ (Jo. xvi. 8), "And when He is come, He will reprove (ἐλέγξει) the world of sin;" compare Philo—who also adds a remark that suggests the thought (Jo. i. 9) of "the Light that lighteth every man"—"As long as the *divine Word* has not come to our soul, all its actions are blameless; but when the priest, conviction (or "reproval," ἔλεγχος), enters our heart like a most pure ray of light, then we see that our actions are liable to blame" (*On the Unchangeableness of God*, 28).

In the face of all these passages (and many others might be quoted) the difficulty would seem to be, at first sight, not to prove that the Alexandrian theory of the Logos was the parent of the Christian theory, but to find any difference between the two. The difference, however, is in reality very great, and very readily explained. Philo looked on the manifestation of God through the Logos as being the old inferior dispensation, while the new dispensation was to be the manifestation of the Supreme as τὸ ὄν, absolute Being. The Logos manifestation of Philo was a manifestation of God through visible creation; the higher manifestation was to be independent of visible objects. The former was the manifestation of "God as man"—*i. e.*, as liable to anger, change, repentence, etc.; it was also (*On the Unchangeableness of God*, xi.) an appeal to fear through rewards and punishments, not strictly true, and not intended for the esoteric sage, but only for the unspiritual multitude. The latter, on the other hand, was the manifestation of God as not man—a fatherly revelation, appealing to love. It followed that Philo not only did not identify his Logos with the Messiah, but would have regarded any such identification with one who had "become flesh" as a degradation. It followed also that, although Philo declared the highest revelation to be a revelation of love, there was really no basis for love at all in it. Of God as τὸ ὄν, Philo could not say that He was good, or holy, or loving, because He was superior to all goodness, holiness, and love: "His existence indeed is a fact which we do comprehend concerning Him; but beyond the fact of His existence we can understand nothing" (*On the Unchangeableness of God*, 13).

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[1] The writer is indebted to Dr. Hort for the suggestion that the transition may be from (1) "thou knowest not whence He cometh," to (2) "He alone knoweth," etc., and thence, the "alone" being understood, to (3) "He knoweth," etc. Yet, when all due weight is given to this suggestion, it will be difficult to deny that the context of John iii. 8 has little in common with the context in Polycarp, "the Spirit is not to be deceived," and that Polycarp's words indicate rather a vague reminiscence of tradition than a quotation from a Gospel supported by the authority of the apostle John.

[2] Some degree of uncertainty whether to call the Word a person or not appears to be implied in the following passage (*Questions*, 54): "The expression 'one of us' (Gen. iii. 22) indicates a plurality of beings, unless we are to suppose that God is conversing with his own virtues;" but Philo seems to incline to the personal theory.

Imagine the early Christian teachers and preachers, in the cities which were earliest influenced by Alexandria, brought into contact with the Alexandrian theory of the Logos, or possibly in some cases (as in that of Apollos perhaps) themselves trained up in the Alexandrian theory, and now superadding to it the belief in an incarnate Son of God—and what would be the consequence? Not, surely, that they would cast the Logos theory aside as baseless; for how could they deny that "by the Word of the Lord were the heavens made"? or how cancel the words of Wisdom in the book of Proverbs (viii. 22–30), "The Lord possessed Me in the beginning of His way, before His works of old. . . . When He prepared the heavens I was there. . . . I was by Him as one brought up with Him; and I was daily His delight, rejoicing always before Him"? Paul might possibly eschew the actual use of the word Logos, as savoring of men's philosophy, and alter the πρωτόγονος, "First-begotten," of Philo into πρωτότοκος, "First-born," to prevent the inference[1] derivable from the former title, that the Lord, being First-begotten, was not "Only-begotten;" but how could he, or any Christian who believed Christ to be the Redeemer of all mankind and the Eternal Son of God, do other than adopt the Old Testament theory about the Word of God, and at the same time Philo's language, so far as it was personal, while discarding all that was impersonal? If Christ was not identical with the Word of God and the Wisdom of God, then there seemed to follow the intolerable inference that He must be inferior to it; but if He was identical with it, then the introduction of Philo's felicitous language into Christian thought was simply a matter of time.

The introduction would be a very easy process, requiring nothing but a few omissions of expressions implying passive instrumentality (*e. g.*, the instrumental dative), and the addition of an emphatic protest that the manifestation of the Supreme as Love, even though it were through visible objects,—yes, even though it were through the Word of God becoming "flesh,"—nevertheless constituted not an inferior but a superior revelation, the highest revelation of all. To the Logos theory of Philo, which stated that all men were made in the image of the Word, the Christians could add that, through forgiveness and by faith, fallen mankind was destined also to be raised up and conformed to that Word, so that He was the goal as well as the starting-point, the Ω as well as the Α; or, as Paul expresses it, "All things are not only created in Him," but "to Him (εἰς αὐτόν)," Col. i. 16 (Lightfoot). This is accordingly expressed emphatically in the Fourth Gospel. Although "no man hath seen God at any time," yet "the only-begotten Son, who is in the bosom of the Father, He hath declared Him" (Jo. i. 18); and again, "Have I been so long with you, and hast thou not known Me, Philip? he that hath seen Me hath seen the Father" (Jo. xiv. 9).

This is the full Christian development of Philo's doctrine, as applied to the "First-born" becoming "flesh." But there is not only no evidence that Justin quotes from any written document exhibiting this development, but rather evidence to the contrary, that his doctrine of the Logos, though affected by the teaching of the Ephesian school, had not yet been imbued with it. For, in speaking of baptism, he calls attention to the fact that, in that rite, God is mentioned *only* by the name of "God the Father and Lord of the Universe; for," he continues, "no man can utter the name of the ineffable God; and if any one dare to say that there is a name he is incurably mad" (*First Apology*, lxi.). Looked at in the light of the context, this word ἄρρητος, "ineffable," implies a conception of the revelation of God through Christ hardly reaching the level of the Ephesian doctrine, which teaches that, though God had never been seen, He had been *declared* by the only-begotten Son, so that whoso had seen Him had seen the Father. But it is in harmony with what Justin says soon afterwards (*Ib.* lxiii.), that Jesus is also called "Angel" and "Apostle" (compare also Heb. iii. 1); and it harmonizes well too with the doctrine of Philo, that "no mortal thing could have been framed in the similitude of the supreme Father of the universe, but only after the pattern of the second Deity, who is the Word of the Supreme Being" (*Solutions*, 62).

It appears therefore that, although Justin knew certain traditions embodied in the Fourth Gospel, yet (1) it was not read in the church services of the district in the same way as the "memoirs of the apostles;" (2) he did not use the Gospel as an authoritative document; (3) his teaching exhibits less of development than the teaching of the Fourth Gospel. An inevitable inference follows that, if he knew of the existence of the Fourth Gospel as a document, he did not believe it to be the work of the apostle John.

The general conclusion to which we are thus led by the external evidence of quotations is that, although some of the *doctrine* of the Fourth Gospel, expressed in words similar to the words of the Fourth Gospel, was probably current in the Ephesian church towards the end of the first half of the second century, yet it was not by that time widely used, if at all, as an authoritative document; nor have we proof that it was so used till the times of Irenæus, *i. e.*, towards the end of the second century, by which time the Gospel was authoritatively quoted as a work of John; and those who so quoted it probably meant by "John" John, the son of Zebedee, the apostle.

Summary of evidence from quotations.

Internal Evidence.

The Fourth Gospel compared with the Synoptic Narrative.—In estimating the Fourth Gospel as a history, we must necessarily attach a special importance to those portions in it which cover the synoptic ground; for these will afford us the best means of judging how far the facts of the life of Christ, as well as the language of Christ, may have been transmuted by the author. We will therefore first consider those parts of the Fourth Gospel which afford us an opportunity of comparing it with the Gospels of the synoptists.

The first point of comparison is the greater scope of the Fourth Gospel as compared with the other three. It includes all past time in its prologue, and exhibits the incarnation of the divine Word as but one act in the drama of the universe.

Nor is its scope in space narrower than in time. The limited scenery of the synoptic stage—Galilee, Samaria, Judæa—is (in spirit, though not in letter) exchanged here for "the world." As Philo tells us that the tabernacle figured the universe, and that the robes of the high priest represented (*Moses*, iii. 12) the different parts of the world, so the High Priest of the Fourth Gospel, though speaking or working in a narrow province of Syria, is always regarded as officiating at the altar steps of the universe, and bearing with Him the destinies of humanity. "The world" is continually on His lips; and John the Baptist is made to proclaim, even at the very outset of the Messiah's career, that the Lamb of God will take away the sins, not of "the Jews," but of "the world." It is true that Judaism is not ignored. Prophecy is constantly appealed to; and the motive of the Gospel is undoubtedly to show that Jesus is "the Christ" (xx. 31), as well as to show that He is the Son of God. Yet nowhere in the Fourth Gospel is found any marked distinction between the Gentiles and Samaritans on the one side and the Jews on the other, as if the former must be neglected for a time (Matt. x. 5; Lu. ix. 52), and as if the latter were entitled to priority in the offer of salvation; on the contrary, Christ is described, early in the narrative, as preaching to the Samaritans, and the Samaritan faith (far more general than the isolated case of the Samaritan leper in Luke) serves as a foil to the Jewish unbelief. "The Jews," so far as they are distinguished from others, appear throughout as a nation with whom the writer has no sympathy, as the emblem of rebellious, unspiritual scepticism.[2] Viewing the drama at a greater distance of time than the synoptists, and purposely withdrawing himself to a still more subjectively distant point of view, for the purpose of unity and compression, the author almost ignores the minor distinctions of Pharisees, Sadducees, Herodians, scribes, and lawyers, with which the synoptists have made us familiar.[3] Palestine is seen no longer with the distinctions of a neighboring diversified coast-line, but like a dark mass upon the horizon of the distant East, serving as a foil to the splendor of the rising Sun of Righteousness, which it strives in vain to obscure.

In the miraculous part of our evangelist's narrative especially, there is visible this artistic power of selection and compression. Few miracles are described, not more than eight in all (including the post-resurrection miracle of the draught of fishes), and among these not a single case of exorcism. The element of mere wonder (which comes too prominently forward, at least for a pupil of Philo, in the synoptic miracle on the Gadarene) is carefully subordinated to the symbolical element. It is true that the whole Gospel breathes a supernatural atmosphere. Although the Logos, becoming "flesh" (i. 14), is immediately afterwards called Jesus (i. 17) or the Son (i. 18), and is never henceforth mentioned by the name Logos throughout the whole of the Gospel, yet in reality it is still the Logos, rather than Jesus, that is described in the following pages. The Logos is never (as in Mark) "unable" to work miracles, never liable to "marvel," never "in an agony," never (with the single exception of the scene at the grave of Lazarus in which ἐτάραξεν ἑαυτόν, John ix. 33) "sorrowful and very heavy;" the words ἔλεος, ἐλεεῖν, σπλαγχνίζομαι occur repeatedly in the synoptists, never in the Fourth Gospel; the Logos "knows what is in man," sees Nathaniel "under the fig-tree," discerns from the first that one of the twelve whom He had chosen is "a devil;" when He asks advice from His followers, it is a mere form, merely "to prove them, for He Himself knew what He would do;" there is not in the drama of the Fourth Gospel (as in Mark) any development of thought or plan in the chief actor: the development must be looked for in the drama taken as a whole, and including the creation, the fall, and all the preparation of the world for the coming of the Word as flesh; but the life of Christ on earth is, in the Fourth Gospel, only one act as it were, in which the previous action of the drama is simply carried on and sustained; the whole of the future, His destined "lifting up," His death, His rising in three days, all lie mapped out before the Saviour, so that He walks in a known country and in light, while all around, friends and foes alike, are stumbling or groping in the dark. In this sense, therefore, it is true that the supernatural element is even more prominent in the Fourth Gospel than in the synoptists. But the miracles themselves are subordinated. Though frequent reference is made to the vast number of them (ii. 23; iii. 2; vi. 2; vii. 31; ix. 16; xi. 47; xii. 37; xx. 30), yet, not only are very few described, but even those few are described rather as "emblems" than as "mighty works." It is remarkable that the word σημεῖα ("signs"), which the synoptists almost always use in a bad sense (to denote the "sign from heaven" demanded by the Pharisees, or the "signs" which the false Christs shall work to deceive, if it were possible, even the elect, Mk. xiii. 22), is the very word selected by John to describe the miracles of Jesus; while the word δυνάμεις ("mighty works"), which in the synoptists generally denotes the works of Jesus, is never used in the Fourth Gospel. Partly, no doubt, the author may have felt that miracles were made cheap by excessive enumeration, and that the narrative of a multitude of miracles without apparent motive created a stumbling-block rather than a help to philosophic and educated readers. Especially might this be felt in Ephesus, the home of wizards and wonders and "curious arts" (Acts xix. 19), where even the last-called of the apostles had worked cures and exorcisms past numbering (*ib.* 12). Accordingly the author, though he makes mention of very many miracles, describes none but those which are obviously emblematic. It has been stated above that the 1st Epistle of John was not only written by the author of the Fourth Gospel, but must be considered as a kind of postscript or appendix, commending the Gospel to the church. Remembering, therefore, the important passage in the Epistle (1 Jo. v. 8), which describes the three witnesses on earth as breath (or spirit), water and blood, and bearing in mind that "blood" in all probability has (among other possible meanings) a reference to the eucharistic wine, we shall not be surprised that the first miracle of all describes the changing of the water into wine. Next is a miracle exemplifying the power of the word of Jesus, where faith is present (iv. 50, and *cf.* iv. 41); then the Messiah manifests (in the cure of the impotent man) the superiority of the ever-flowing fountain of life to the intermittent power of the pool of the law (v. 3); then comes the eucharistic feeding of the five thousand with bread and fishes, wherein "the Lord gave thanks," εὐχαριστήσαντος τοῦ Κυρίου (vi. 23), followed by the walking on the water, which is also appended by Matthew and Mark to the eucharistic miracle; then the opening of the eyes of the blind by Him who was the Light of the world (ix. 5); the raising of Lazarus by Him who was the Resurrection and the Life (xi. 25); and lastly, the miraculous draught of fishes, taken at the command of Him who had sent His apostles to be fishers of men, and to cast the net of the gospel (xxi. 6).

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[1] Paul nowhere uses the word Logos to denote Christ; but he uses the expression ὁ λόγος τοῦ Χριστοῦ in one place (Col. iii. 16) to denote what is more commonly denoted by the Spirit of Christ, the in-dwelling presence of Christ in the heart manifesting itself in word; *cf.* Lu. xxi. 15, στόμα καὶ σοφίαν.

[2] The passages iv. 22; x. 16; xi. 52, though they give a kind of precedence to the Jews, yet treat of the passing of salvation from the Jews to the Gentiles, in the way of climax; and these two or three passages (which occur in dialogue and not in narrative) cannot count for anything against the forty or fifty passages wherein the author, in his own person, speaks of "the Jews" as "murmuring," "seeking to slay Jesus," "taking up stones to stone Him," and always systematically opposing themselves to Jesus.

[3] It has been ingeniously suggested that a distinction is drawn by the author between the "Jews" in the south and the "multitude" (ὄχλος) in Galilee (Westcott, *Introd. to St. John*). But the term ὄχλος is also applied to the mixed multitude of pilgrims in Jerusalem at the Passover (xii. 12, 17, 18, 29, 34); and besides, if the author had intended to deny any such distinction, he could hardly have expressed himself more cogently than in xii. 9, where he adds that this "multitude" was of the "Jews" (ὄχλος πολὺς ἐκ τῶν Ἰουδαίων).

In all these narratives, although the common people are exhibited as wonder-struck, yet the impression left on the reader is that, for the Word of God, such works are matters of course, and only important because of their inner spiritual meaning. Philo says (*Life of Moses*, i. 38) that such miracles as the production of the water from the rock by Moses and the like are the sports (παίγνια) of God, and not so really great or deserving of serious attention as the revolutions of the planets. There is no trace of "sport" in any of the works of the Word of God narrated by the author of the Fourth Gospel; yet both he and Philo agree in looking through the letter of the narrative of every miracle to the spiritual essence contained in it, which alone constitutes the importance of the act. Now Philo in speaking of the creation of Eve from the rib of Adam, declares at once that the literal meaning is fabulous (μυθῶδες); whereas he treats the emission of the water from the rock as historical, although he suggests, as a first explanation, that possibly there may have been a latent spring in the rock. Yet Philo proceeds to deduce his spiritual inferences as freely from what he deems "fabulous" as from what he deems historical. It is not necessary to assume in the author of the Fourth Gospel precisely the same indifference to the distinction between spiritual and historical narrative; but it appears certain that, in his writings, as in Philo's, the historical is subordinated to the spiritual. Not but that the picturesque incidents of each miracle received from him due attention; but it seems to be for the most part the picturesqueness resulting from the skill of a graphic teacher, rather than from the memory of an eye-witness. Compare, for example, Mark's with John's account of the feeding of the five thousand. There is less motive, less art, about Mark's detail than about John's. John's omissions and additions all point to one object, the desire to heighten the Logos and to subordinate the disciples and the crowd. Mark begins by saying that "Jesus had compassion on the multitude;" but the Logos, knowing beforehand "what He would do," determines His course at once as soon as He "lifts up His eyes" and discerns the multitude. In Mark, the disciples come to Jesus begging Him to send the multitude away; in John, it is Jesus who first "proves" one of the disciples with the question, "Whence shall we buy bread that they may eat?" Then (giving a picturesque variety to the story) Andrew, as well as Philip, and a servant-lad (παιδάριον) are introduced, the latter carrying the *viaticum* of the apostles. The loaves, a new circumstance not found in the synoptists, are of an inferior kind, "barley;" and Andrew bases an expostulation on the smallness of the provision. After the command to "sit down," Mark says that they sat "down on the green grass," an epithet natural enough for a speaker perhaps, but inartistic, because too prominent, in a written narrative. John, on the other hand, turns a defect into an excellence, by judiciously connecting the "grass" with the command to sit down, so as to enhance the forethought of the wise Master of the feast, who made provision for the comfort of His guests in the minutest details: "Jesus said, Make the men sit down. Now there was much grass in the place." Lastly, in the synoptic narrative, the gathering of the fragments is the spontaneous act of the disciples; but in John, the feast ends as it began, with the display of the wisdom of the Master, even in the smallest matters, "Gather up the fragments that remain, that nothing may be lost." It is scarcely possible to deny that, in the symmetrical manner in which the story gathers itself around the Logos as its object and centre, the narrative of the Fourth Gospel is far superior to that of the synoptists, and that many of the additional touches of the former are dictated by what has been happily described by Canon Westcott as "an instinctive perception of symmetry in thought and expression.[1]

[1] The only points in which this narrative can be illustrated by Philo's remarks (*Alleg.*, iii. 56–8) on the manna are two or perhaps three:—(1) As Philo says that the soul is fed not by earthly food but by "words," so the Gospel says that "words" are the source of life (vi. 63); (2) Philo, speaking of the manna, praises those who seek the food for its own sake and not for ulterior advantage; compare John vi. 26 on the "loaves and fishes;" (3) Philo, speaking of the object of the miracle, quotes Exod. xvi. 4, "that I may prove them;" this may possibly, but not probably, illustrate John vi. 6.

The same remark applies to the other miracle which John has in common with Matthew and Mark, viz., the healing of the "nobleman's" son.[1] Every detail of difference in John heightens the dignity of the Saviour. In the synoptic account, Jesus offers to go to the house to heal the youth; in John, no such offer is made, and the nobleman and his companions are accosted with a rebuke, "Except ye see signs and wonders, ye will not believe." In the synoptists, the man is represented as living at Capernaum, and Jesus as entering Capernaum, so that the father sends but a short distance; in John, Jesus is represented as remaining at Cana, while the suppliant father journeys thither in person from Capernaum, a distance of twenty-five miles. In the synoptists, the father sends a message, praying Jesus not to trouble Himself to enter his roof, but to "speak the word only;" in John, the father piteously supplicates the Saviour to "Come down, ere my child die." In the synoptists, it is recorded that Jesus "marvelled;" in the Fourth Gospel, He simply pronounces the authoritative words, "Go thy way, thy son liveth." In the synoptists, Jesus avails himself of this incident to proclaim, almost as if it were (and probably it was) a development of his work suddenly revealed to Him by His Father, that many of the Gentiles shall be admitted into the kingdom; in the Fourth Gospel, which exhibits no development, these words would necessarily seem out of place, and are omitted. Contrast could scarcely be more complete; and it is not surprising that many commentators, rather than identify such opposites, prefer to suppose that, about the same time in the life of Jesus, two men, both in high positions, had sons at the point of death, in the same place (Capernaum), both of whom petitioned Jesus to heal their children, and both of whom obtained from Him miraculous cure, performed at a distance from the two patients. To some, however, as to the candid author of *The Authorship and Historical Character of the Fourth Gospel*, it will appear more probable that we have the same event, differently described. But those who accept the theory of identity ought to consider how much is involved in it. For the defenders of the difference of the two miracles are undoubtedly justified in drawing a contrast between them in almost every point of spiritual importance (Augustine, *Ev. Joh. Tract.*, 16). If, therefore, the Fourth Gospel is historically accurate, then (on the supposition of the identity of these two narratives) the three synoptic Gospels are historically inaccurate; but if the synoptic narrative is historically accurate, the narrative of the Fourth Gospel must be considered rather a new dramatic version, than an independent historical account; and the same remark will necessarily apply to, and affect our estimate of, all the accounts of miracles in the Fourth Gospel.

Gaining light thus from the comparison of the Fourth Gospel with the synoptists, wherever they occupy common ground, we shall find it useful, before proceeding to the summary of the Fourth Gospel, first to touch on the few remaining points which the fourth has in common with one or more of the three. Luke contains most of these. For example, if we accept the passages Lu. xxiv. 12, xxiv. 40, as being not interpolations, though perhaps additions made by the author to a subsequent edition of his Gospel, it will follow that, in the account of the resurrection, Luke and John agree identically in adopting the traditions (1) that Peter "beheld the linen clothes laid by themselves in the sepulchre;" (2) that the Lord showed His disciples, after His resurrection, His wounded body in token of His identity. In both these cases several minute details are added by John; and this also applies to another important incident which Luke and John have in common, viz., the "entering of Satan" into Judas. Luke records it briefly in two words (xxii. 3), and makes the "entrance" occur some time before the last supper; but John, in a far more powerful scene, reserves the "entrance" for the moment when the "sop" is handed to the traitor by the Saviour, and the disciples seated at the last supper. Here again the incident is the same; but the treatment is very different.

The agony described by Luke (xxii. 44, and, without Luke's additions, in Mat. xxvi. 39 and Mk. xiv. 35, 36), when the Lord prayed that "the cup might pass from Him," and when an "angel" appeared from heaven strengthening Him, may seem, at first sight, to have no counterpart in John. And indeed the synoptic description of the agony in Gethsemane is not adapted for the Fourth Gospel. Inserted in any page of that Gospel it could not fail to jar upon us as being out of harmony with the context. Nevertheless, a remarkable passage in John (xii. 27) appears to bear a striking resemblance to the account in Luke: "Now is My soul troubled." Thus the Saviour avows a certain conflict in His heart, yet by the very deliberateness (as well as by the publicity) of the avowal takes from it something of the intense and almost passionate humanity of the synoptic narrative. Immediately after these words the Saviour, in the Fourth Gospel, deliberately suggests to Himself the synoptic prayer, and repeats it: "What shall I say? 'Father, save Me from this hour?' But for this cause came I to this hour." At once triumphing over the—from the point of view of the Fourth Gospel—unworthy suggestion, He exclaims, "Father, glorify Thy name." Upon this comes the heaven-sent message, but not (as in Luke) an angel to "strengthen" one "in an agony praying more earnestly;" on the contrary, the voice does but ratify the Saviour's utterance: "I have both glorified it, and will glorify it again." Finally, the author adds, as usual, the babble of the multitude, as a foil to the all-knowing wisdom of the Divine Word: "The people therefore that stood by and heard it said that it thundered; others said, An angel hath spoken to Him." No answer to their doubts and questionings is given by Jesus; but we are left under the impression that the "I" is uttered, neither by thunder nor by any mere angel of God, but by the Father Himself. A soul "troubled;" a prayer to be saved from the trouble; the suppression of that prayer, after more or less of conflict, and the substitution of another prayer in its place; and lastly, a message or messenger (ἄγγελος) from heaven—the facts are much the same both in Luke and in John, yet how different is the treatment of the facts, and what a world of difference in the spiritual result!

Almost the only passage in which John adopts a few consecutive words of the synoptic narrative is the narrative of the anointing (xii. 3–8). There is much less similarity between Peter's confession, as recorded in Jo. vi. 68, and as recorded in Mat. xvi. 16; Mk. viii. 30; Lu. ix. 20; but the narratives appear to refer to the same event, and if so, the comparison between the two is most instructive. In Matthew and Mark the confession of Peter constitutes a turning-point in the life of Jesus; it is the sign which convinces Him that, the seed of a living faith having been sown, His work is now done, and that the hour of his departure is at hand: "From that time forth" (Mat. xvi. 21; Mk. viii. 31) "began Jesus to show unto His disciples how that He must go unto Jerusalem, and suffer," etc.; and accordingly the Lord prepares the disciples with the greatest care, and even tenderness, for the all-important answer to the question which He is to put to them, "Whom say ye that I am?" and when the question is answered, pronounces a fervent blessing on Simon, the son of Jona, but better called Cephas, a rock, whose faithful confession is the token of the laying of the foundation stone of the new temple. If Jesus is to be regarded as a man, "who, though He were a Son, yet learned obedience by the things which He suffered" (Heb. v. 8), then in the whole synoptic narrative of the life of Christ there is not a more important crisis than this. But in the Johannine narrative crises are altogether out of place, where all is pre-ordained; and instead of the tender questioning, the inspired confession, and the fervent blessing, we have simply an almost casual appeal of the Lord to His disciples, "Will ye also depart?" which, when a response has been made by Peter, is followed, not by a blessing, but by sad words conveying the assurance that the Word of God, who chose the twelve, knows all their weakness as well as their strength, and cannot be surprised either by confession or by betrayal: "Jesus answered, Have not I chosen you twelve, and one of you is a devil?" Both in the Fourth Gospel and in the synoptists (Mat. xvi. 23; Mk. ix. 33), immediately after the blessing of Peter, mention is made of "Satan" or "Devil." To bless Peter, and to call him "Satan" immediately afterwards, is consistent with the human Christ described by Mark and Matthew. The difficulty is avoided, in Luke, by omission; but the Fourth Gospel, retaining the traditional mention of the word "Satan," or "Devil," directs it to Judas; upon whom elsewhere the Fourth Gospel (xii. 4–8) concentrates the faults imputed by Matthew (xxvi. 8) not to Judas alone but to all the disciples.

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[1] It is here assumed (with Dr. Sanday, *Fourth Gospel*, p. 100) that they are the same. The assumption of their difference involves even greater difficulties than the assumption of their identity.

Readers who may think that this last dislocation of the words of Jesus appears somewhat improbable should consider carefully the patent instance which follows. In the synoptic account of the betrayal, Matthew and Mark represent Jesus as awaking the sleeping disciples (at the moment of the arrival of the traitor and his band), with the words, "Rise, let us be going (ἐγείρεσθε, ἄγωμεν). Behold, he that betrayeth Me is at hand" (Mat. xxvi. 46; Mk. xiv. 42). Luke alters this; it is too human for him, seeming to imply flight; and therefore he substitutes a command, in the second person, "Rise up and pray, lest ye enter into temptation" (Lu. xxii. 46). But John, while averse to this change of the traditional words, neutralizes their questionable effect by taking them completely out of their context. Accordingly, he places them between the discourse on peace in ch. xiv. and the discourse on the vine in ch. xv., just at the point when we may suppose the Master with His disciples to be rising from the table, purposing shortly to pass quietly from the lighted upper-room where He had been celebrating the last supper down into the streets of Jerusalem, on His way to Gethsemane. Taken in this context, the words are free from all suspicion of haste or trepidation; on the contrary, they betoken authoritativeness and decision. Rising from the sacred meal, and going forth to welcome "His hour," the Saviour says,—as if with the consciousness that He is the High Priest of the World, going forth to celebrate the sacrifice foreordained before the foundations of the world,—"But that the world may know that I love the Father, and as the Father gave Me commandment, even so I do. Arise, let us go hence (ἐγείρεσθε, ἄγωμεν ἐντεῦθεν)."

The entry into Jerusalem, the crucifixion, and resurrection, are almost the only remaining events common to the Fourth Gospel with the synoptists. The entry is much condensed, and closely connected with the raising of Lazarus (xii. 18); the lengthy account of the sending for the ass is passed over in the words—"Jesus, when He had found a young ass, sat thereon;" and the acclamations of the multitude and the pomp of the procession are all omitted or lightly touched, as if the gleam of popular favor which so impressed the synoptists scarcely deserved the attention it had received from them. It was a mere consequence of the raising of Lazarus: "For this cause the people also met Him, for that they heard that He had done this miracle." Yet in Matthew (xxi. 11), when the city asks "Who is this?" the crowd replies, "This is Jesus, the prophet from Nazareth of Galilee"—making no mention of the wonder which—according to the Fourth Gospel—was the sole cause of the procession.

After this, John omits the purification of the temple, which he has placed earlier, at the first visit of Jesus to Jerusalem (ii. 15),[1] and passes rapidly to the last supper. Here, as is well known, there are great difficulties in reconciling the account of the Fourth Gospel with that of the synoptists. In the synoptists the last supper is (apparently) the passover, in which the Lord bequeaths Himself to His disciples as their sacrifice, giving them His body and blood; in John the last supper, so far as he describes it, is merely the last meal shared by the Master and His disciples, at which he washes their feet, and exhorts them to humility, patience, and peace; and it is expressly described as being "before the feast of the passover" (John xiii. 1). Again, in the synoptists, Mark places the crucifixion at the third hour (9 A.M.), and the darkness is made by all the synoptists to last from 12 to 3 P.M.; but John (who is describing in the crucifixion the sacrifice of the passover, the slaughter of the Lamb of God which was to take away the sins of the world) naturally places the crucifixion later, in order that the Lamb may be slain "between the two evenings," as prescribed in the law; and therefore he does not place even the delivery of Pilate's verdict till the sixth hour, *i. e.*, 12 o'clock, and the crucifixion, consequently, later still. The symbolism which prevails in the Fourth Gospel may incline us generally to accept the synoptists' narrative in preference. But there are special reasons why, at a very early date, a slight misunderstanding, among the Gentile churches, of Jewish custom and of the common tradition may have led to an erroneous supposition that the last supper was the passover meal; and the explanation suggested by Canon Westcott (*Introduction to the Study of the Gospels*, p. 344) seems a very reasonable one. In this case, therefore, the Fourth Gospel must have the credit of dissipating an error which had very early crept into the synoptic narrative (namely, the insertion of the words "The first day of unleavened bread," Mat. xxvi. 17; Mk. xiv. 12; Lu. xxii. 7); nor is it at all unlikely that this rectification came from the apostle John himself. But as regards the hour of the crucifixion, it seems more likely that the account of Mark is correct, not only because it leaves more time for the burial before sunset, but also because the later hour implied in the Fourth Gospel appears naturally suggested by the same symbolism which afterwards finds in the wounded body of Christ a fulfilment of the two prophecies, "A bone of Him shall not be broken," and "They shall look on Him whom they pierced."

Passing now to those details of the crucifixion wherein the Fourth Gospel differs from the synoptists, we find in almost each case but one motive—to enhance the majesty of the Saviour. Even in the arrest of Jesus this motive appears. The synoptists tell us that he was arrested by a "crowd" (ὄχλος), servants, sent apparently from the houses of (παρά Mat.; ἀπό Mk.) the chief priests and elders; and as the moon shone at the full, so brightly that the disciples could discern their Master from some distance (a stone's cast), and perceive His agony, as well as hear the words of His prayer in the stillness of the night, they do not think it necessary to make mention of "lights" or "torches." The Fourth Gospel describes how the "cohort" of the citadel of Antonia is called out, together with the servants of the priests, making up in all, if the whole cohort is meant, five or six hundred men; and these approach, not with "swords and clubs" (as Mk.), but with "torches and lights and arms." Jesus goes forward to meet them, and intrepidly declares that He is the person whom they are seeking, upon which they "recoiled and fell to the ground." Nothing of all this is found in the synoptists.

Though John agrees with Luke in the tradition that the servant's ear cut off by Peter was the "right" ear,[2] he entirely omits Luke's narrative of Christ's examination before Herod; but this is in accordance with his fixed purpose—while by no means neglecting graphic and picturesque detail—to ignore all petty local distinctions, and to draw none but large and clear outlines on his canvas. Rome and "the Jews" alone appear round Christ on the stage of his drama; not one of the Herods is so much as once mentioned from the beginning to the end of it. The irony of providence, by which Pilate is made to proclaim that Jesus is "King of the Jews" (xix. 20), reminds us of the similar irony by which Caiaphas, not speaking "of himself" but inspired by God, is forced to publish the suffering of the Saviour (xi. 51); and both passages are quite in the manner of the Fourth Gospel. So also is the very natural application of the prophecy, "And for My raiment did they cast lots," to the seamless tunic of Christ. Remembering what stress is laid by our author's teacher, Philo, on the high priest's garments (*Moses*, 14; *Dreams*, 37), which "represent the universe," we shall readily perceive that while the outer garment of Christ is freely given to the four quarters of the world, the inner seamless tunic (χιτών), that which He wears next to His heart, is not to be rent, representing as it does the regenerated world, "those who receive remission of sins through Him" (*Dialogue* liv.).[3]

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[1] The purification of the temple, placed as Christ's first public act, is as suitable an introduction to the life of Christ in the Fourth Gospel as the sermon in Nazareth is to the life of Christ in the Third Gospel. In Luke (the Gospel of mercy), the proclamation of the "healing of the broken-hearted" to his friends at Nazareth; in John (the Gospel of the Word of God, in which the words ἔλεος, ἐλεεῖν, σπλαγχνίζομαι, so often repeated by the synoptists, are altogether absent), the purifying of the temple of God,—is the most appropriate commencement of the Saviour's public work. Besides, the prophecy of Malachi (iii. 1),—"Ἰδοὺ ἐξαποστέλλω τὸν ἄγγελόν μου, καὶ ἐπιβλέψεται ὁδὸν πρὸ προσώπου μου (John the Baptist), καὶ ἐξαίφνης ἥξει εἰς τὸν ναὸν ἑαυτοῦ κύριος ὃν ὑμεῖς ζητεῖτε,"—predicts a "sudden" coming of the Lord into the temple, following on the steps of his "messenger." This prophecy is better fulfilled, if the Lord comes to the temple *immediately after* the preparation of John the Baptist; and, besides, the "sudden" coming is better fulfilled in the early entry of Jesus (John ii. 14) than by the later entry in the synoptists, which was preceded by a public procession. Thus prophecy, as well as appropriateness, might induce an account of an early purification of the temple.

[2] Note also that the Fourth Gospel is the first to give the servant's name, Malchus. In the same way the *Acta Pilati* for the first time give the names of the two thieves, Dysmas and Gestas.

[3] Only the Fourth Gospel thus distinguishes between the ἱμάτια and the χιτών. But compare Lev. xvi. 4, where the χιτὼν ἡγιασμένος is prescribed as the dress for the high priest on the day of atonement; and see also Philo (*Dreams*, 37); and especially note Philo's remark that this χιτών is "not easily rent" (ἀρραγέστερος).

Comparison with First Epistle of John.

The Motive of the Fourth Gospel illustrated by the First Epistle of John.—It has been said above that the 1st Epistle of John is most closely connected with the Gospel. The connection is so close, in thought as well as in language, that the former may almost be called a summary of the latter. In the Epistle, even more clearly than in the Gospel, we see the author's habit of dealing rather with elements than with nations or individuals. With the exception of the illustration of "Cain," which he possibly borrowed from Philo (who uses Cain and Abel to denote the earthly and the spiritual principle, *Sacrifices of Cain and Abel*, 1), he prefers to dispense with personal illustrations of principles. He does not, like Paul, speak of Abraham, or Hagar, or Sinai, or Isaac, or Melchisedek, or the Jews, or the Gentiles; but of the world and the flesh, the water, the blood, and the spirit, light and darkness, life and death. In the Epistle, as in the Gospel, we see the rejection of Christ explained, not as a casual outcome of individual caprice or wickedness, but as an inevitable result of the eternal antagonism between light and darkness. In the Epistle, as in the Gospel, the author insists that the new commandment of Christ to "love one another" is really an old commandment which men have had from the beginning: a commandment as old as the promptings of the Light which from the beginning has "lighted every man coming into the world,"—an old commandment only so far made new as it has been brought home to the hearts of men with a quite new intensity by the manifestation of the incarnate Love of God. In the Epistle, as in the Gospel, it is recognized that the antagonism between the world and the spirit, between light and darkness, must go on without truce till one has prevailed; and each man must take one or other side, putting away all hope of compromise. There are two principles, says Philo, contrary to and at variance with one another,—the one represented by the God-loving Abel, the other by the self-loving Cain, which must needs be at variance when born, "for it is impossible for enemies to dwell for ever together." In precisely the same way does our author illustrate the same antagonism by the same personality: "Not as Cain, who was of that wicked one, and slew his brother. And wherefore slew he him? Because his own works were evil and his brother's righteous;" and then, relapsing from the unfamiliar method of personal illustration into his habitual language about principles or elements, he substitutes for Cain the "world," and for Abel the "children of God," and bids his readers "marvel not if the world hate you."

In this continuous strife between light and darkness the victory is to be gained by faith,—but faith supported by witnesses; and we read in the Epistle that the object of our victorious faith is "He that came through (διά) water and blood, Jesus Christ; not with the (ἐν τῷ) water only, but with the water and the blood; and the Spirit is that which beareth witness, because the Spirit is truth; because they that bear witness are three, the spirit (or breath, τὸ πνεῦμα) and the water, and the blood, and the three are united so as to make up the one" (εἰς τὸ ἓν εἰσι) (1 John v. 6–8).

Passing over many differences of interpretation, and asking, What is the meaning of the water and the blood? we turn to the Gospel, and, in the account of the crucifixion, we find (xix. 34) especial stress laid upon the fact that from the side of Jesus "there came out blood and water; and he that hath seen hath born witness (μεμαρτύρηκεν), and his witness (μαρτυρία) is genuine (ἀληθινή), and he knoweth that he saith true, that ye might believe." In what sense is the "blood" here to be understood? As nourishing? or as cleansing? Almost certainly as cleansing; because above, in this very Epistle, the blood of Jesus is described (i. 7) as cleansing us from all sin. Inferring, then, that the blood signifies a superior purifying or baptismal influence, we necessarily infer simultaneously that the water signifies an inferior baptismal influence. Two purifications are mentioned in all the four Gospels, an inferior and preparatory, and a superior and final: the former is the baptism with water, the latter is the baptism with the Holy Spirit, or (as in Lu. iii. 16) with the Holy Spirit and fire (*cf.* also Lu. xii. 49). But the conception of "baptism with fire,"—though it is based on the early history of Israel (Num. xxxi. 23), and appears occasionally in the shape of a "fiery trial" of faith, as well as in the fiery tongues of Pentecost—was soon supplanted by one of two other conceptions, either sprinkling with sacrificial blood, or baptism with the Spirit. This higher purification, or baptism with blood, Jesus brought into the world. He not only came working by means of it (διά with gen., as above in the passage quoted, 1 John v. 6), but also, in a certain sense, in it (ἐν). That is to say, He himself underwent the higher baptism with blood as well as the lower purification with water, which he received from John the Baptist. "Can ye be baptized with the baptism wherewith I shall be baptized?"—He said to the sons of Zebedee (Mk. x. 38). The agony in Gethsemane, which was that baptism, was typified by Luke in an exudation of "sweat, as it were great drops of blood falling down to the ground" (Lu. xxii. 44). But this baptism was scarcely public enough to be a sufficient fulfilment of the prophecy which predicted that "In that day there shall be a fountain opened to the house of David, and to the inhabitants of Jerusalem, for sin and for uncleanness" (Zech. xiii. 1). When it became recognized that the Lord was this "fountain," and that His blood was the cleansing stream, then the piercing of His side and the visible emission of the purifying blood from the wound became an effective and almost necessary type of the spiritual purification, and the type of the blood of sprinkling, suggested perhaps by Luke in his description of the agony, fell into the background, being supplanted by the more natural type of the pierced side.

Such a type would all the more commend itself because, without it, the crucifixion might almost seem incomplete. The mere piercing of the hands and the feet might seem an insufficient fulfilment of the prophecy of the "fountain;" and besides, since crucifixion was generally a lingering death extending over many hours, and since the body of Jesus was taken down on the same day on which it had been attached to the cross (and, according to John, only three or four hours after the commencement of the crucifixion), the record of His death, without the spear wound, might seem to justify the statements of those who maintained that Christ never died at all, and that He was a man only in appearance. Therefore, as a proof of His humanity and of the reality of His death and sufferings, no less than as a fulfilment of the prophecy of the "fountain," it was natural that the latest Gospel should insert, and that the church should readily accept, the witness through blood as well as water, which is so emphatically related by the author of the Gospel, and here appealed to by the author of the Epistle.

But the question remains, What is meant by the connection of the water and the blood with the breath or spirit —"They that bear witness are three, the breath (or spirit), and the water, and the blood"? Philo may throw light both on the number and on the nature of the witnesses. Only to earthly matters did the rule apply that "in the mouth of *two* witnesses shall every word be established:" heavenly matters required, so Philo teaches, "*three* witnesses" (ἅγιον δὲ πρᾶγμα δοκιμάζεται διὰ τριῶν μαρτύρων, *Posterity of Cain*, 27). He also calls attention to the fact that Moses declares with apparent inconsistency (1) in Leviticus (xvii. 11) that blood is the essence of life, (2) in Genesis (ii. 7) that breath is the essence of life; and he reconciles the two statements by assigning to men two kinds of life: (1) the irrational, which they have in common with beasts, which life has for its seat (ἔλαχε) blood; (2) the rational, which flows from the fountain of reason (λογικῆς πήγης), which has for its seat breath (or spirit), "not (mere) air in motion, but a kind of type and impress of that divine power which Moses calls by a name especially appropriated to it (κυρίῳ ὀνόματι), image (of God)" (*The Worse plotting*, etc., 23). Elsewhere (*Who is the Heir*, 11) he says that blood is the essence of the entire soul, but divine spirit (πνεῦμα θεῖον) the essence of the dominant part of the soul, On the metaphor of the water also Philo throws light. Water and earth, he says, represent the origin, growth, and maturity of the human body; consequently, he tells us, purification by water is that preliminary recognition of one's own nature ("know thyself") which is required from those who aspire to the higher purification. Hence purification by water, he asserts, was appointed by the law as a preparation for the purification by sacrificial blood; and hence the Sacred Word thought meet that the high priest, whenever he purposed to perform the sacrifices ordained by law, should previously sprinkle himself with water and ashes (*Dreams*, 36, 37; *Those who offer Sacrifice*, 1, 2).

If now we could find in the Gospel narrative of the crucifixion some mention also of the breath or spirit, nothing would remain wanting to make up the triple purification and triple witness mentioned in the Epistle, of "the spirit and the water and the blood." Such a mention is probably intended in the willing surrender of the "breath" or "spirit," which is mentioned (xix. 30) in the Fourth Gospel alone [Mk. *ἐξέπνευσε*, Mat. *ἀφήκε*; Luke (xxiii. 46) who comes nearest to John only describes the intention, not the fact, *παρατίθεμαι*]: "He bowed His head, and gave up His breath" (or spirit). Thus the meaning both in the Gospel and in the Epistle appears to be the same. (1) Jesus took unto Himself not only (*a*) the dead fleshly nature of man, typified by water, but also (*b*) the life and passions of man, typified by blood, and (*c*) that higher life of man (in virtue of which he is described as made in the image of God), typified by the spirit. (2) In these three departments of existence He made three several sacrifices, pouring forth (*a*) water and (*b*) blood from His side, and giving up (*c*) His breath as the last sacrifice of all.[1] (3) Thus these three sacrifices betoken three several purifications:—(*a*) the purification, by water, of the body in baptism; (*b*) the purification of the soul by the death of the lower nature (what Paul calls "the old man"), which partakes in the death of Christ; (*c*) the purified life of the soul rising from the dead through the Spirit, and living with, and in, the risen Saviour. The two latter purifications are two phases of the same (the former implying dying in the blood of Christ, the latter rising again and living in His Spirit); but there is sufficient difference to warrant a distinction. (4) These three purifications go to make up the one perfectly pure and ideal purification and sacrifice for sin, which is the Lamb of God, the Word (*εἰς τὸ ἓν εἰσιν*).[2]

Stress has been laid upon this important passage in the Epistle because it appears to be a key to much that we shall find in the Gospel. It reveals an exaggerated notion of the importance of baptism with water, against which the author feels compelled to contend; "not by water only, but by water and blood." Somewhat in the same way Paul uses not water but earth (Philo using water and earth) to contrast the natural man, the mere "living soul," with the "lifegiving breath, or spirit" (1 Cor. xv. 45, 47). But that which distinguishes John from Paul is the use of mystical imagery, arranged with a certain numerical symmetry. Sometimes the imagery is dual, when it describes incompleteness, such as the conflict between the world and the children of God, between light and darkness, between God and the devil. But in other cases it is triple: he appeals to three classes, the children, the young men, the fathers; contending against three enemies, the lust of the flesh, the lust of the eyes, the imposture (*ἀλαζονεία*) of life; and strengthened in their faith by three witnesses on earth, the water, the blood, and the spirit—all of which dimly tends towards that other triple witness which has been inserted in the Epistle by later scribes (v. 7), the Father, the Word, and the Holy Spirit.

If we could be sure that the Second Epistle was from the same pen as the First, then the very great probability that the "elect lady" and the "elect sister" (2 John 1; *ib.* 13) represent two churches might prepare us for similar personifications in the Gospel; yet as this personification is disputed by some, we must not lay much stress on it.[3] Nevertheless we have seen enough of the nature of the Epistle to be prepared (in passing to the larger work by the same author) for a Gospel of types and symbols, a Gospel of selection rather than of continuous narrative, a Gospel in which principles on a large scale rather than individual characters shall be represented, and in which light and darkness, death and life, the word and the world, the water and the spirit, and the spirit and the blood, shall play no inconsiderable part.[4]

Analysis of the Fourth Gospel.

As was to be expected from a writer conversant with the system and thought which, for brevity, we call the school of Philo, the prologue of the Gospel opens with a protest against Philo's doctrine of an impersonal or quasi-impersonal Logos. The Logos or Word is at once declared to be (i. 1), not the mere instrument by which the world was made, but the companion of God, and God; a Light, from the beginning shining in darkness, received by some, to whom power was given to be born of God, but rejected by others who were the children of the flesh. John the Baptist is introduced, in marked distinction from the Word, as a "man;" not the Light, but a witness to the Light; and the Baptist declares at the very outset of the public life of Jesus (i. 16) that, though the law was given by Moses, the gifts of divine grace and truth came through Jesus, and that He, being the only begotten Son in the bosom of the Father, has manifested the invisible God to men. The baptism of Jesus by John is omitted; but John bears witness to the visible descent of the Spirit upon Jesus, adding that it "abode upon Him," and he bears record that his own baptism with water is but to prepare the way for Him who will baptize with the Holy Spirit; and that He on whom the Spirit thus descended is the Son of God, the Lamb of God that is to take away the sins of the world. Here, then, at the very outset, we see the thoughts, and one may almost say the *dramatis personæ*, of the Epistle re-introduced in the Gospel—light and darkness, the word and the world, the law and grace, the Father, the Spirit, and the Son. The three grades of purification are not as yet mentioned; yet there is perhaps a side-reference to them in the three grades of the world, *i. e.*, of impure existence, which are alluded to in the contrast between those who are born "of God" (i. 13) and those who are born (1) of blood, (2) of the will of the flesh, (3) of the will of man.

Calling of the disciples.

The narrative of the calling of the disciples implies unmistakably that this book is not to follow the common tradition, nor to be a complete narrative, but rather a selection; for it only narrates the calling of six of the twelve, and one of these Nathanael (significantly described as a man of Cana, where two out of the eight miracles in this Gospel are to take place), is so far from being universally identified with one of the twelve that Augustine excluded him from the number. The earlier names are mentioned in the same order as in Papias (see above, p. 729), and suggest the inference that some of these apostles, or their disciples, dwelling in the neighborhood of Ephesus, furnished some of the materials of which the Fourth Gospel is composed. Two points are further to be noted in this narrative. (1) In order to enhance the dignity of the central character, the writer causes the inferior characters to revolve around Jesus, conversing with and questioning one another, doubting and erring, before venturing to obtrude themselves upon Him (see, besides this passage, iv. 27, iv. 33, vii. 27, 40–43, xi. 16, xi. 37, xii. 20–22, xiii. 24, xvi. 17; and note how, both in xvi. 19 and in other passages, Jesus, after the manner of a king, takes the initiative in addressing His disciples, instead of their bringing their difficulties to Him unbidden, as they do for the most part in the synoptists). (2) The second point is the error of Philip in saying, "We have found Him, of whom Moses in the law, and the prophets, did write, Jesus of Nazareth, the son of Joseph" (i. 45). Philip introduced with this slightly pompous and erroneous statement—in a kind of irony highly characteristic of our evangelist—seems intended as a contrast to the humiliated and wiser Philip of the fourteenth chapter: "Have I been so long time with you, and yet hast thou not known Me, Philip?"

The first "sign."

The next chapter (ii.) opens with a "sign," of which the symbolism is obvious.[5] The water changed into wine evidently typifies the substitution of grace for the law. It was a common metaphor among the Jews to express the superiority of the oral tradition to the written law by saying that "the law is water, but the words of the scribes are wine"—a metaphor that exactly recalls the words of Origen about this very sign: "Before Jesus the Scripture was water, but from the time of Jesus it has been made wine for us" (*Comm. in Ev. Joann.*, xiii. 60). A somewhat similar comparison of old wine and new wine had been adopted by Jesus Himself to illustrate the difference between His teaching and the law of Moses. The identity between the purifying blood of Christ's sacrifice and the nourishing blood of His sacrament is understood even by Justin independently of the Fourth Gospel, and would be a natural inference from the Messianic prophecy (Gen. xlix. 11), which identified the cleansing stream that was to purify the robe of the Messiah with the blood of the grape, declaring that He should "wash His robe (*i. e.*, as Justin explains, it His church) in the blood of the grape." Therefore, in changing water into wine, the Messiah is, by His first sign, striking the key-note of all that is to come, indicating the object and nature of His work, viz., the supersession of the law by the gospel, and the introduction of a new spiritual nutriment and purification, which shall at once cleanse and strengthen and gladden the soul—all this to be effected by and in Himself through his blood.[1]

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[1] A somewhat similar compound sacrifice of "blood" and "mind" is described by Philo (*Alleg.*, ii. 15), who represents the High Priest as "having put off the robe of opinion and fancy, and as coming disrobed into (the Holy of Holies) to make an offering of the blood of life (*σπεῖσαι τὸ ψυχικὸν αἷμα*) and to offer up as incense all his mind to the God of salvation."

[2] No doubt these three sacrifices are also connected, in the author's mind, with the three gifts: (1) the water springing up into everlasting life; (2) the wine of the Lord's blood; (3), the spirit which He breathed into the souls of His disciples.

[3] Dr. Lightfoot (Col. iii. 12) accepts the personification in 1 Pet. v. 13 as "probably" intended.

[4] The numerical symmetry that pervades this Gospel is fully recognized by Canon Westcott, who sees "three pairs of ideas" running through the work, and "seven witnesses" corresponding to the seven times repeated "I am" (vi. 35; viii. 12; x. 7: x. 11; xi. 25; xiv. 6; xv. 1), and to the seven "signs" of Christ's ministry on earth, followed by one "sign" of the risen Christ.

[5] It is true that the symbolism of this "sign" is not indicated in the text in the same clear manner in which the symbolism of the feeding of the 5000 is avowed (vi. 32, 33); but there is a clear reference to it in the words (ii. 4) "Mine hour is not yet come," which seem to look forward to the hour when the "blood of the grape" should stream from the wounded side of Jesus. It may be necessary to point out, at the outset of this analysis, that the language of the Gospel may naturally have been affected, not only by the thought and language of Philo, but also by what was called the "Asiatic" style, which was prone to metaphor and symbolism: see Lightfoot's

Prediction regarding the temple.

The prediction here made of "the hour" when the "blood of the grape" should stream from His wounded side is at once followed by a second similar prophecy. After leaving Cana for the passover in Jerusalem (where He purifies the temple by expulsion of the money-changers; see above, p. 736), Jesus answers the request of the Jews for a sign with these words, "Destroy this temple, and in three days I will raise it up." It is added that He "spake of the temple of His body."[2] It is interesting to note four different stages of development in the expression of this prediction. The synoptists Matthew and Mark declare that a very similar charge (differing only in "I will destroy" and "I am able to destroy," Mat. xxvi. 61; Mk. xiv. 58) was brought against Jesus by false witnesses; and they give us no hint that the witnesses erred by a simple and natural misunderstanding. Luke, however, who not only wrote after the destruction of Jerusalem (when it would be a common saying that the Lord Jesus had destroyed the temple), but also modified his Gospel in many respects to suit it to the requirements of the changed times, makes no mention of any false accusation. In his subsequent treatise of the Acts he goes a step further; for there the accusation is repeated (Acts vi. 14), and not denied. Now, lastly, the author of the Fourth Gospel adopts the charge as in the main a true one, or at all events as an inevitable misunderstanding in which His disciples, as well as His enemies, participated. At the same time, this prophecy, like the symbol of the wine, prepares the way for Christ's subsequent doctrine (xiv. 23) that every man is a temple of God, and that He Himself is that Temple in the highest sense. This doctrine had been taught even before Paul by Philo, who scouts the thought of preparing for the Supreme a "house of stone or wood," and declares (*Cain and his Birth*, 20) that the invisible soul is the terrestrial habitation of the invisible God. Yet though Philo's language may have influenced the language of the Fourth Gospel in such passages as xiv. 23, it is most certain that this doctrine is a necessary inference from the teaching of Christ Himself, who taught us that the body must be "full of light." There is therefore no essential misrepresentation in this introduction of the Pauline doctrine of Christ the Temple or Church.

The doctrine of water.

The whole of the next chapter (iii.) deals with purification by water and the spirit. The learned but timid Nicodemus, "the teacher" of Israel (iii. 10), exhibits the blindness of carnal learning as contrasted with the knowledge that belongs to those who are born of the spirit. A third prediction of "the hour" is expressed through a third figure, the serpent in the wilderness. But this figure introduces a new conception, that of faith, an intense *looking* towards Christ, even as the children of Israel looked on the healing serpent.[3] This thought of faith as sight, illustrated perhaps by the statement that Nicodemus had come by night, introduces a few remarks on a subject hereafter to be more amply treated by the evangelist—the difference between the children of light and the children of darkness (iii. 18–21). In the second section of this chapter the subject of water-purification is taken up again by the Baptist, who contrasts his own inferior purification with the higher purification of the Messiah, and his own decrease with Christ's increase, describing himself (almost in the language of Paul) as "earthly," whereas the Messiah is "from heaven." But the Baptist also introduces the subject of faith; the path of life is through faith in the Son of God; "He that believeth in the Son hath everlasting life" (iii. 22–36).

Christ's relations with John the Baptist.

Particularly to be noted is verse 24 of this chapter, in which it is expressly stated that "John was not yet cast into prison." It will be remembered that the synoptists give no account of the public appearance of Jesus till after the imprisonment of John. It was therefore open to the enemies of the church to maintain that Jesus was but a pupil of the Baptist, and that He did not venture to teach till His master John had been shut up in prison. Much more might this be asserted in Ephesus, where, as we have seen, there were some who were baptized only with the baptism of John, and who knew nothing of the Holy Spirit. On this account probably it is that our author introduces Jesus as working by the side of John, before his imprisonment, and even then inevitably, and against His own will, drawing multitudes from the Baptist to Himself. The apostle John himself is one of the first to leave the Baptist for the Greater Teacher (i. 37); but the Baptist also is made to witness, and to rejoice in, the desertion: "He must increase, but I must decrease." And finally, we are told that the superiority of Jesus over the Baptist had become

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Galatians, p. 362, where we find that Polycrates, bishop of Ephesus (born or converted about 130 A. D.), described John (probably metaphorically) as a priest, wearing the πέταλον or high priest's mitre, and speaks of Melito as a "eunuch," meaning merely that Melito devoted himself to Christ ("propter regnum Dei eunuchum"). It is noteworthy in this context, that the Epistle to the Ephesians is the only Epistle that appears to contain an extract from one of those early hymns which, as Pliny says, the Christians used to "sing to Christ as a god," and this hymn, as is natural, deals in metaphor: "Awake thou that sleepest, and arise from the dead, and Christ shall give thee light" (Eph. v. 14). Probably from some such Asiatic metaphor (that "John, though dead, still breathed in the church") arose the tradition, of which mention is made by Augustine, that the earth over the apostle's body still rose and fell with his breath.

[1] This narrative may be abundantly illustrated from Philo. (1) He speaks of "the veritable High Priest," who pours forth a libation of "pure wine, namely *himself*" (*De Somniis*, ii. 27); (2) he connects this High Priest with the Logos by describing the Logos as a priest having for his inheritance the Eternal (τὸν ὄντα), a priest of the most high God (see also *De Somniis*, i. 37); (3) he speaks of this priest (under the type of Melchisedek) as substituting wine for water: "Melchisedek shall bring forward wine instead of water, and give your souls to drink" (*Allegories*, iii. 26).

[2] An inference has been drawn from the words Τεσσεράκοντα καὶ ἓξ ἔτεσιν ᾠκοδομήθη ὁ ναὸς οὗτος (ii. 20), that because the year so indicated would be the same year as that assigned by Luke to our Lord's commencement of His public work, therefore, by their coincidence, the two Gospels mutually support each other. But it seems natural that the writer of this Gospel, an educated Jew, should know both the date of the commencement of the temple and the date as given by Luke of the commencement of our Lord's ministry; and it seems characteristic of the author, by details of this kind (and especially by numbers), to add picturesqueness and realism to his narrative: *cf.* the 200 pence (vi. 7), the 200 cubits (xxi. 8), etc. However, it must not be forgotten that Origen (*Comm. in Ev. Joann.*, x. 22) throughout his long discussion of this passage assumes that the meaning is "in" not "during" forty-six years. And this seems to be the natural translation of the words—"the temple was built *in* forty-six years" (although the dative may be used for duration of time, the aorist hardly permits the English version); and if so, the author is under a mistake in supposing that the temple was completed. Yet from this passage (ii. 20), and from other indications of a knowledge of Jewish customs, Messianic expectations, and the geography of Palestine, it has been inferred that the author was a Palestinian Jew. A stronger argument is the author's preference of the Hebrew rather than the LXX. version of the Old Testament (Canon Westcott quotes vi. 45; xiii. 18; xix. 37), which certainly shows either that he used the Hebrew version himself, or that the Ephesian doctrine was based upon that version. The knowledge of the country does not seem to exceed what might be attained by any Alexandrian Jew who had spent one or two passovers in Jerusalem and had travelled for a short time in Palestine; and the geographical argument has been unduly strained by such suggestions as that a "minute knowledge" of the relative positions of Cana and Capernaum is implied in the expression "He went down" (ii. 12). The same argument would show that the author of the book of Jonah had a "minute knowledge" of the position of Joppa (Jonah i. 3), or that the author of the Acts of the Apostles had a "minute knowledge" of the places from which he or Paul "went down" to Attalia, Troas, or Antioch (xiv. 25; xvi. 8; xviii. 22). Any traveller might know that Capernaum was in the low-lying basin of the Jordan, down on the edge of the sea of Galilee, without having a "minute knowledge" of its position relatively to the inland villages of Galilee.

[3] According to Philo, the brazen serpent represents temperance, the antidote of pleasure; and he who has strength to behold the beauty of temperance, and to "discern God through the serpent" shall live (*Allegories*, ii. 20).

so manifest that the Pharisees had heard that Jesus made and baptized more disciples than John, and upon this, desiring to avoid this appearance of superiority, Jesus retired to Galilee[1] (iv. 1). It would not be possible more effectively to repel every suggestion of the pupilage of Jesus, or of his subordination—even His temporary subordination—to John the Baptist.[2]

The dialogue of the well.

Now follows (ch. iv.) what may be called the foreign section of the Gospel. We noticed that, even in Luke, the Samaritans assume a prominent position, their faith and unconventional goodness being twice contrasted with the carnal formalism of the Pharisees, at one time in a miracle (Lu. xvii. 16), at another time in a parable (Lu. x. 33). We are now to see how the contrast between Samaria and Judæa is handled in the Fourth Gospel in the dialogue on the living water, which might fairly be called, from its subject, as from its scenery, the "Dialogue of the Well." The well is a frequent figure in the books of Philo. To all men, says Philo (*Planting of Noah*, xix.), there is, in common, the desire to find drink; but some seek drink for the body, others for the soul. The seekers after truth are as those who dig wells, and many seekers have dug wells without finding water; and taking the LXX. version of Genesis xxvi. 32, "We have *not* found water," he comments on the well of the oath (Beersheba), which is discovered to be "dry;" and he declares that the dry well illustrates the failure of all human search after knowledge, as compared with the ideal God-given knowledge which is like a gushing spring. Elsewhere (*Dreams*, ii. 2, *et seq.*) he says, even more explicitly, that the well is the emblem of knowledge; that its depth signifies the difficulty of the attainment of knowledge; and that concerning all knowledge the well-diggers have to make but one sad confession, "We can find no water." Moses sits by the well "waiting to see what water God will send forth for his thirsty soul" (*Alleg.*, ii. 4); Israel "sang the song of the well," *i. e.* sang a song of triumph at the discovery of knowledge (*Dreams*, ii. 4); and the remark of the daughter of Samaria (iv. 11) that "the well (φρέαρ) is deep," followed by the contrast of the "fountain" (πηγή) of water that "leaps up" (iv. 14), at once suggests Philo's contrast between the bond-woman Hagar at "the deep *well*" and Rebecca who nourishes those who come to her with "the *fountain* that never fails" (*Posterity of Cain*, 41). Origen, in the same way, considering Jacob's well to mean the Old Testament, contrasts Samaria leaving her ὑδρία (the old implement of knowledge) with Rebecca at the fountain (*Comm. in. Ev. Joann.*, xiii. 10 and 29). The four wells dug by the patriarchs Abraham and Isaac represent (*Dreams*, ii. 3, 4) four departments of knowledge. The fourth and dry well represents the search after the fourth and incomprehensible immaterial element corresponding to the material heaven —a search that is necessarily fruitless. This being Philo's interpretation (and he indignantly protests against any other, as being unworthy of wise men), we shall also see a singular propriety in placing the dialogue on the living water in the neighborhood of "the parcel of ground that Jacob gave to his son Joseph" (iv. 5); for here also Philo has prescribed a metaphorical interpretation, declaring that "Jacob gave Joseph Shechem, meaning thereby the bodily things which are the objects of the outward senses" (*Allegories*, iii. 8). But there is also an appropriateness in the use of the name (iv. 5) "Sychar." For whether the name be a corruption of "Shechem" or of "Askar" (Sanday, *Fourth Gospel*, p. 93), in either case the name contains a possible reference to "drunkenness" (Isaiah, xxviii. 1, 7; *Dict. of Bible*, s. v.), and serves as a suitable contrast to the Living Water. The next point for consideration is the "five husbands" of the woman of Samaria. Is there any special meaning in the number "five"? Turning again to Philo, we find, a little after the passage about wells quoted above, the statement that "the number five is appropriate to the *outward sense*" (*Planting*, 32), and that it represents material enjoyment. This is certainly a natural use of the number, if it is to be used emblematically.[3] Further, the number "five" is connected also by Philo, not indeed with "husbands" but with "seducers." Philo (*Allegories*, iii. 88) says that the lawful husband is the mind (νοῦς), the unlawful husband or seducer (φθορεύς) is represented by the five objects of the senses working through the five senses.[4] Immediately before the passage, Philo adopts the more common metaphor of the Old Testament in speaking, not of the mind, but of the Lord Himself, as the Husband, being the Father of the perfect nature, and sowing and begetting happiness in the soul. Samaria is supposed by Justin (*Dial.* lxxviii.) to represent in Isaiah (viii. 4) "sinful and unjust power;" but here it rather typifies sense-wrapped ignorant unbelief. The whole of this imagery seems so well connected and so appropriately transferred from the pages of Philo to the pages of the Fourth Gospel, that one hesitates to accept another explanation (Keim) which would otherwise seem extremely probable—an explanation borrowed from the five religions of the five nations of Samaria (2 Kings xvii. 30–37). In either case, the sixth "husband" may very well refer to Simon Magus, who, as we know from the Acts of the Apostles (Acts viii. 11), had very early in the history of the church "for a long time" held the Samaritans "bound with his enchantments."[5]

Like all the other narratives of our evangelist, this narrative is in the highest degree dramatic. From her previous repellent attitude, the woman of Samaria is led, first into wonder, then into interest, then into conviction of sin (becoming ashamed of her false husbands) and into admiration of the New Prophet; lastly, she receives from the Messiah a draught of that spiritual water which alone can satisfy the longing soul; and in the climax she is brought to the very brink of the eternal fountain—"I that speak unto thee am He."

The journey into Galilee.

The journey into Galilee adds one more to the instances in which the Fourth Gospel corrects the synoptists. The saying that "a prophet is not without honor save in his own country" is stated by the synoptists to have been uttered by Jesus in Galilee (Matt. xiii. 57; Mk. vi. 4; Lu. iv. 24) *after* the unexpected rejection of Him by his countrymen; and Mark adds one of those passages which were early "stumbling-blocks" to the church, viz., that "He was not able to do there any mighty work, . . . and He marvelled because of their unbelief." Not content with Luke's considerable modification of this passage, the author of the Fourth Gospel boldly places this saying of Jesus *before* the visit to Galilee, and assigns it as *a reason for His going thither:* "After two days He departed thence (from Samaria) and went into Galilee; *for* Jesus Himself testified that a prophet hath no honor in his own country" (iv. 44). The motive is obvious: Jesus is desirous of escaping from notoriety. He has found that the Pharisees (iv. 1) are aware of His superiority to John the Baptist, and that His disciples exceed John's in number; and for this very reason He leaves Judæa, and comes to Samaria, a hostile district. Even here, however, He cannot help making converts. But having made them, He leaves them and goes into Galilee, where at least He is sure to find "no honor." Yet even here, adds the author, He *was* honored; for "the Galileans received Him, having seen all the things that He did at Jerusalem at the feast" (iv. 44). Thus skilfully, after his manner, the author takes those very sayings and traditions which had been turned against Jesus, and, by his delicate handling, uses them to enhance the glory of the Messiah, "who knew what was in man" (ii. 25).

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[1] The insertion of the remark that "Jesus himself baptized not, but his disciples," serves two purposes:—(1) to magnify the Messiah; (2) to disparage the mere baptism with water.

[2] It is, of course, possible that here (as in the matter of the last supper) the Fourth Gospel may have preserved some historical traditions concerning the acts of the Lord in Judæa, which have not been preserved in the synoptic record. Nor is it denied that elsewhere, *e. g.*, in the matter of the three passovers, the Fourth Gospel may be historical. There is scarcely evidence enough to admit of absolute demonstration on either side. All that is contended is that, whether historical or not, the incidents recorded in the Fourth Gospel are suggested (1) often by a clearly discernible motive in the mind of the writer contrasting forcibly with the motiveless, simple, inartistic narrative of St. Mark; (2) sometimes by a desire to supplement, if not to correct, the previous narratives of the synoptists. The presence of such a motive and desire is not, of course, absolutely inconsistent with historical accuracy; but, the more we consider the synoptic narrative to be objective, and the more we consider the Fourth Gospel to be subjective, the more we shall be disposed to believe that, in proportion as incidents in the latter are suggestible by motives and desires, in that proportion are they likely to be non-historical, especially if they appear to be difficult to harmonize with the earlier narrative of the synoptists. It has been suggested that the lamentation over Jerusalem (Mat. xxiii. 37; Lu. xiii. 34), expressed in the words, "How often did I desire to gather together thy children . . . and ye would not," implies many previous visits. These words were no doubt spoken in Jerusalem, where Matthew (not Luke, see p. 711, above) places them; but still, may they not refer to the many occasions in Galilee where the Redeemer, striving to "gather together" the children of Israel, had surely included the "children of Jerusalem" in the scope of his efforts? Even if the words "thy children" are to be taken literally, they may refer to the occasions when the scribes and Pharisees had come down from Jerusalem to test the Messiah, and Jesus had proclaimed the new kingdom to them in vain. Though preaching in Galilee, Jesus was really conflicting with the spirit of Jerusalem, and striving to "gather together the children of Jerusalem." In any case the supposition that ποσάκις refers to previous public visits to Jerusalem results in an incompatibility. For no one maintains that Jesus had made more than two previous public visits to Jerusalem; and it is impossible that "how many times" can mean twice.

[3] Origen (*Comm. in Ev. Joann.*, xiii. 9) speaks of "the five husbands as corresponding to the *five senses;* and he says that Samaria is the type of a soul which has once been wedded to the objects of sense, but has recently divorced herself from these and allied herself to a "sixth husband," a false semblance of spiritual truth. If this stood by itself, we might regard it as one of many other specimens of Origen's baseless allegory; but it assumes importance when we find Philo, who wrote long before the composition of this Dialogue of the Well, using nearly the same language as Origen, who wrote after it and (apparently) without any knowledge of Philo's pre-existing metaphor.

[4] Elsewhere (*Migration of Abraham*, 37) he says that the "five daughters" of Salpaad represent the "outward senses." The same thing is represented (*Abraham*, 5) by "the five cities of Sodom."

[5] Yet the "sixth husband" may possibly be illustrated by the contrast which Philo (*Abraham*, 5) draws between the "seventh power," the "power of peace," and the "six powers of turbulence," which consist of "the five senses" and uttered "speech" (ὁ προφορικὸς λόγος) which prates of things that should not be uttered (ἀχαλίνῳ στόματι μυρία τῶν ἡσυχαστέων ἐκλαλῶν); see Rev. xiii. 5.

The pool of Bethesda.

Passing over the cure of the nobleman's son, which has been discussed above, we come to the first "sign" wrought on the sabbath (v. 2–9). Once more there is a contrast between the water of the law and the fountain of the Messiah. The rejection of this divine act of mercy, simply because it was wrought on the sabbath, introduces, almost for the first time, the conception of "judgment" or "condemnation." The word "judgment" had been mentioned in the dialogue with Nicodemus, as a necessary result, though not an object, of the coming of the Light, which, by its very presence, distinguishes and "judges" those who love the darkness (iii. 17–21); and now we have an example of the way in which the Light divides all who hold it into two classes—those who love it and those who hate it. This is in accordance with the spirit of the synoptists, who (Mat. xxiii. 13; Mk. xii. 40; Lu. xx. 47) describe Jesus as addressing the sabbatarian sign-hinderer as "hypocrite," and as pronouncing on "hypocrites" greater "judgment" or condemnation (περισσότερον κρῖμα). But that part of the discourse in which Christ describes Himself, in the presence of the multitude, as having received all power to judge and to quicken the dead, does not resemble anything in the synoptic narrative, except the discourse—"All things are delivered unto Me of My Father" (Mat. xi. 27; Lu. x. 22); and that was uttered privately to the disciples, after their return from their mission. It is possible that the author here (as elsewhere) sets down, as a public discourse, some sayings that may have been uttered privately; and the words "that all men should honor the Son, even as they honor the Father," remind us at once of the synoptic saying, "He that receiveth you receiveth Me, and He that receiveth Me receiveth Him that sent Me" (Mk. ix. 37, etc.); which again, in the synoptists, was a private, not a public saying.

The doctrine of faith.

The author's fidelity to the spirit rather than to the letter of the words of Jesus appears also in the reference to the quickening and raising from the dead. Jesus had in Matthew (x. 8) bidden his disciples to "raise the dead," and this precept is amplified in the Fourth Gospel into "The hour is coming and now is, when the dead shall hear the voice of the Son of God; and they that hear shall live" (v. 25),—a saying that would naturally be interpreted in a purely spiritual sense.[1] No less spiritual is the doctrine here enunciated on faith. As elsewhere in this Gospel (i. 50; iii. 1, 2; iv. 39–41; xx. 29; and, if rightly considered, vi. 26), the author lightly esteems belief based on "mighty works" or wonders. The right faith is that of the Samaritans, who, rising out of the lower wonder-faith, attain to the higher faith which comes from hearing Christ (iv. 42). For to this, and to no other testimony, does Christ, in the Fourth Gospel, make His ultimate appeal. Christ does not indeed despise the testimony of John to Himself, but he does not accept it as a final basis for the true faith (v. 32–34). He appeals to the Scriptures, it is true, but rather as an unerring guide to the true source of faith than as being of themselves able to generate faith in the reader (v. 39). What then is the living final testimony to which He appeals? It is to His "works,"—not the "mighty works," or "wonders," but all "the works (ἔργα) which the Father hath given Me to do," meaning the whole of His life, and including both words and deeds. In other words, the Fourth Gospel appeals to that which we should call the influence of the life of Jesus, but which the evangelist better calls the "Spirit" of Jesus, passing from Jesus to His disciples, and from those disciples to others who had not seen Jesus—as the final testimony, convincing every honest heart, and generating in every conscience that loves the light a belief in Jesus as the true Light. In the synoptists, "faith" is, for the most part, that half physical thrill of trust in the presence of Jesus which enables the limbs of a paralyzed man to make the due physical response to the emotional shock consequent on the word "arise," so that in the strength of that shock the paralytic is enabled to shake off the disease of many years; or, at the highest, it is a thrill through the inner being, whereby the soul shakes off the burden of sin. But in the Fourth Gospel faith implies even more than in Paul's Epistles; it is a faculty that tests, transmutes, and develops the recipient soul; it means a trust in Christ, not only as a sacrifice, nor as propitiation, nor as miracle-worker, nor as Son of God, but as source and object of all love, and the be-all and end-all of every human life. If such a Being is best expressed by "Word," then the human receptiveness of such a Being will be best expressed by the metaphor of "hearing." Accordingly the Samaritans believe, not because of miracles, nor because He told the woman "all that ever she did," but because they had enjoyed His presence for two days, and had *heard* him. "Now we believe, not because of thy saying; for we have *heard* Him ourselves, and know that this is indeed the Christ, the Saviour of the world." Here we have at last a doctrine not borrowed from Philo, a doctrine that constitutes the great difference between Philo's philosophy and the religion of the Fourth Gospel, making the latter a powerful and life-inspiring motive for all classes of men, while the former remains a barren philosophy fit only for meditative hermits. For in Philo, faith, as in the Old Testament (Lightfoot, *Galatians*, pp. 154–162), has a passive meaning—trustworthiness, stability, constancy,—rather than the active meaning of trust, by which the lower nature is raised to the level of the higher; the "dog" to the level of "man" (Bacon, *Essays*, xvi. 79); the man to the level of Christ, and, through Christ, to God (1 Cor. iii. 23). Faith, in Philo, is a prize rather than an effort, a harbor rather than a voyage; it is "the only sure and infallible good, the solace of life, the fulfilment of worthy hopes" (Lightfoot, *Gal.*, p. 158); whereas, in the New Testament, it is the faculty by which one is able to trust in Christ, to love Christ, and to serve Christ—a faculty implying continuous effort, loyal and enthusiastic service, and progressive activity. The nearest approach in Philo to the Pauline and Johannine faith is perhaps in the words that describe it as "the entire amelioration of the soul which leans for support on Him who is the cause of all things, who is able to do all things, and willeth to do those which are most excellent" (*ib.* p. 158); but even this, though the same in theory, is very different in practice from the faith of the New Testament. For—faith being neutral and colorless and taking its color from its object—how different must needs be even the faith that is based upon the *things* that are "most excellent" from the faith that rises to the Father through such a one as Jesus of Nazareth, concerning whom even the most incredulous must admit that He made peace in man's troubled heart, banished sin from those who trusted in Him, and "constrained" (2 Cor. v. 14) even His bitterest persecutor to join in laying the foundations of His empire.[2]

In the discourse that follows the miracle of the feeding of the five thousand,[3] it is noteworthy that the author speaks of the eucharistic food not as the Lord's body and blood, but as his "flesh" and blood. Most characteristically: for "flesh" is, as in Paul's epistles, a principle, an element, and the author desires to show that the Lord's flesh and blood are the only satisfying element for the human soul. He has before spoken of blood and flesh and man (i. 13) as antagonistic elements to the divine elements; now he wishes to point out the divine elements themselves, and they are the flesh and blood of the Word, who "became flesh" (i. 14, σὰρξ ἐγένετο) for men. Here, as before, we must add that the use of this language—"Whoso eateth My flesh and drinketh My blood"—in a public discourse is quite unlike anything in the synoptists, and though it represents the essence of the teaching of the Lord's supper, somewhat amplified, it can hardly be considered in its chronological, or even perhaps in its artistic place, as a public discourse here. Yet it is necessarily placed here to account for the desertion of many of His followers.

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[1] Compare Philo, *De Profugis*, 10, "Some that are living are dead; and some that are dead live."

[2] It is a remarkable fact that this evangelist never uses the noun πίστις, which is frequently used by the synoptists, while he uses the verb πιστεύειν about twice as often as it is used by all the synoptists put together. He appears to prefer to contemplate faith, not as in itself a virtue, but rather as a mental act or state taking its quality from its object. Note also that he seems to distinguish between πιστεύειν μοι and πιστεύειν εἰς ἐμέ. The former is generally used in questions and negations (v. 38; viii. 45, 46; x. 38), or else of temporary and progressive trust, *e. g.*, trust in God, in the word of Jesus, or in the Scriptures; all of which are regarded as preparatory acts leading to that final state of trust which can only be obtained by *coming to* Jesus (iv. 50; v. 24; v. 46; v. 47 (*bis*); x. 38). The latter (πιστεύειν εἰς) denotes the final state of fixed trust and repose on Jesus, and it is only once used by the synoptists (Mat. xviii. 6; ? Mk. ix. 42).

[3] Nothing has been said here about the difference of John's chro-

The confession of Peter.

In the synoptists the desertion is otherwise explained. There we see Jesus, as He develops the constitution of His Kingdom, alienating, step by step, the Pharisees, Herod, the patriots or Galileans, the followers of John the Baptist, and at last the whole of His countrymen, till He is compelled to flee from Herod to the neighborhood of Cæsarea Philippi, where, as an exile with no more than twelve other outcast companions, He who had never revealed Himself to be the Messiah finds, upon questioning His disciples, that they have been led by the divine guidance to the sense that He and He alone must needs be their Redeemer; so that the seed of faith has at last begun to germinate, and He can now prepare to leave them, because he discerns already the temple of the new kingdom founded upon the inspired confession of Simon Peter. In the Fourth Gospel, on the other hand, the desertion of the disciples is represented as due to another cause, namely, their unspiritual dulness and their inability to understand the doctrines of their Master. Here and there in this discourse appear glimpses of the synoptic utterances,—for example, in the words "No man can come unto Me except My Father draw him" (vi. 44); and in the words "It is the Spirit that quickeneth, the flesh profiteth nothing" (vi. 63), one seems to recognize a version of part of the blessing of Peter, "Blessed art thou Simon, son of Jona, for flesh and blood hath not revealed it unto thee, but My Father which is in heaven." But elsewhere, in the greater part of this discourse, the author departs entirely from the synoptists. In the confession of Peter, a very striking peculiarity is presented. Not only do we find brought out in a very touching manner what may be almost called the despairing faith of the confessing apostle—"Lord, to whom shall we go?"—as though the disciples were driven in desperation to remain with Jesus because, if they deserted Him, they had no hope, no refuge, elsewhere; but we also find Peter avowing the cause of his belief, and it is the same cause as moved the believing Samaritans; it is not the "signs" but the "words" of Jesus—"Thou hast the *words* of eternal life."[1]

Hitherto the Gospel has dealt with the Word as purifying and nourishing; now it has to speak of it as enlightening. The types have hitherto been water (under various aspects), wine, flesh, blood, bread; now we are to read of Jesus as Light. This is the highest or nearly the highest doctrine; for it is another aspect of the doctrine of the Spirit. The two doctrines are closely connected in Philo, who (*Creation of the World*, 8) declares that God assigned a "pre-eminence to the elements of spirit (or breath or air) and light, calling the former the spirit of God because it is the most life-giving element, and God is the cause of life;" and the visible light Philo declares to be the image of the invisible light, which is the image of God. In the short summary of Christ's doctrine set forth to Nicodemus (iii. 3–21), a brief suggestion of the doctrine of the light follows on the doctrine of baptism; now the higher doctrine is to be expanded. But light implies darkness, and therefore the development of the doctrine of light connects itself naturally with the period of conflict between light and darkness, *i. e.*, between the Word and "the Jews,"—a conflict that becomes from this time more and more prominent.

Climax of the doctrine of water.

First of all, however, comes a climax of the doctrine of water, and a preparation for the doctrine of light. This section (vii. 2–40) begins with a very distinct indication, differing widely from the synoptic treatment, of the relations between the Lord and his brethren. It is possible that the Ebionite school based their low views of Christ's nature upon traditions derived, or supposed to have been derived, from the Lord's brethren, and that the author is here striking at a particular school of thought. Comparing Mk. iii. 21 with Mk. iii. 31, we see clearly that the mother and brethren of Jesus, alarmed perhaps for His safety, and deceived by false reports about His sanity, desired to place Him under restraint; and Matthew and Luke unite in asserting that the mother as well as the brethren desired to speak to Him, and were rejected. But there is no mention of the mother in the Fourth Gospel as ever doubting or ever alarmed concerning her Son; the brethren alone doubt, and their doubt amounts almost to an antagonistic scepticism. They do not "believe in Him," yet they urge Him to go to "Judæa that the disciples may see the works that Thou doest. *If Thou doest these things,* show thyself to the world" (vii. 3–5). No reproof could be more severe (from the point of view with which the Fourth Gospel regards the "world") than the reply of Jesus: "The world cannot hate you; but Me it hateth." So imbued are the Lord's brethren in fleshly worldliness, that the world recognizes in them that familiar darkness which it loves, because its works are dark, while it hates the convicting light. It is not surprising, after this, that Mary, who throughout this Gospel is regarded with affectionate reverence, is not committed to the guardianship of these sceptical brethren of the Lord.

The discourse itself is, as has been said, mainly preparatory. After one brief appeal to the conscience as the final test of the truth of His teaching (vii. 17), the conflict is predicted: "Why go ye about to kill Me?" A hint of the synoptic saying "He casteth out devils through Beelzebub" is perhaps contained in the reply of the people, "Thou hast a devil;" but the author deviates from the synoptists, in the justification of the sabbath-cure, not from the "ass" or the "ox" in the pit (Lu. xiv. 5), but from the practice of circumcision on the sabbath (vii. 22, 23). The violent spirit first manifested after the cure of the impotent man (v. 16, 18) now breaks out again, and a direct attempt made by the Pharisees to arrest Him (vii. 32), frustrated by the wonder of His words (vii. 46; and compare xviii. 6), leads Jesus once more to predict that he will soon pass away from them, and finally to conclude the "doctrine of water," by exclaiming in "the last day, the great day of the feast, . . . he that believeth in Me, as the scripture hath said, out of his belly shall flow rivers of living water"[2] (vii. 38). The spiritual climax thus given to the doctrine of water is very striking. The well of living water, before promised to the woman of Samaria, is now not merely to spring up in the believer, as there stated (iv. 14), but it is

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nology from that of the synoptists, because, if the Fourth Gospel is a spiritual rather than an historical composition, it is scarcely to be expected that its chronology should be limited by historical considerations; and, in any case, the subject is too large a one to be discussed here. Canon Westcott remarks (*Gospels*, p. 285) that "a very strong case has been made out by Mr. Browne (*Ordo Sæclorum*) for the limitation of the Lord's ministry to a single year. If there were *direct* evidence for the omission of τὸ πάσχα in John vi. 4, his arguments would appear to be convincing." The context suggests that the words τὸ πάσχα may not improbably be an insertion based on a sense of the spiritual meaning of the narrative rather than on history.

[1] Although the word used by Peter (ῥῆμα) is not the same as that used by the Samaritans (λόγον), yet a comparison of a great number of passages in which the "word" of Jesus (λόγος μου) is said to be the object of belief, and the source and province of spiritual life (ii. 22; iv. 50; v. 38, the word of God; viii. 31; viii. 37, 43, 51, 52; xii. 48; xiv. 23, 24) seems to show that the name Λόγος itself had some influence in leading the author to insist so frequently upon the "word" rather than "the works" as being the prime cause by which the incarnate Word generated faith in the souls of men. In the Fourth Gospel the plural λόγοι is only once used by Jesus of His words (xiv. 24); and there in a passage where (seemingly) it is desired to distinguish the separate from the collective "words:" Ὁ μὴ ἀγαπῶν με τοὺς λόγους μου οὐ τηρεῖ· καὶ ὁ λόγος ὃν ἀκούετε, οὐκ ἔστιν ἐμὸς ἀλλὰ τοῦ πέμψαντός με πατρός. On the other hand, the synoptists frequently represent Jesus as speaking of "my words" and of "the word," but never of "my word." Note also the remarkable passage (xii. 48) where it is said that Jesus does not judge men, but that the word which He has spoken will judge them.

[2] These words have caused perplexity, as not being found in any book of the Old Testament; but they are probably a corrupt reading or reminiscence of the LXX. version of Isa. xliv. 3, 4, "I will give water in the midst of drought to them that walk in a waterless land; I will place My spirit upon thy seed, and My blessings upon thy children—καὶ ἀνατελοῦσιν ὡς ἀνὰ μέσον ὕδατος, etc." The Greek words quoted above were probably separated from their context; ἀνατελοῦσιν was taken transitively and connected with ὑδώρ (ὑδὼρ ἀνατέλλειν, Pind. *Is.*, 6 (5) 111, being a recognized phrase for "to make water gush forth"); and ἀνὰ μέσον was rendered "the middle parts," ἐκ κοιλίας. Such corruptions of the Old Testament are readily paralleled from Barnabas and Justin, although altogether unlike the method of quoting the Scripture assigned to our Lord by the synoptists.

also to flow forth from Him to others, thus preparing the way for the higher doctrine of the Spirit of fellowship which the author touches on in the next verse: "But this He spake of the Spirit, which they that believe on Him should receive" (vii. 39).

Irony of the Fourth Gospel.

The method of the author is admirably illustrated by the dialogue between the people (vii. 41, 42): "Others said, This is the Christ, but some said, Shall Christ come out of Galilee? Hath not the scripture said that Christ cometh of the seed of David, and out of the town of Bethlehem where David was?" It is a curious instance of the degree to which the dramatic character of the Fourth Gospel has been ignored, that even an acute commentator has inferred from this passage that John "was not aware of the birth at Bethlehem." The fact is that the author uses these and similar errors and blind gropings of the people, the enemies, and even the disciples of the Lord, to enhance the majesty and insight of Him who walks above them all, high in the light of heaven, while they are creeping in the mist around His feet. He does not stop to correct these vulgar errors, for he presupposes that his readers are in the light, and able to see through them all; and it is with a frequency almost betokening enjoyment that he repeats this device over and over again, in every case holding up the error in silence to the contempt or pity of his reader, and delighting to exhibit human folly glorifying the wisdom of God. Instances of this device occur in this very chapter. "Who goeth about to kill Thee?" says the ignorant multitude (vii. 20), at the very time when the arrest of Jesus is being planned by the Pharisees: "Out of Galilee ariseth no prophet," say the learned students of the law (vii. 52), so blinded by their malignity that they cannot even read the books that describe the birthplaces of Elijah and Jonah: "We have found Him of whom Moses in the law, and the prophets, did write, Jesus of Nazareth, the son of Joseph," says Philip, happy in the completeness of his new-fledged knowledge (i. 45), and ignorant that a time will come when he will hear from the "son of Joseph" this humiliating rebuke, "Have I been with you so long, and hast thou not known Me, Philip?"

The doctrine of light.

Passing over the story of the woman taken in adultery as being an interpolation, we are led to that section of the Gospel which treats of the doctrine of light. The mention of the Father and the Son, as being two witnesses, bearing witness to the Son—according to the saying of "your law" that "the testimony of two men is true" (viii. 12–17)—is a subtle use of the words of Scripture, such as we look for vainly in the teaching of Christ as preserved by the synoptists.[1] But the connection between the light and the truth, and between truth and freedom, and the dialogue that follows upon the genuine children of Abraham, remind us, in part, of the synoptic version of the Baptist's teaching about the children of Abraham (Mat. iii. 8; Lu. iii. 8); in part, of the teaching of St. Paul concerning the freedom of "Jerusalem which is above" (Gal. iv. 26; and compare Rom. vi. 16–20).[2]

The climax of hatred and insult of the Jews is most appropriately expressed (viii. 48), "Say we not well that Thou art a Samaritan and hast a devil?" and it is also appropriate to a discourse on "the Light that lighteth every man coming into the world" that the Jews should be informed that even Abraham saw that light and rejoiced. It is probable that both here and in xii. 36 we ought (in spite of the LXX. usage) to translate *ἐκρύβη* "was hid" (*cf.* Lu. xix. 42; Heb. xi. 23), and that we must suppose the intervention of some supernatural agency in a judicial retribution hiding the Light from the children of darkness who seek to destroy it.

The opening of the eyes of the blind man.

The section on light terminates with an appropriate sign, the opening of the eyes of the blind man, who is sent to wash his eyes in the waters of a pool named Siloam. The evangelist sees a mysterious meaning in the name of the pool. As the Baptist had baptized in Ænon near to Salim, *i. e.*, the "waters" near to and preparing the way for "peace;"[3] and the Samaritan woman had boasted of her well of Sychar or drunkenness, and the impotent man had been healed in Bethesda, or the "house of mercy," so now the opening of the eyes of the blind man is effected in part by the direct action of the Light of the world, but in part also by the instrumentality of water at a pool named "Sent,"—a word which may apply to an aqueduct, "*missio* aquarum," or to Him whom the Jews expected as the "Sent," *i. e.*, the Messiah. The conclusion of the section on light (ix. 39), "For judgment I am come into this world; that they which see not might see, and that they which see might be made blind," accords with the passage in Matthew and Luke where Christ acknowledges to the Father that it hath seemed good to Him to reveal these things to babes and to hide them from the wise and prudent (Mat. xi. 25; Lu. x. 21); and the climax appropriately introduces the Pharisees, confident in the "lamp of the law," asking, in a tone which suggests the utter impossibility of an affirmative answer, "Are we blind also?" The answer of Jesus distinguishes two kinds of darkness in the soul—the involuntary darkness arising from inexperience of the light, and the voluntary darkness which arises from experience and rejection of the light. His answer explains the sense in which the word "hypocrite" was so often applied to the Pharisees by Jesus in the synoptists. The Pharisees were in darkness, and, like all other men, had received gleams from "the light which lighteth every man," convicting them of their darkness, and leading them to say, "We see not," if they had but been honest. But they persisted in saying, "We see."[4] Therefore, it is said to them, "Your sin remaineth" (ix. 41). These latter words, whether uttered or not by Jesus in the exact shape in which the Fourth Gospel gives them, are undoubtedly true to the spirit of His teaching; and they furnish a suitable end to the discourses on light, bringing prominently forward that "reproving" or "convincing" power of light which is one of the special attributes of that Holy Spirit to whom, step by step, the Fourth Gospel is leading us.

The good shepherd.

The metaphor of the good shepherd suggests an important difference between the Fourth Gospel and the Gospels of Matthew and Luke, viz., the absence of all allegory and almost all parable in the former. Why did the author, who rejected so many other parabolic subjects, retain only this parable of the shepherd in common with them? The answer may be, partly that it is a parable based upon the teaching of Philo, who distinguishes between mere indulgent "keepers of sheep" and "shepherds," somewhat in the same way in which our parable distinguishes between "hirelings" and shepherds; and he adds that the Supreme Shepherd is God, who orders all His flock of created things through the Logos, His first-born Son (*Plantatio*, etc., 11). In part, perhaps, the author may have felt that the synoptic picture of the shepherd "leaving the ninety and nine sheep in the wilderness" while He seeks the single wanderer, requires at least to be supplemented by the picture of Him who putteth forth His sheep, and is followed by them, so that none of them wander. But a principal reason for introducing this parable at the conclusion of the doctrine of light, and before the narration of the death of Christ, is to prepare the way for that death, by exhibiting the reason for it in a clear light. It is true that Jesus has, before now, predicted that He is to be "lifted up" (iii. 14, viii. 28) and slain (vii. 19, viii. 40); but it needs to be distinctly stated that Jesus will not only be slain, but voluntarily slain; and the motive requires to be expressed. This is explained in the synoptists by saying that He came to give His life as a ransom (*λύτρον*) for many (Mat. xx. 28; Mk. x. 45). But to whom was this "ransom" to be paid? To God or to the evil one? The question was a difficult one to answer; and the Fourth Gospel avoids, though it does not solve, an insoluble difficulty by substituting a new metaphor for that of ransom: "I am the Good Shepherd. The Good Shepherd giveth His life for the sheep." Then, in a master-piece of delicate spiritual subtlety, while the expression "the Good Shepherd will even be slain by the wolf for the sheep's sake"—which would have introduced all sorts of intricate difficulties—is avoided, the same thing is, by antithesis, indirectly suggested—"But the hireling seeth the wolf coming, and leaveth the sheep, and fleeth." A repetition of this statement leads to a more emphatic reiteration that the Shepherd will lay down His life of His own free will (the essence of sacrifice), "in order that He may take it again" (x. 17)—thus entirely neutralizing the suspicion (so carefully avoided above) that the Good Shepherd may be doomed to succumb to the wolf.[1]

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[1] It appears to mean the Son, on the one side, manifesting Himself by *ἔργα*, and the Father, on the other side, abiding in the heart of the hearer, and influencing the conscience to acknowledge and believe in the Son.

[2] Ver. 35 and 36 seem difficult to connect with ver. 34, "*Whosoever committeth sin is the servant of sin.* And the servant abideth (*μένει*) not in the house for ever, but the Son abideth ever; if the Son therefore shall make you free, ye shall be free indeed." The italicized words seem to confuse the thought. The argument that seems required is this. "No mere servant, such as Moses, is a safe patron for those slaves who desire the master of the house to enfranchise them; the safe patron is the Son, whose influence in the house is permanent." Just such an argument is found in the Epistle to the Hebrews (iii. 5; viii. 3). "Moses was faithful in all His house as a servant, . . . but Christ as a son over His own house, whose house are we;" and in the same epistle Christ is said to "abide" (*μένειν*) a priest continually, and to be able (Heb. vii. 24, 25) to save men to the uttermost, because He "abideth" (*διὰ τὸ μένειν αὐτὸν εἰς τὸν αἰῶνα*). It seems probable, therefore, that some early teaching of the church is here confused by the addition of the italicized words.

[3] Philo (as well as the author of the Epistle to the Hebrews) emphasizes the fact that Melchisedek, the true High Priest, the giver of wine instead of water, is the King of Salim or peace (*Alleg.*, iii. 25).

[4] *Cf.* Philo, *Who is the heir?* 15, "Look up, so as to convict (*ἐλέγχειν*) the blind race of common men, which, though seeming to see, is blinded."

Two points remain to be considered in this chapter (x.). The words, "All that ever came before Me are thieves and robbers," have naturally caused some difficulty; but it is possible that some words, such as "in comparison with Me," are to be understood; and if the meaning was, "all previous redeemers of mankind have been, in comparison with the true Redeemer, self-interested and ambitious," then, such language becomes compatible with the author's point of view; and even looked at from the synoptic side, it presents little more difficulty than the saying that John the Baptist, though the greatest of the prophets, was less than the least in the kingdom of God.[2] But the second point is of more importance. In defending Himself (x. 35) against the charge of making Himself God, Jesus is made by the author to argue that, if the judges of Israel in the Psalms are addressed as, in a certain sense, divine and gods,—"I have said ye are gods,"—*a fortiori* might He Himself without blasphemy call Himself the Son of God. But, if this argument might be adopted, then it might be urged that the Son of God differed from other sons of God only in degree, or, if in anything else, only in pre-existence, and the special privilege of pre-existence has been already destroyed by the evangelist; for, in the introduction to the healing of the blind man, he has caused the disciples of Jesus to take for granted, and Jesus not to impugn, the doctrine that all men exist before birth: "Master, who did sin, this man or his parents, that he was born blind? Jesus answered, Neither this man nor his parents; but that the works of God should be made manifest in him" (ix. 2, 3). But if all men pre-exist, and if to all men, in a certain sense, may be addressed the title of "God," it would follow that even the Eternal Son of God, by whom the world was made, would be but the eldest among many brethren. It is scarcely possible that the evangelist intended his readers to follow out this train of thought; but it is unquestionable that in spite of the readiness to admit supernatural incidents, the author's habit of referring all phenomena to the action of certain elements—water, spirit, light, darkness, flesh, blood, and the rest—leads him (perhaps unconsciously) into a habit of describing and perhaps even conceiving the life and work of Christ Himself as conforming itself to an unalterable law, which is none the less a law, because it is also a will, the will of our Father. The works that He does are "prepared by the Father." His sheep hear Him; those that are not His sheep do not hear Him. The same thought is expressed, whether the law be regarded as the fixed order of things or as the will of the Father: "No man can come unto Me except the Father which has sent Me draw him."

Again and again He disclaims caprice, and even the exercise of an independent will: "I came down from heaven not to do Mine own will but the will of Him that sent Me" (vi. 38). Though judgment is committed to Him by the Father, yet so rigidly is His power and desire to judge restrained by facts or laws (or by whatever other name the truth may be called), that He solemnly declares that *He* does not really judge, it is the *facts* that judge. "I do not judge," He says (xii. 47), but "the word that I have spoken shall judge him;" and even where He accepts the task of judging, He declares that He judges "as He hears" (v. 30), and "with the Father that sent Him" (viii. 16) *i. e.*, according to truth. The same conception of the work of the Word as being (like the working of the elements) universal, continuous (v. 17), and according to law, is expressed both in the prologue to the Gospel (John i. 1–9), and in the Epistle also, where the writer declares that the commandment which he gives to the church from Christ is "no new commandment," but an old commandment which men had had "from the beginning."

The raising of Lazarus.

We come now to the last of the pre-resurrection "signs" of Jesus—the raising of Lazarus. Even those who maintain the historical accuracy of every detail of this narrative will scarcely deny that its symbolic meaning goes down, and is intended to go down, to an act far deeper and far vaster than the revivification of the brother of Mary and Martha. Remembering the teaching of Paul (1 Cor. xv. 45) that there are two men,—the former the "living soul" or fleshly animal nature (*ψυχὴ ζῶσα*), the latter the "quickening or life-giving spirit" (*πνεῦμα ζωοποιοῦν*); the former the first Adam, the latter the second Adam—we see at once in this miracle the second Adam raising up the first Adam from spiritual death, by imparting to him His own life. The very word used by Paul to describe the second Adam (*ζωοποιεῖν*) is used by our author to describe the prerogative of the Son—"the Son quickeneth (*ζωοποιεῖ*) whom He will" (v. 21). Other meanings may, no doubt, be conveyed beneath this central incident of the Fourth Gospel; nor is it impossible that the author, before describing how the Saviour laid down His life for mankind, wished to give the best possible proof of the spontaneousness of the action (asseverated above, x. 17, 18) by showing that He was actually the source of life to others. As a preparation for His resurrection on the third day, what could be better than that He should raise from the dead one who had been four days lying in the grave? If, also, a preparation was needed for the doctrine of the Spirit, which is soon to come before us, the resurrection of Lazarus would serve this purpose too. For the Spirit is the source of life (*ζωτικώτατον*, Philo calls it, *Creation*, 7); and, therefore, just as the doctrine of the living water is preceded by the miracle of the water changed into wine, and the doctrine of bread by the miracle of bread, and the doctrine of the supersession of the intermittent sabbath by the continuous loving activity of the Father and the Son (v. 17) is preceded by the miracle of sabbath-healing vouchsafed to the man to whom the intermittent spring was useless, and the doctrine of the Light of the world is preceded by the miracle of giving light to the blind, so is it natural, and, as it were, proportionate, that the doctrine of the quickening Spirit (*cf.* vi. 63, *τὸ πνεῦμά ἐστι τὸ ζωοποιοῦν*) should be preceded by some miracle of quickening the dead.[3]

The doctrine of the Spirit.

The anointing and the triumphal entry into Jerusalem having been discussed above, we pass to the last discourses (xii. 20 to xvii. 26). The last discourses in the synoptists treat of the second coming of Jesus in the clouds of heaven, and of the day of judgment; the last discourses in the Fourth Gospel treat rather of the continuous and increased presence of Jesus in the hearts of the disciples, of the reproving or judgment of the world by the Holy Spirit, and generally of the function of the Spirit in the church. In other words, the Fourth Gospel exhibits in a spiritualized form that which the synoptists set forth through material imagery. The promise of the future presence of Christ had been expressed by the synoptists in the legacy of His body and blood, which Christ is described as bequeathing to His disciples. The Fourth Gospel, which omits this incident (possibly as being already sufficiently known and receiving sufficient attention), lays more stress on the presence of the Spirit as Christ's substitute. It is important to observe that both the synoptic account of the last supper, and the last discourses in the Fourth Gospel, are founded on one and the same basis of historical fact, viz., that Christ approached death with the expressed conviction that His work would not be frustrated by it, but that He would remain for ever a living power in the hearts of His disciples. There is also, even in the Gospel of St. Mark, an intimation that His disciples were to be aided by a "Holy Spirit," which should speak for them before princes and kings: "And when they lead you away betraying you, take no forethought what ye shall speak, neither rehearse it; but whatsoever shall be given to you in that hour, this speak: for it is not ye that speak, but the *Holy Spirit*" (Mk. xiii. 11). To the same effect Jesus speaks in the parallel passage of Luke (xxi. 14, 15), bidding His disciples not to rehearse their defence (προμελετᾶν ἀπολογηθῆναι), for He will give them "a *mouth* and wisdom," which their adversaries shall not be able to gainsay. Thus, even from our earliest Gospel, it would seem that to those unlettered Galilean peasants, diffident (as Moses had been before them) of the sufficiency of their rhetoric to plead their cause before the bar of the great ones of the earth, a promise had been made of a "mouth" that should plead for them. The Holy Spirit was to be their Advocate. It is not likely that Jesus should have uttered these two expressions (quoted above) and no more, about the Spirit which was to be His substitute. Therefore, if the author of the Fourth Gospel had access to any apostolic sayings and traditions that illustrated the teaching of Christ during the last two or three days before His death, we might naturally expect to find in these traditions something more about the Spirit which was to be the Advocate of the disciples when pleading without their Master before the Sanhedrin, and before princes and kings. Accordingly, finding in the last discourses of the Fourth Gospel an ampler doctrine on this subject, we have no ground, *a priori*, for regarding it with suspicion. True, the doctrine is set forth here, as elsewhere, in the peculiar language of the writer, so that we are absolutely certain that we have not the exact words uttered by Jesus; but this need not hinder us from accepting the thoughts as the thoughts of Jesus, if we can throughout trace the synoptic doctrine. In the synoptists Jesus predicts that He will "rise again;" obviously the letter of this prediction, though important, implies a still more important spiritual meaning beneath it. For this prediction would not have been satisfied by any amount of literal fulfilment if Jesus had merely walked from His grave and exhibited Himself alive, by tangible as well as ocular proof, to thousands of curious observers, hostile as well as friendly, unless He had at the same time poured a new influence or influent spirit into the hearts of those to whom He manifested Himself. It is characteristic of our evangelist that he realized (1) that the essence of the resurrection of Christ consists in His spiritual resurrection and intensified presence in the hearts of His disciples; (2) that this resurrection, triumphing over death, and making death the stepping-stone to a more active life, is as much in accordance with law, as is the growth of the corn of wheat which (xii. 24), "except it fall into the ground and die, abideth alone; but if it die, it bringeth forth much fruit." This law—illustrated daily by the increased influence of the dead upon the living, no less than by the fruitful death of the "corn of wheat"—a law so simple and yet so profound, like all the other laws enunciated by Jesus, can hardly have proceeded from any other than from Jesus Himself. The spiritual depth of the doctrine, and the similarity which it bears to the synoptic prediction (in spite of the difference of outward form), furnish strong arguments that, in the last discourses of the Fourth Gospel, we have much of our Lord's own teaching, though modified by the medium through which it is conveyed to us.

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[1] The use of ὑψοῦν ("exalt") to denote what the synoptists (Matt. xx. 19; xxvi. 2; Luke xxiv. 7) denoted by σταυροῦν ("crucify") is very remarkable. In the synoptists, ὑψοῦν always means "to honor highly" ("every one that *exalteth* himself shall be abased") (Matt. xxiii. 12; Luke xiv. 11); but, in the Fourth Gospel, Jesus uses it in addressing (viii. 28) His future murderers, "When ye *exalt* (ὑψώσητε) the Son of Man:" comp. viii. 40, "Ye seek to slay Me." Strictly speaking, of course, we must say that ὑψοῦν is not the σταυροῦν, but the result of it.

[2] Compare Philo, *Abraham*, 44, where a similar contrast is drawn between the distinctive "kingdoms" of human rulers and the beneficent "kingdom" of the ideal man.

[3] The complete discussion of this, the crowning "sign" in the Fourth Gospel, is not adapted for these pages. It would require a close examination of Luke xvi. 20–31, together with Lightfoot's (*Horæ Hebraicæ*) comment on "Lazarus." On this point see also Wünsche, *Neue Beiträge zur Erläuterung der Evangelien*, p. 467; and compare Philo on the meaning of Eliezer (Lazarus) in *Who is the Heir?* 11, 12. The greater part of Origen's commentary on this portion of the Fourth Gospel has unfortunately perished; but some light may be thrown on it by a study of his *Comm. in Ev. Joann.*, xxviii. 5, 6, 9, as well as by Augustine, *In Joann. Evang. Tract.*, 49. The reasons usually alleged for the omission of this "sign" by the synoptists would also require careful consideration.

The doctrine of the Spirit, regarded not now as the purifying element in conjunction with water, but as the Advocate or Paraclete—being the highest and most esoteric doctrine of all—is reserved for the inner circle of His disciples. First, therefore, it is necessary to bring to an end the doctrine of Jesus to the outside world; and the battle between light and darkness, between Jesus and the Pharisees, ends with a recapitulation and conclusion of the doctrine of light. The Gentile world, appearing on the stage in the person of some inquiring Greeks, stretches out her hand to the Messiah (xii. 20); a voice from heaven attests His glory (xii. 28). The Son of God pronounces the fall of the evil one, and, almost in the same word, His own victorious death (xii. 31, 32). Then the light is hidden from the rebellious nation (xii. 36); the evangelist pronounces against them the sentence of condemnation, that they are blinded because they loved darkness more than light, and the praise of men more than the praise of God; and for the last time the voice of Jesus is heard, as it were from behind a cloud, warning those whom He has left in darkness that in rejecting Him they have rejected the Father also (xii. 37–50).

The esoteric doctrine begins with a parable of action, in which the Lord, by washing the feet of His disciples, teaches them humility. Two classes of heretics seem aimed at in this parable,—those who reject the washing of Jesus, to whom Jesus replies, "If I wash thee not, thou hast no part with Me;" and those who laid stress on repeated baptisms or purifications, "He that is (wholly) washed (λελουμένος) needeth not save to wash (νίπτειν) his feet." Now Judas, the child of darkness, goes forth from the chamber, and the evangelist seizes the moment to tell us that "it was night" (xiii. 30). Yet in this hour of darkness the hour of glorification is hailed by Jesus; and He conveys to His disciples, not indeed a new testament, but a new commandment, "that ye love another" (ver. 34). How could this be called a new commandment for those who had been commanded long ago by Jesus to love even their enemies, much more their friends? The answer is found in the context: "As I have loved you, that ye also love one another," the meaning being, that after the death of Jesus, the memory of His love, enhanced in his absence, would spring up as an entirely new power within their hearts, so that "love" would assume a new meaning, and the command to love—though as old as the first influence of the Word, and therefore as the creation of man—would become essentially a new commandment. These words occur almost verbatim in the First Epistle of John (ii. 7), and, from their language, they can hardly be accepted as giving the letter of the words of Jesus; but they go down to the very roots of his teaching. The importance here attached to this new commandment of love leads us to observe that, throughout the whole of these discourses, love, almost as much as the Spirit, occupies the thoughts; and, indeed, in chapters xiii., xiv., xv., and xvii.,[1] the word ἀγαπᾶν occurs 24 times, against 10 times in all the rest of the Gospel. The connection is obvious; step by step we are being led up to God; and God is love. The doctrine of the Spirit can reveal no higher manifestation of Him than this; and the Spirit itself is a Spirit of love, which will find its home only in the hearts of those that love.

Although Jesus has not expressly predicted His death, yet the warnings of betrayal and departure have troubled the hearts of His disciples. To comfort them Jesus promises that He will return, and be still present with them. But neither is the path of His departure and return, nor is His presence itself—so He warns Thomas and Philip—to be regarded as material. He will (spiritually) be more present with them, when, and because, He will be (materially) absent. Greater works will they do than He has done, because He, abiding with the Father above, will lift up their hearts to heaven—their home henceforth because their treasure, Christ, is there—and will make them one with Himself and with the Father, in will and in power. And here is repeated the saying, also found in the synoptists, that whatsoever the disciples pray for they shall obtain,—joined with the assurance that they shall do greater works (ἔργα) than He Himself does (xiv. 12). Note here that our evangelist brings out more clearly than the synoptists the spiritual meaning of the promise concerning prayer, and makes it evident that, as above, the works (ἔργα) meant are not "miracles" (δυνάμεις),—not the casting of a material mountain into the sea, as might be inferred from a misinterpretation of the synoptists,—but the Messianic "works" of forgiveness and regeneration.

The nature of Christ's future presence in the hearts of His disciples is differently described in different passages. At one time (xiv. 30) He declares that He Himself, together with the Father, will take up His abode in every heart that loves Him; but more often He uses the word used by Mark above, and speaks of a *Spirit* which shall be sent to them by the Father. He applies to the Spirit the very title we have been led to apply to the Spirit as described by Mark—the Advocate (Παράκλητος, or Advocatus). As a paracletus or advocatus was wont to explain the law to Greek or Roman clients, and to put words into their mouths, or rather to be himself their spokesman, so the spiritual Paraclete or Advocate would not only put words into the mouths of the disciples when they stood before the bar of kings (Mk. xiii. 11), but would also teach them all things, and bring to their remembrance all the spiritual laws laid down by their lawgiver Christ (xiv. 26). In one sense, the Spirit is a witness, because He testifies of Christ (xv. 26); but even here He is in reality an advocate, for the testimony is regarded as not uttered by the Spirit directly, but indirectly through the mouths of the inspired disciples who are to be "martyrs" or witnesses (*μάρτυρες*) for Christ (xv. 27). It was very natural that that aspect of the advocate's work which most impressed the editor of our earliest Gospel should retire into the background when the first blunt of the collision between the church and the world was over; and that gradually the work of the advocate should assume a wider province than that of merely educating the disciples to plead the cause of Christ in the presence of Gentile judges. Hence Paul regards the Spirit as teaching the disciples not so much what to say in their defence before earthly kings as rather in their prayers before the King of Kings: "We know not what we should pray for as we ought: but the Spirit itself maketh intercession for us with groanings which cannot be uttered" (Rom. viii. 26); "The Spirit searcheth all things, yea, the deep things of God, . . . which things also we speak, not in the words which man's wisdom teacheth, but which the Holy Spirit teacheth" (1 Cor. ii. 10–13). But this conception, carried a stage further, makes the paraclete an advocate not revealing the laws of the celestial kingdom to the enfranchised citizen of it, nor yet revealing the will of the Father in heaven to the child on earth, but rather pleading the cause of the child before the offended Father; and in this sense Philo seems to use the word when he describes the high priest as clothed in the garb which is typical of the invisible universe, *i. e.*, typical of the Logos or Son of the Supreme Father of the world—because it was necessary for the priest consecrated to the Father of the world that he should have as his paraclete the Son, in order (through Him) to obtain pardon of sins and supply of blessings (*Life of Moses*, 14); and he also introduces Joseph (ch. 40) saying to his brethren, "I forgive you; seek no other *paraclete*," *i. e.*, no one to act between me and you as your advocate; and lastly, in this sense, the First Epistle of John (i. 1, 2) seems to use the word in the passage, "If any man sin, we have an advocate with the Father, Jesus Christ the righteous; and He is the propitiation for our sins."[1] But though our evangelist uses the word in this somewhat lower sense in the Epistle, in the Gospel he nowhere uses it thus. There the Paraclete's function is to be, as in Luke, "a mouth, a wisdom" (Lu. xxi. 15); to be a substitute for the helping presence of Christ (xiv. 16); to teach and remind (xiv. 26); to testify and to aid the disciple to testify (xv. 26); and to convict the world of sin (xvi. 8);—but nowhere to obtain forgiveness of sins from the Father by pleading the cause of the disciples in His presence. It is not an unreasonable inference that the evangelist's different use of this word in the Gospel and the Epistle may have arisen from the fact that in the former he is adhering more closely to the original use of it as handed down by Christ Himself.

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[1] Note the curious break in chapter xvi., where the word ἀγαπᾶν does not occur at all, and φιλεῖν is twice used, xvi. 27.

Besides describing the work of the Paraclete as a consequence of the departure of the Son to the Father, the discourse touches upon the enmity which the disciples must be prepared to meet, and enforces the necessity of unity through love. Only in two points does the thought seem to suggest the influence of Philo; and in both of these Philo is rather corrected than followed. Philo says (*Giants*, 7) that it is impossible that the Spirit of God should remain for ever in the soul (though it may for a time) because of our inseparable connection with the flesh; he adds (in language which is at least liable to the interpretation of asceticism) that, as Moses fixed his tent outside the camp, so those who would have the Divine Spirit as a permanent tenant of their souls must put off all the things of creation; the safest course being to contemplate God, not even through the uttered word, but without utterance, as absolute, indivisible existence (*ib.* 11, 12); with the mass of mankind the Spirit remains only for a moment, nor would it ever have visited them but to convict (*διελέγξαι*) them of choosing what is disgraceful instead of what is good (*ib.* 5).[2] The Fourth Gospel emphasizes no less the work of the Spirit in "convicting" (*ἐλέγχειν*) the world of sin; but it is also careful to say that the gift of the Spirit shall be permanent, "not as the world giveth give I unto you" (xiv. 27), and that the disciples are to remain in Jesus, while nevertheless not taken out of the world (xvii. 15). The Saviour is no more in the world, and the disciples are in the world (xvii. 11); yet He will not pray that they should be removed from the world, but only that they should be delivered from the evil (ver. 15). The discourse concludes with the prayer that all future believers may be knit together into one great body, which shall be in the Father and the Son, while at the same time the Father and the Son are in it (ver. 21, 23); and the last words of all, after innumerable periphrastic metaphors to describe the promised presence of Christ with His disciples, recur at last to the plain expression of His presence, "and I in you"—not greatly differing from the promise in the First Gospel (Mat. xxviii. 20), "I am with you always."[3]

There is doubtless a purpose in this accumulation of obviously inconsistent statements of the local relations between the Father, the Son, the Spirit, and the Church: "I am in the Father and the Father in Me;" "Ye in Me, and I in you;" "I go unto the Father;" "The Holy Spirit, whom the Father will send in My name;" "The Comforter whom I will send unto you from the Father;" "I came forth from the Father, and am come into the world;"—the intention being to prevent the mind of the reader from attaching any importance to mere local relations between the Three Persons, and to force him to form spiritual conceptions instead of local by showing that the most opposite local relations may be simultaneously predicated. Thus contradiction after contradiction leads the reader at last to pierce beneath the literal integuments to the spiritual truth concealed below them; and, aided by the bold analogy (xvii. 21) derived from human unity ("that they all may be one; as Thou, Father, art in Me, and I in Thee, that they also may be one in us"), we are led at last to discern that the unity is not that of place, but of will; and that the bond of unity is not sight working through material presence in material light, but Love working through spiritual sight or the spirit of truth, independently of material presence. And so, after all, the evangelist leads his reader to see that the coming of the Paraclete (like all things else in his Gospel) is according to law; "If I go not away, the Comforter will not come unto you" (xvi. 7); "The Holy Spirit was not yet given, because that Jesus was not yet glorified" (vii. 39). Not until the dead has passed away from us does the "idea of his life" creep into our minds—

> "Apparelled in more precious habit,
> More moving-delicate and full of life
> Than when He lived indeed;"

and the Eternal Word, who subjected Himself to the laws of human nature in birth and life, may be supposed without irreverence to have subjected Himself to, or perhaps rather we should say to have availed Himself of, the same laws of human nature which regulate God's ordinance of death.

The resurrection.

The crucifixion having been considered above, we pass to the narrative of the resurrection. Matthew and Mark imply that Jesus manifested Himself to the disciples in Galilee; Luke mentions none but manifestations in Judæa; the Fourth Gospel mentions manifestations in both places. Compared with Matthew and

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[1] *Cf.* Schoettgen, vol. ii, p. 659, where it is shown that the Jews adopted the Greek word *συνήγορος* (not in its classical sense of "prosecutor," but in the sense of "advocate for the defence"), under the form סניגור, and applied it to Michael, who defends Israel from the accusations brought against him in the presence of God.

[2] Comp. Philo, *Quod Deus Immutabilis*, 26: "When the high-priest, conviction, like a pure ray of light," flashes on our minds, we realize our pollution; and thus conviction may be said, as it were, to pollute our former imaginary and self-satisfied righteousness.

[3] There is an attractive symmetry in the supposition of Canon Westcott (*Introd. to St. John's Gospel*), that these discourses (xiii., xiv., xv.), in which alone is any mention made of "commandments," are intended to be a kind of Sermon in the Chamber, corresponding to the Sermon on the Mount. The Sermon on the Mount sets forth the new law of Christ; the Sermon in the Chamber vivifies the new law with the new Spirit. This supposition exactly corresponds with the "spiritual" (Muratorian fragment) motive of the Gospel; and the esoteric nature of the doctrine is not inconsistent with the statements which are said to be mainly "based on direct knowledge of Papias's book" (Westcott, *Canon*, p. 76), that Papias, "a dear disciple of John," wrote five books entitled "exoterica." For "exoterica" imply "esoterica."

Luke, the Fourth Gospel may be said to handle the subject more familiarly, taking the resurrection, so to speak, more as a matter of course, and representing Jesus as moving in a more human fashion among His disciples after He had risen from the grave, helping them in their fishing, holding long conversations with them, and, in a word, renewing almost without a break the intercourse of the days before the crucifixion. In Matthew, the Christ after death appears once, upon a mountain, doubtfully discerned by some, and emits one final message, sending His disciples to evangelize the world, and promising them His perpetual presence. In Luke the risen Christ "vanishes," causes fear and terror to His disciples, and is supposed to be a "spirit" till He eats food in their presence; finally He is "parted from them." In John, the ascension, though alluded to, is not described; and everything else that might give the manifestation a phantasmal character is studiously kept in the background. No mention is made of the angel who descends (Mat. xxviii. 2) from heaven to roll away the stone from the sepulchre, terrifying the keepers of the grave, and bidding the women "fear not." It is rather assumed that, by His own unaided strength, Christ burst the bars of the grave, and after leisurely laying aside the grave-clothes, and the "napkin in a place by itself" (John xx. 7), went forth to converse with His disciples. It is true that the Fourth Gospel does not attempt to conceal the fact that the manifestations of Jesus were more than once not recognized by His disciples at first; but, in the cases of non-recognition, it is suggested (as in Luke), not that the manifestation was faint or shadowy (as seemingly in Mat. xxviii. 17, "And when they saw Him, they worshipped Him; but some doubted"), but that they mistook Him for a stranger (xx. 14; xxi. 4). That Jesus ate in the presence of his disciples is not stated, nor can it be said to be implied; but His familiar presence at the meal of the disciples (xxi. 13) suggests a real presence almost as effectively as the narrative of the eating of the fish and honeycomb in Luke. Additional conviction is also obtained by taking one of the apostles, Thomas, as a type of resolute scepticism, refusing to believe unless he touches the body of the risen Saviour, and by describing how even such scepticism as this was converted into certainty. Moreover, as the water and the blood were visibly given by Jesus on the cross, so—lest the giving up of the breath on the cross should be a scarcely sufficiently noticeable type of the gift of the holy breath or Spirit—our evangelist records that Jesus breathed on His disciples and said, "Receive ye the holy breath" (or Spirit)—at the same time connecting with this highest gift the highest activity for which a human soul can be inspired by God, the faculty of forgiving sins. It is probable that the Gospel originally ended at xx. 31: "But these are written that ye might believe that Jesus is the Christ the Son of God, and that believing ye might have life through His name." This is a most appropriate termination; and what follows bears every appearance of being an appendix added by the author, describing a miraculous draught of 153 fishes, and a meal of Jesus with seven of the disciples, followed by a dialogue between Jesus and Peter, in which the death of the latter is predicted, and the erroneous tradition that the beloved disciple should not die is shown to be baseless.

Three inferences seem probable from this last narrative:—(1) that there had been at Ephesus a tradition (arising perhaps from the extreme old age of John, and from some such expression as is recorded in John xxi. 22) that John would not die till the Lord had appeared; (2) that John had died when this account was written (for if he were living and past his ninetieth year, at a time when the church daily expected the coming of the Lord, the Ephesian Christians would not have needed any explanation or softening away of a prediction which would seem to them very likely to be fulfilled); but (3) if John was dead, it must seem that the words "we know" *could* not have been added (as they might be supposed to have been added, according to the Muratorian legend) by Andrew and Philip, who in all probability died before John died; and if John was dead, it must seem that the words *would* not have been added by any elders of Ephesus representing the generation after John; for how could they—who stood on a footing altogether subordinate and inferior in point of reputation, and with no opportunities of information—have ventured to ratify the testimony of the "beloved disciple"?

Authorship of Fourth Gospel.

It is more easy to arrive at negative than at positive results, when evidence is so slight; but it seems probable that the author, attempting to give the spiritual essence of the gospel of Christ, as a gospel of love, and assigning the Ephesian Gospel to the beloved disciple who had presided over the Ephesian church, by way of honor and respect (for the same reasons which induced the author of the 2d Epistle of Peter to assign that Epistle to the leading apostle), and being at the same time conscious that the book (though representing the Ephesian doctrine generally, and in part the traditions of John the apostle, as well as those of Andrew, Philip, Aristion, and John the elder) did not represent the exact words and teaching of the disciple—added the words "We know, etc.," partly as a kind of *imprimatur* of Andrew, Philip, and the rest; partly in order to imply that other traditions besides those of John are set forth in the book; partly to characterize the book as a Gospel of broader basis and greater authority than the less spiritual traditions issuing from non-apostolic authors, which our evangelist desired to correct or supplement. Nor is it in the least unlikely that this Gospel does represent the teaching of Andrew and Philip, and Aristion and John the elder, as well as that of John. If Papias of Hierapolis gathered up the traditions of these apostles and elders, why not also our author, writing in Ephesus perhaps several years before Papias? It is assuredly not for nothing that the name of "Matthew," mentioned in Matthew, Mark, and Luke, is not found in the Fourth Gospel; nor is it without significance that the Gospel begins and ends with an inner apostolic circle. The "twelve" are indeed mentioned, but as in the background. The beloved disciple, Andrew and Peter, Philip and Nathanael—these, and these only, are mentioned as called by Jesus in the beginning; Peter and Thomas, Nathanael and the sons of Zebedee, and two other disciples (presumably the same list as those above, with the addition of James, the son of Zebedee, and Thomas), are mentioned as alone admitted to the sacred meal which closes the Gospel. This fact marks the whole character of the book; it is esoteric and eclectic, and designedly modifies the impression produced by the tradition previously recorded by the synoptics.

Criticism of synoptic Gospels.

The Criticism of the first three Gospels.—For fourteen centuries the church was content to follow Augustine (*De Consensu Evangelistarum*, i. 4) in believing that Mark was "as it were the humble companion (pedissequus) and abridger" of Matthew. Towards the end of the 18th century this dogma was shaken, and two different hypotheses were put forward: (1) that the evangelists had borrowed from one another, either Matthew from Mark, or Mark from Luke, or even (so capricious and baseless were the hypotheses which now started into existence) Matthew and Mark from Luke; (2) that all the three Gospels depended upon an original and common Gospel. The first of these hypotheses may for convenience be called the "borrowing" hypothesis; the second may be called the "traditional" hypothesis. Eichhorn was the first to systematize the "traditional" hypothesis, maintaining (1794) that the original tradition was a written Aramaic Gospel, known to the three synoptists, but afterwards (1804) so far modifying his views as to recognize that the Aramaic tradition had been translated into Greek, and passed through several documentary stages, before it assumed the form preserved in the triple version of our synoptists.

Inside the circle of those who maintained the traditional hypothesis there now arose inner divisions upon the question, which evangelist most closely approximated to the "original" tradition. Eichhorn had assigned (1804) the priority to Matthew, Grätz (1812) to Mark. Moreover, a new form of the hypothesis was shaped out by Schleiermacher (1817), who maintained that our Gospels were composed on the basis of a number of disconnected documents; while Gieseler (1818) showed that it must have been, in any case, oral tradition which served the needs of the earliest disciples,—tradition stereotyped by time, and reduced to some kind of similar pattern before being committed to writing by the synoptists. Still no certain conclusions were arrived at. De Wette (beginning from 1826) assumed a common oral tradition for Matthew and Luke, and treated Mark as an epitomizer. Credner (1836) joined Schleiermacher in tracing our Gospels back to a collection of words of the Lord, which he supposed Matthew to have combined with the oldest Gospel, viz., Mark; similarly Lachmann (1835). Bleek (1862–1866) relapsed into Griesbach's view (1784–1790) that Mark was based on Matthew and Luke.

All these conflicting hypotheses might naturally induce those who had not themselves closely studied the synoptic texts to believe that the truth of the matter was unattainable, and that, in any case, the synoptic narratives (not being the records of eye-witnesses, nor being preserved in unaltered documents written contemporaneously with or soon after the events) must necessarily be untrustworthy. Accordingly, in 1835, Strauss maintained that the whole synoptic narrative was legendary or otherwise untrustworthy. The defenders of the synoptists against Strauss found little consideration, and the hypothesis that Mark contained the original Gospel was discredited by the extravagance of its supporters. In 1846–7 Schwegler and Baur, recurring to the "borrowing hypothesis," issued it in a new form as an "adapting hypothesis." The original Gospel was now supposed to be the Gospel of the Hebrews (see p. 727 above), which was imagined to contain in all its bare truthfulness the Ebionite doctrine of the early church. Matthew combined this original Jewish-minded document with some other document of more liberal sentiments. Luke was at first a Pauline protest against Judaism, but was afterwards supplemented, in a conciliatory spirit, with passages colored with Ebionitic and Jewish thought; Mark was treated as a neutral and colorless adapter of Matthew and Luke,—"pedissequus et breviator." This was the Tübingen doctrine, sometimes called the "tendency hypothesis," because the adaptations were supposed to proceed from theological "tendencies."

Ewald (beginning from 1849) combated the Tübingen theory, maintaining that (1) there was an original Gospel, perhaps composed by the evangelist Philip (2) in addition to this, there was a collection of "logia" made by Matthew; (3) and, out of both these documents, or by an author acquainted with these documents, was formed Mark, or, at all events, Mark in its original shape; (4) Matthew contains (1) (2) and (3), together with extracts from a "book of higher history;" (5) three anonymous evangelists revived this narrative, which received its last form at the hands of Luke (see the account of Ewald's theory in Westcott's *Gospels*, p. 203). From this time the compilatory and artistic character of Luke began to be generally recognized; and even the Tübingen school gave up the theory that Mark had adapted Luke. Hilgenfeld, "in a five years' literary struggle with Baur" (see Holtzmann, in Schenkel's *Bibel-Lexicon*, art. "Evangelien"), proved Mark's independence. Köstlin (1853) advocated an original Mark as the groundwork of the synoptists; together with a "Gospel of Peter" as the basis for the parts common to Matthew and Luke. Ritschl (1851), recanting his former opposition, and Meyer (1853) became converted to the belief in an "original Mark." Volkmar (1857) and a number of other theologians took the same view; Weiss (1861) advocated a parity of originality, or rather a common original source, from which Matthew and Mark borrowed equally, while occasionally Matthew borrowed from Mark itself. But the work which most approximates to a proof of the originality of the tradition contained in Mark is Holtzmann's *Die Synoptischen Evangelien*, etc., 1863, from whose summary of the criticism of the first three Gospels (Schenkel's *Bibel-Lexicon*, "Evangelien") these statements are mainly drawn. The author of *Jesus of Nazara*, Dr. Keim, of whom, for the sake of that interesting work, we would speak with all respect, was almost alone in defying, in his last work (p. vii. *Aus dem Urchristenthum*, 1878), the "mane-shaking of the Mark lion;" but even he, with qualification (*ib.* p. 30).

The work of Dr. Holtzmann last referred to is of great value; and so are Dr. Weiss's *Marcusevangelium* (1872) and *Matthäusevangelium* (1876); but it is truly lamentable that nearly a century has passed in the accomplishment of so little. The reason is perhaps to be looked for (1) in the amount of personality which has been introduced into discussions of this kind; (2) in the haste with which theories have been erected upon the basis of single causes; (3) in the general absence of attempt to classify and concentrate evidence; (4) in the failure to recognize the distinction between probabilities and certainties, and the amount of labor necessary to attain certainty; (5) most of all, in the absence of mechanical helps. It is probable that the publication of Bruder's *Concordance* in the middle of this century has done more than all the rest of the hypothesis inventors, from Augustine to Hitzig, to forward the scientific study of the synoptic Gospels; nor could Dr. Holtzmann's valuable work have been written but for the humble assistance of Bruder. It is lamentable to think how much industry, ink, and paper, and occasionally intellect as well, might have been saved if there had been in common circulation from the beginning of this century, along with Bruder, a harmony of the Gospels, printed after the manner suggested above (p. 703), from which any one, almost without knowing Greek at all, could have seen at a glance that the "pedissequus" theory of Mark was not for a moment tenable, and that Mark *contains*—by no means, necessarily, *is*—the original tradition from which, at least in some places, Matthew and Luke independently borrowed.

There are signs that a similar waste of industry is to be apprehended in the further discussion of the question whether the common tradition is derived from oral or documentary sources. When, for example, we find so able a critic as Dr. Holtzmann (Schenkel, "Evangelien," p. 210) laying stress on the irregular form ἀπεκατεστάθη occurring in the same place in all the three synoptists (Mat. xii. 13; Mk. iii. 5; Lu. vi. 10) as a convincing proof that the copying of documents (and not oral tradition) can alone explain so strange a similarity, we naturally suppose that this irregularity is nowhere else found in the Old or New Testament. But so far is this from being the case that the irregular form may be with greater truth said to be the only form current in the Old and New Testament, occurring not only in the three passages above, but also in Mk. viii. 25 (ἀπεκατεστη); in Jerem. xxiii. 8; in Exod. iv. 7; in var. interpret. Gen. xxiii. 16 [Trommius quotes 3 (1) Esdr. i. 36 (? 33), but Tischendorf reads ἀπέστησεν]; and the only passage in which the regular form is found, Gen. xl. 21, contains a var. lect. ἀπεκατέστησεν, which, no doubt, ought to be inserted in the text. This may serve as an example to show how ultimately circuitous the path must be through these attempted short cuts to certainty. The truth is that the question of oral or documentary sources is not to be settled without a great deal more of labor and of judgment than the subject has hitherto received. For a statement of the oral hypothesis, which is generally adopted by English scholars, the reader is referred to Westcott's *Introduction to the Gospels*, pp. 161–208. It has been pointed out, however, by Dr. Sanday (*Academy*, Sept. 21, 1878) that there has been of late an increasing tendency in the three theories—the Tübingen or adaptation theory, the documentary Mark theory, the oral tradition theory—to approximate to each other; so that the tendency theory has given less weight to dogmatic tendencies and more weight to literary considerations. The documentary Mark theory allows the previous influence of tradition, only stipulating for some lost documentary links between the oral tradition and our Mark; while the oral theory approaches to the documentary Mark theory in assuming that the oral Gospel is represented most nearly by our present Mark. Nevertheless, says Dr. Sanday, between the two last theories (for the Tübingen theory may be left out of account) "the struggle has yet to come. The division between these is almost national. In Germany no one of any significance as a critic holds the oral theory. In England none of our prominent writers hold anything else. France is divided. Godet ranges himself on the side most popular in England. Réville was an early supporter of a view similar to that which is gaining the ascendency in Germany; and the same is substantially adopted by M. Renan."

It is greatly to be desired that, in this "struggle," the disputants may illustrate the subject in a somewhat ampler manner than has been hitherto common. Different versions of the same original—tales, histories, ballads—transmitted through documentary and oral sources should be compared together; and more especially the phenomena of the ante-Jerome versions of the New Testament should receive the most careful study, before even the ablest commentator should allow himself to use the dogmatic tone which unfortunately characterizes Dr. Weiss's *Matthäusevangelium* in deciding against the oral theory. But this is a natural characteristic of an author who sees in a single Ἱερουσαλήμ convincing proof of an Aramaic original (see p. 716 above), and to whom a καὶ ἰδοῦ settles all critical disputes. With this dogmatism the tone of Canon Westcott's remarks on the oral Gospel contrasts advantageously. Nevertheless, it will probably be hereafter found that the phenomena of our present synoptists are due not to one, but to all, of the causes advocated by the various disputants of the 18th century. Tradition, documents, theological tendencies, literary modifications, misunderstanding of metaphorical parable, misunderstanding of eucharistic language, misunderstanding of spiritual language—all these causes will be found to have contributed to produce the present synoptic result; and it will not improbably be found, as Dr. Sanday shrewdly suggests, that early documents have been much more modified, and early oral traditions much less modified, than modern associations might have led us to suppose. Future investigations will receive a considerable stimulus and help, as soon as a harmony of the synoptists showing the Triple Tradition as well as the double traditions (pp. 707–711 above) becomes a recognized text-book for all students of the Gospels. It will also be a useful check, if no demonstration of different documents (in Luke, for example), be recognized as sound until it has been tested by application to other authors. For example the proof from καί, δέ, τε, εἶπε, λέγει, λαλεῖ, Ἱερουσαλήμ, κύριος, ἐνώπιον, εὐθύς, καὶ ἰδοῦ, is by no means to be despised; but it requires expression in a clear picturesque way by the well-known means of curves; and no proof of this kind ought to be accepted until it (or corresponding proof) has been applied,—first (*α*) negatively, to several passages recognized as genuine productions of the same author (Plato, for example), and then (*b*), positively, to several passages, some of which are recognized as genuine, others as spurious. In the first case (*a*) the curves will exhibit no fluctuations; in the second (*b*) the curves will exhibit fluctuations corresponding to the fluctuations in Luke; and this will be a strong and clearly intelligible proof (even to those who know no Greek—for the same illustrative proof might be deduced from the application of the test to *Titus Andronicus* and to *Hamlet*) that the fluctuations of the curves are caused in each case by the incoming of different documentary strata. But perhaps, to do this thoroughly, it would be necessary to do it four or five times over for each of the four or five principal ancient MSS. (nor ought, perhaps, even varieties of spelling, and certainly not varieties of form, such as ἦλθαν, etc., to be neglected, as possibly pointing to the incoming of different documents); and the labor is so great that, even with the avoidance of all broaching of hasty theories and all personalities, a single worker could hardly accomplish it with the devotion of a life,—at least that is the conclusion to which the present writer has been forced after devoting some years to this labor. Yet, in any case, one signal advantage will result from our keeping before ourselves a high standard of demonstration, viz., that, although we may bring forward theories for discussion, we shall draw a very distinct line between what is proved and not proved, and shall shrink with a just horror from short cuts to knowledge.

Criticism of Fourth Gospel.

The Criticism of the Fourth Gospel.—No criticism of a systematic kind, says Dr. Holtzmann (Schenkel's *Bibel-Lexicon*), began till the publication of Bretschneider's *Probabilia* (1820), which provoked so much opposition that the author retracted it. The apostolic authorship was supported by Schleiermacher, and by Credner (1836), even while admitting that the Gospel could not be regarded as a purely objective work. Similarly De Wette, after some doubt and hesitation (1837), and Reuss (1840–64) decided for the Johannine authorship,—the former being influenced by a comparison of the Fourth Gospel with the other works of the 2d century. The attack of Strauss, in his *Life of Jesus*, being passed over (as indicating no attempt, or possibly ability, to appreciate the depth of the spiritual doctrine in the Fourth Gospel, in spite of the suggestiveness and occasional accuracy of his method), we come to Baur (1847), who pronounced the Gospel to be a religious ideal poem, composed in the 2d century. A great number of writers accepted this theory; among them, Zeller and Hilgenfeld, and Schenkel and Keim in their lives of Christ, together with Réville (1864) and Scholten. In the meantime an hypothesis of "partial authorship" had been suggested, some (Weisse in 1838, and Freytag in 1861) believing that the discourses, others, as Renan (1863), believing that the historical narratives, were genuine; while some wished to detach the Judæan from the Galilean portion of the Gospel, as being distinct in authorship and origin. Lücke, Ewald, Brückner, and Wittischen, adopting in various forms the view of a divided authorship, recognized in the Gospel a framework of historical fact, but noted also the prominence of the ideal, the want of historical development, and the subjective coloring given by the author to the discourses of Christ—views which find a full expression in Weizsäcker's *Untersuchungen über die evangelische Geschichte* (1864). Canon Westcott, in his *Introduction to the Gospels* (5th ed., 1875), maintains apostolic authorship, which is also in a special treatise (*Authorship and Historical Character of the Fourth Gospel*, 1872) maintained by Dr. Sanday. The latter work lays perhaps somewhat too much emphasis on the geographical expressions which are used to prove that the author was a Jew of Palestine. Many of these would appear natural for an Alexandrian Jew who had spent two or three passovers at Jerusalem, and had travelled through the country. Still more doubtful is the canon assumed throughout the treatise, that graphic details, particularities of name, place, etc., imply an eye-witness—the contrary being suggested by the phenomena of the apocryphal Gospels. Nor does Dr. Sanday make any attempt to illustrate the Fourth Gospel (except in respect of the Logos doctrine) by the teaching of Philo. Nevertheless the book is eminently candid, and there is no other book in English to compare with it for the light it throws, not only on the Fourth Gospel itself, but also on the history of its criticism. Dr. Sanday also recognizes, even more fully than Canon Westcott, the subjective nature of the Gospel, at least so far as to make this admission, that the words of Jesus himself and the words of the evangelist are, in more than one instance, so inextricably intermixed that it is impossible to tell where the former end and the latter begin. In the *Introduction to the Gospel of St. John*, published (1879) in the *Speaker's Commentary*, Canon Westcott has greatly amplified the valuable remarks on the Fourth Gospel contained in his *Introduction to the Study of the Gospels*, and states most forcibly the views of those who see in the multiplicity of detail in the Fourth Gospel one among many proofs that the Gospel was composed by an eye-witness of the events which it records. For the doctrine of the Logos Canon Westcott gives the following list:—Gfroerer, *Philo u. d. Jud.-Alex. Theosophie*, 1835; Daehne, *Jud.-Alex. Religions-Philosophie*, 1834; Dorner, *Person of Christ* (Eng. trans.); Jowett's "St. Paul and Philo" (*Epistles of St. Paul*, § 363 ff.); Heinze, *Die Lehre v. Logos in Griech. Philosophie*, 1872; Siegfried, *Philo von Alexandria*, 1775. Grossmann (*Quæstiones Philoneæ*, 1829) gives a complete summary of the use of the word in Philo. An account of the Logos literature up to 1870 is given by Dr. Abbot in his appendix to the article on "The Word" in the American edition of the *Dictionary of the Bible*, and Soulier includes several later works in *La doctrine du Logos chez Philon d'Alexandrie*, Turin, 1876.

(E. A. A.)

GOSPORT, a fortified seaport and market-town of Hampshire, England, on the western side of Portsmouth harbor, near its mouth, directly opposite and about a mile from Portsmouth, with which it is connected by a floating bridge moved by a steam engine working on two fixed chains. The old fortifications built at the end of last century are now obsolete, and a line of new forts has been erected about two miles from the town, extending from the Solent to the upper part of Portsmouth harbor, with accommodation for two regiments of infantry and a brigade of artillery. Near the town is the royal St. Clarence victualling yard, with brewery, cooperage, powder-magazines, biscuit-baking establishment, and storehouses for various kinds of provisions for the royal navy. Adjoining this yard there are large government powder-magazines and a laboratory for making fusees and rockets. Within the old fortifications a fine new barracks has been erected with accommodation for 1100 men, and another barracks with accommodation for 1600 men adjoining it. The principal other buildings are the town-hall and market-place, the church of Holy Trinity, erected in the time of William III., and the magnificent Haslar naval hospital, capable of containing 2000 patients. Gosport has an extensive establishment for the manufacture of anchors and chain cables, and it is also celebrated for its yacht-building and sail-making establishments. The coasting trade is considerable. The town is said to have received its name, Gosport or God's Port, from Bishop Henry de Blois, who put in here for shelter during a severe storm in 1158. It was then only a small fishing village. According to another supposition its original name was Gorse Port, and it was so called from the gorse and furze with which the commons in the neighborhood were thickly covered. The population in 1871 was 7366.

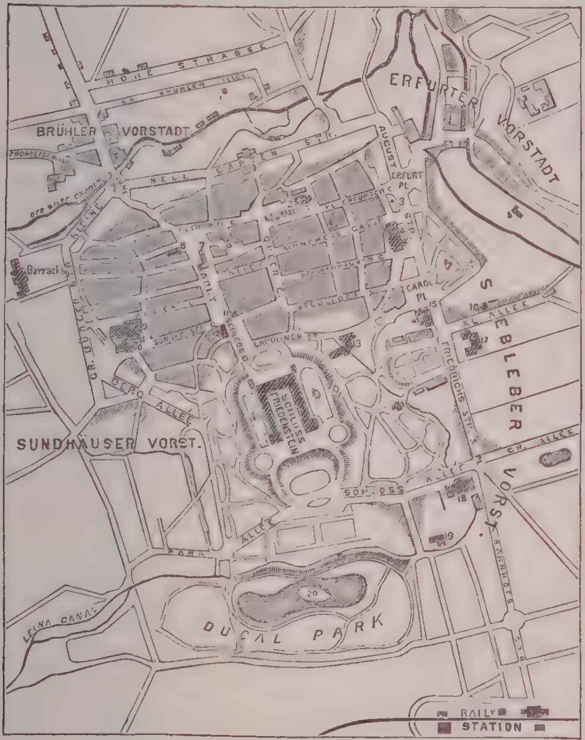
GOSSART, JAN, born at Maubeuge towards the close of the 15th century, is better known to Englishmen by the name of Mabuse than by that of Jenni Gossart, with which he signed some of his pictures, or that of Jennyn van Hennegouwe (Hainault), under which he matriculated in the guild of St. Luke, at Antwerp, in 1503. We know nothing of his life before he attained to manhood; but his works at least tell us that he stood in his first period under the influence of artists to whom plastic models were familiar; and this leads to the belief that he spent his youth on the French border rather than on the banks of the Scheldt. In no seat of artistic culture is this feature more conspicuous than at Tournai, Douai, or Valenciennes, and it may be that in one of these cities Mabuse learnt to commingle the study of architecture with the gaudy system of coloring familiar to tinters of stone. Without the subtlety or power of Van der Weyden, he had this much in common with the great master of Tournai and Brussels, that his compositions were usually framed in architectural backgrounds; and this marked characteristic is strongly displayed in the pictures which he executed in the first years of the 16th century. But whilst Mabuse thus early betrays his dependence on the masters of the French frontier, he also confesses admiration for the great painters who first gave lustre to Antwerp; and in the large altar-pieces of Castle Howard and Scawby, he combines in a quaint and not unskilful medley the sentiment of Memling, the bright and decided contrasts of pigment peculiar to colored reliefs, the cornered and packed drapery familiar to Van der Weyden, and the bold but Socratic cast of face remarkable in the works of Quentin Matsys. At Scawby he illustrates the legend of the count of Toulouse, who parted with his worldly goods to assume the frock of a hermit. At Castle Howard he represents the Adoration of the Kings, and throws together some thirty figures on an architectural background, varied in detail, massive in shape, and fanciful in ornament. He surprises us by pompous costume and flaring contrasts of tone. His figures, like pieces on a chess-board, are often rigid and conventional. The landscape which shows through the colonnades is adorned with towers and steeples in the minute fashion of Van der Weyden. After a residence of a few years at Antwerp, Mabuse took service with Philip, bastard of Philip the Good, at that time Lord of Somerdyk and admiral of Zeeland. One of his pictures had already become celebrated—a Descent from the Cross (50 figures) on the high altar of the monastery of St. Michael of Tongerloo. Philip of Burgundy ordered Mabuse to execute a replica for the church of Middleburg; and the value which was then set on the picture is apparent from the fact that Dürer came expressly to Middleburg (1521) to see it. In 1568 the altar-piece perished by fire. But its principal features were preserved in a large arras hanging, recently exhibited at the Archæological Museum of Brussels. In 1508 Margaret of Austria sent Philip of Burgundy to Italy to negotiate for the treaty of Cambrai. On this mission he was accompanied by Mabuse; and by this accident an important revolution was effected in the art of the Netherlands. Mabuse appears to have chiefly studied in Italy the cold and polished works of the Leonardesques. He not only brought home a new style, but he also introduced the fashion of travelling to Italy; and from that time to the age of Rubens and Van Dyck it was considered proper that all Flemish painters should visit the peninsula. The Flemings grafted Italian mannerisms on their own stock; and the cross turned out so unfortunately that for a century Flemish art lost all trace of originality.

In the summer of 1509 Philip returned to the Netherlands, and, retiring to his seat of Suytburg in Zeeland, surrendered himself to the pleasures of planning decorations for his castle and ordering pictures of Mabuse and Jacob of Barbari. Being in constant communication with the court of Margaret of Austria at Malines, he gave the artists in his employ fair chances of promotion. Barbari was made court painter to the regent, whilst Mabuse received less important commissions. Records prove that Mabuse painted a portrait of Leonora of Portugal, and other small pieces, for Charles V. in 1516. But the only signed pictures of this period are the Neptune and Amphitrite of 1516 at Berlin, and the Madonna, with a portrait of Jean Carondelet, of 1517, at the Louvre, in both of which we clearly discern that Vasari only spoke by hearsay of the progress made by Mabuse in "the true method of producing pictures full of nude figures and poesies." It is difficult to find anything more coarse or misshapen than the Amphitrite, unless we except the grotesque and ungainly drayman who figures for Neptune. In later forms of the same subject—the Adam and Eve at Hampton Court, or its feebler replica at Berlin, we observe more nudity, combined with realism of the commonest type. Happily Mabuse was capable of higher efforts. His St. Luke painting the portrait of the Virgin in Sanct. Veit at Prague, a variety of the same subject in the Belvedere at Vienna, the Madonna of the Baring collection in London, or the numerous repetitions of Christ and the Scoffers (Ghent and Antwerp), all prove that travel had left many of Gossart's fundamental peculiarities unaltered. His figures still retain the character of stone; his architecture is as rich and varied, his tones are as strong as ever. But bright contrasts of gaudy tints are replaced by soberer greys; and a cold haze, the "sfumato" of the Milanese, pervades the surfaces. It is but seldom that these features fail to obtrude. When they least show, the master displays a brilliant palette combined with smooth surface and incisive outlines. In this form the Madonnas of Munich and Vienna (1527), the likeness of a girl weighing gold pieces (Berlin), and the portraits of the children of the king of Denmark at Hampton Court, are fair specimens of his skill.

Philip of Burgundy had been deputed in Italy (1515) to escort Charles V.'s sister, Isabella, to Denmark. She was the affianced bride of Christian II., whose subsequent attempt to unite Denmark and Sweden ended so fatally. Here a favorable opportunity was afforded for introducing Mabuse to the Danish court; and it is possible that the opportunity was not neglected. Yet Mabuse may have become acquainted with the Danish king at a later period. As early as 1523, when Christian came to Belgium, he asked Mabuse to paint the likenesses of his dwarfs. In 1528 he requested the artist to furnish to Jean de Hare the design for Isabella's tomb in the abbey of St. Pierre near Ghent. It was no doubt at this time that Mabuse completed the portraits of John, Dorothy, and Christine, children of Christian II., which came into the collection of Henry VIII. No doubt, also, these portraits are identical with those of three children at Hampton Court, which were long known and often copied as likenesses of Prince Arthur, Prince Henry, and Princess Margaret of England. One of the copies at Wilton, inscribed with the forged name of "Hans Holbein, ye father," and the false date of 1495, has often been cited as a proof that Mabuse came to England in the reign of Henry VII.; but the statement, it is clear, rests on no foundation whatever. At the period when these portraits were executed Mabuse lived at Middleburg. But he dwelt at intervals elsewhere. When Philip of Burgundy became bishop of Utrecht, and settled at Duerstede, near Wyck, in 1517, he was accompanied by Mabuse, who helped to decorate the new palace of his master. At Philip's death, in 1524, Mabuse designed and erected his tomb in the church of Wyck. He finally retired to Middleburg, where he took service with Philip's brother, Adolph, lord of Veeren. Van Mander's biography accuses Gossart of habitual drunkenness; yet it describes the splendid appearance of the artist as, dressed in gold brocade, he accompanied Lucas of Leyden on a pleasure trip to Ghent, Malines, and Antwerp in 1527. The works of Mabuse are those of a hardworking and patient artist; the number of his still extant pictures practically demonstrates that he was not a debauchee. The marriage of his daughter with the painter Henry Van der Heyden of Louvain proves that he had a home, and did not live habitually in taverns, as Van Mander suggests. His death at Antwerp, on the 1st of October, 1532, is recorded in the portrait engraved by Jerome Cock. (J. A. C.)

GOSSELIES, a town of Belgium, in the arrondissement of Charleroi and province of Hennegau, is picturesquely situated on the Piéton and on the Brussels and Charleroi canal, 8 miles N. W. from Charleroi. There are extensive coal-mines in the neighborhood, and the town possesses breweries, tanneries, bleachworks, and manufactories of hats, knives, and nails. Here the French gained a victory over the Austrians, 26th June, 1794. The population is about 7000.

GOTHA (originally *Gotegewe*, or *Gotawe*, and later *Gotaha*, or *Gothau*), a town of Germany, formerly capital of the old duchy of Gotha, and now, alternately with Coburg, the residence of the duke of Saxe-Coburg. Gotha is situated on a canal of the Leina, and on the Thuringian railway, about 6 miles north of the Thuringian Forest. It consists of the town proper and four suburbs, which are grouped in the shape of a half-moon to the north, west, and east of the hill on which, at the height of 1086 feet, stands the castle of Friedenstein. With the exception of those in the older portion of the town, the streets are handsome and spacious, and the beautiful gardens and promenades between the suburbs and the castle add greatly to the town's attractiveness. On the other side of the castle there is an extensive and finely adorned park. To the north-west of the town the Gulberg hill,—on which there is a public pleasure garden,—and to the south-west the Leeberg hill, rise to a height of over 1300 feet, and afford extensive views of a beautiful panorama. The castle, begun by Ernest the Pious in 1643 and completed in 1654, occupies the site of the old fortress of Grimmenstein. It is a huge square building flanked with two wings, having towers rising to the height of about 140 feet. It contains the ducal coin cabinet, and the ducal library of nearly 200,000 volumes, among which are several rare editions, and about 6900 manuscripts. The picture gallery, the cabinet of engravings, the natural history museum, the Chinese museum, and the cabinet of art, which includes a collection of Egyptian, Etruscan, Roman, and German antiquities, are now included in a new building, completed in 1878, which stands on the southern terrace of the castle. The principal other public buildings are the Margaret church,—with a beautiful portal and a lofty tower,—founded in the 12th century, twice burnt down, and rebuilt in its present form in 1652; the Augustines or Cloister church, with an altar-piece by the painter Jacobs; the theatre; the fire insurance bank and the life insurance bank; the ducal palace, in the Italian villa style, with a winter garden and picture gallery; the buildings of the legislature of the duchy; the hospital; the old town-house, dating from the 11th century; the old dwelling-house of the painter Lucas Cranach, now used as a girls' school; the ducal stable; and the Friedrichsthal palace. The educational establishments include excellent city schools, a gymnasium (founded in 1524, one of the most famous in Germany), a ladies' school of the first order, a training school for teachers and another for female teachers, a free school, a trade school, and a commercial school. Among the other institutions are a lying-in hospital, a surgical and eye hospital, a private lunatic asylum, an orphanage, a reformatory, a magdalen institute, and a school for the board and education of destitute girls. The observatory, erected by Duke Ernest II. in 1787, was in 1857 transferred to a new site in the neighborhood of the park. Formerly the town obtained its water supply by means of the Leina canal, which was excavated in 1369, but water for drinking purposes has, since 1874, been obtained from the Thuringian Forest. Gotha is one of the most active commercial towns of Thuringia, its manufactures including sausages, for which it has a great reputation, porcelain, tobacco, sugar, machinery, mechanical and surgical instruments, musical instruments, shoes, lamps, and toys. There are also a number of nurseries and market gardens. The book trade is represented by about a dozen firms, including that of the great geographical house of Perthes. Population (1875), 22,928.



Plan of Gotha.

1. Catholic Chapel.
2. St. Margaret's Church.
3. Arnold's Monument.
4. Theatre.
5. Lunatic Asylum.
6. Cathedral.
7. Town-Hall.
8. Post-Office.
9. Gymnasium (with Löffler's Monument).
10. Cloister Church.
11. Töchterschule (Lucas Cranach's house).
12. House of the States of the Duchy.
13. Mint.
14. Ducal Palace.
15. Telegraph Office.
16. Perthes's Publishing House.
17. Friedrichsthal Palace.
18. Ducal Stables.
19. Observatory.
20. Ducal Burying-Place.

Gotha existed as a village in the time of Charlemagne. In 930 the Abbot Gotthard of Hersfeld surrounded it with walls. It was known as a town as early as 1109, about which time it came into the possession of the landgraves of Thuringia. On the extinction of that line Gotha came into the possession of the electors of Saxony, and on the division of their estates between Frederick the Soft-hearted and William it fell to the share of the latter, after whose death it was inherited by the Ernestine line of dukes. After the battle of Mühlberg in 1547, the castle of Grimmenstein was partly destroyed, but it was again restored in 1554. In 1566 the town was taken from Duke John Frederick by August of Saxony. After the death without issue of John Frederick's two sons, it came into the possession of Duke Ernest the Pious, the fourth of the line of the dukes of Gotha; and on the extinction of this line it was, in 1826, united, along with the dukedom, to Coburg.

See *Gotha und seine Umgebung*, Gotha, 1851; Kühne, *Beiträge zur Geschichte der Entwickelung der socialen Zustände der Stadt und des Herzogthums Gotha*, Gotha, 1862; Humbert, *Les villes de la Thuringe*, Paris 1869; and Beck, *Geschichte der Stadt Gotha*, Gotha, 1870.

GOTHENBURG (Swedish, *Göteborg*), the second city and chief commercial town of Sweden, and the capital of a "län" of the same name, is situated in a low valley surrounded by bare hills, on the south bank and 1⅔ miles from the mouth of the Götha river, 282 miles W. S. W. of Stockholm by rail (by the Götha Canal 370 miles). Gothenburg is well and regularly built, mostly of stone or brick, with wide and well-paved streets, and in its general appearance much resembles an English town. It consists of two main portions, the town proper and its suburbs—together 5¼ square miles in extent. The first may be described as a semicircle extending south-eastward over a marshy flat from the bank of the Götha as its diameter. This semicircle is crossed by the East and West Harbor Canals and from east to west by the Great Harbor Canal, which divides the town proper into two parts, a north and a south. The canals are enclosed with hewn stone, lined with trees, and crossed by 24 iron bridges. The finest streets of Gothenburg are the North and South Harbor Streets. Gustavus Adolphus's *Torg* (market-place), with a bronze statue of Gustavus Adolphus by Fogelberg, occupies the centre of the town, while the principal market-place is now (since 1849) *Kungstorget* (the king's market-place). The favorite promenades are the Horticultural Society's Park, the King's Park, with Molin's group (the Beltbucklers) and the *Nya Alléen* (new alleys), situated on the south outskirts. Gothenburg has seven Lutheran churches, of which the finest are the cathedral (*Gustavii Domkyrka*), called after Gustavus Adolphus, founded 1633, rebuilt after fires in 1742 and 1815, now a cruciform structure 173 feet high and 194 feet long by 75 feet broad. Haga church, erected in 1856, and the German church, rebuilt 1747–1798; an English Episcopal church (1855); a Catholic chapel; and a synagogue (1855). The other chief buildings are the exchange, in Italian style (1844), with marble statues of Odin by Fogelberg (1855), and of Oscar I. by Molin (1855); the residence house, built by Torstenson after the Thirty Years' War; the townhouse, founded 1670, enlarged 1814; the old *kronhus*, where the diet of 1660 was held; the new custom-house (1866); the artillery barracks (1806) for 750 men; the prison (1854); the railway station (1858); the arsenal (1860); the new theatre (1856-59) seated for 1030; and the Sahlgren new hospital (1848–55). Gothenburg is the seat of a bishop and of a provincial governor. It has 34 schools of various kinds, including two Latin schools, a school-teachers' seminary, an extensive *Elementärläroverk*, founded 1630, rebuilt 1859, with a library of 15,000 vols., a trade institute, the Chalmers' technical school (1869), another technical school (1848), a "real-gymnasium" (1844), and a navigation-school (1862). The museum, founded in 1833, contains collections for natural history, entomology, anatomy, botany, archæology, and ethnography, a picture and sculpture gallery, and a collection of 6000 coins and medals. Gothenburg has numerous benevolent and charitable institutions, mainly supported by the munificence of private citizens. The industries are shipbuilding (carried on in four docks), linen and cotton weaving, brewing, and the manufacture of furniture, machinery, lucifer-matches, paper, sugar, and tobacco. In 1877, 2213 ships of 532,127 tons (Swedish, 1221 of 270,900 tons; British, 267 of 130,219 tons) entered at the port, while 1781 ships of 526,352 tons (British, 264 of 118,236 tons) cleared. The mercantile fleet belonging to Gothenburg consisted on January 1, 1878, of 65 steamships of 21,215 tons, and 156 sailing vessels of 63,913 tons. The exports in 1877 amounted in value to £2,437,200. These included 8,107,326 cubic feet of deals, boards, and battens (6,021,546 cubic feet to England); 6,065,408 cubic feet of pit-props and other timber, besides 7,246,056 pieces of oak and other staves, and laths and carpenters' work valued at £80,083; 90,460 tons of iron and steel (62,480 tons to England); 333,194 quarters of grain, chiefly oats (265,655 quarters to England); also beans and pease, lucifer matches, 2667 head of cattle, and 38,578 cwts. of butter. The imports in the same year amounted to £3,865,000, chiefly made up of cotton (14,540,996 ℔) and cotton yarn (3,608,355 ℔), wool and woollen yarn (3,397,757 ℔), raw sugar (17,289,777 ℔), refined sugar (6,512,919 ℔), coffee (8,239,346 ℔), molasses

(4,883,021 ℔), rice (3,246,247 ℔), olive oil (2,443,804 ℔), salt (796,208 cubic feet), coal and coke (246,205 tons), iron rails (32,059 tons), petroleum (13,243,408 ℔), hides (2,346,577 ℔), and paper (712,538 ℔). Under the peculiar licensing system initiated in Gothenburg October 1, 1865, the town authorities contract for three years with a limited company, which takes the whole number of licenses for selling *brändin*, and hands over to the town treasury the net proceeds of its trade. These amounted to £40,103 in the year ending October 1, 1876, when the company sold 383,561 gallons of spirits, 178,133 gallons of which were consumed on the public-house premises, and realized a gross profit of £52,850. The licenses issued have been reduced from 119 in 1865 to 56 in 1876. All "bars" are closed from 6 P. M. on Saturday to 8 A. M. on Monday, and in the period 1866–76 apprehensions for drunkenness have on the average decreased 22 per cent., though since 1870 there has been a slight increase (in 1876, 2357 persons were fined), usually attributed to the higher rate of wages and the greater efficiency of the police. The population of Gothenburg, including suburbs, was 71,707 in 1877.

Founded by Gustavus Adolphus in 1619, Gothenburg was from the first designed to be fortified, a town of the same name founded on Hisingen (an island 44 square miles in area between the two arms of the Götha river) having been destroyed by the Danes during the Calmar war. From 1621, when it was first chartered, it steadily increased, though it suffered greatly in the Danish wars of the last half of the 17th and the beginning of the 18th centuries, and from several extensive conflagrations (the last in 1813), which have destroyed important records of its history. The great development of its herring fishery in the latter part of the 18th century gave a new impulse to the city's trade, which was kept up by the influence of the "Continental System," under which Gothenburg became a depôt for the colonial merchandise of England. After the fall of Napoleon it began to decline, but since its closer connection with the interior of the country by the Götha Canal (opened 1832) and Western Railway it has rapidly advanced both in population and trade. It is expected that the great line now in course of construction through the mining districts will very greatly increase the importance of Gothenburg. Since the demolition of its fortifications in 1807, it has been defended only by the two redoubts of Billingen and Rya Rabbe. Gothenburg was the birthplace of the poet Bengt Lidner, and of two of Sweden's greatest sculptors, Fogelberg and Molin. After the French Revolution Gothenburg was for a time the residence of the Bourbon family.

See Octavia Carlén, *Göteborg: Beskrifning öfver staden och des närmaste omgifningar* (Stockholm, 1869), and the works therein cited; also J. Hellstenius, *Några blad ur Göteborgs historia* (*ib.* 1870); Axelson and Pabst, *Sveriges industriella etablissementer* (*ib.* 1870, *et seq.*); W. Malm, *Beskrifning öfver segelleden från Stockholms kanalvagar till Göteborg* (*ib.* 1873), *Bidrag till kännedom om Göteborgs och Bohusläns fornminnen och historia*, published by the Economic Society of the län (Gothenb. and Stockh., 1874 *et seq.*), and *Göteborgs Kalendar*, a yearly publication.

GOTHIC LANGUAGE. See under GOTHS, p. 757.

GOTHOFRED or GODEFROY, the name of a noble French family, of which many members attained distinction as jurists or historians.

The first whose name is associated with the active study of jurisprudence, at the close of the 16th century, was DENIS GODEFROY (1549–1621). He was born at Paris, and studied law at the universities of Louvain, Cologne, and Heidelberg. Having embraced the Reformed religion, he found Geneva a safer abode than Paris, and became professor of law there. Some years afterwards he obtained a public appointment in one of the districts in the Jura, but was driven from his home by the troops of the duke of Savoy and retired to Basel. Thence he was induced by the offer of a chair of Roman law to go to Strasburg, but soon changed his appointment for one at Altorf, which then possessed a university celebrated for its late professor of law, Donneau. In 1600 the elector palatine appointed him professor of Roman law in Heidelberg, where he spent the greater portion of the remainder of his life, and was placed at the head of the faculty of law. The most flattering offers from several universities failed to induce him to leave his adopted country, but the invasion of the Palatinate by Tilly's troops forced him to take refuge again at Strasburg, where he died in 1621. His most important work is his edition of the *Corpus Juris*. The text given by him was very generally adopted and used in quotation. More than twenty editions of the work were published in various towns of France, Germany, and Holland. Godefroy's other writings are very numerous; but they are for the most part either editions of classical authors or compilations which display great industry and learning, but are of little use to the modern student.

THEODORE GODEFROY (1580–1649), the eldest son of Denis, forsook the religion which his father had adopted, and obtained the office of historiographer of France, as well as several important diplomatic posts. His historical works are very numerous. The character of his labors will be judged from the title of his most elaborate production—*Le Cérémonial de France*. Many of his smaller works are devoted to questions of genealogy.

JACQUES GODEFROY (1587–1652), the younger brother of Theodore, has a real claim to the remembrance of students of the history of Roman law, in his edition of the *Theodosian Code*, at which he labored for thirty years. It was this code, and not the *Corpus Juris* prepared under the direction of Justinian, which formed the principal, though not the only source from which the lawyers of the various countries which had formed the Western empire drew their knowledge of Roman law, at all events until the revival of the study of law in the 11th century at Bologna. Hence Godefroy's edition was of real value. Jacques Godefroy also completed the difficult and useful task of collecting and arranging those fragments of the *Twelve Tables* which can be discovered, and so an important step was taken towards representing the Roman law in its first definite form. His other works are very numerous, and are principally devoted to the discussion of various points of Roman law. He died in 1652, having served the republic of Geneva both as its principal magistrate and in undertaking important missions to the court of France.

A list of the works of the various members of the family of Godefroy, whose activity extends over a period of nearly 200 years, may be found in the *Biographie Générale*, and fuller particulars of its history in Moreri's *Dictionnaire historique*.

GOTHS. The historical position of the Gothic nation needs to be marked out with special care, both on account of various lax popular uses of the Gothic name, and also on account of much legendary history and many rash ethnological speculations, ancient and modern, which have gathered round the true history of the Gothic people. An ignorant age used the words *Goth* and *Gothic* as vague names of contempt for anything that was thought rude and barbarous. A hardly less ignorant but better disposed age used the word *Gothic* in an equally vague way, but without the same feeling of contempt, for anything which was thought to be mediæval or "romantic," as opposed to "classical." The name came also to be used as a philological or ethnological term; we heard of "Gothic nations," "Gothic languages," etc., meaning "Teutonic" in the widest sense. The name was also, first scornfully, then respectfully, applied to a style of architecture which has some claim to be called Teutonic as opposed to Greek or Roman, but which has nothing whatever to do with the Goths as a nation. Long before this, two European sovereigns who had nothing whatever to do with the national Goths, took the title of King of the Goths out of a mere accidental likeness of names. All these uses of the Gothic name must be carefully distinguished from the history of the true national Goths who play so great a part in Europe from the 3d to the 8th century of our era. The Goths may on many grounds claim the foremost place among the Teutonic nations which had a share in the break-up of the Roman power. They were among the earliest, if not quite the earliest, of the Teutonic nations to establish themselves within the empire, as distinguished from merely ravaging its frontiers. Their history too is closely connected with the geography of the whole empire. Their first historical appearance was in the East; their great historical settlements were made in the West. No Teutonic people fills so great a place in the political and military history of the 4th, 5th, and 6th centuries, and no Teutonic people has left behind it such early remains of a written native literature. The real greatness of the Goths quite accounts for the many vague uses of the Gothic name. Alike in scorn and in honor, the Goths have been, not unreasonably, taken as the representatives of the whole Teutonic race. The wonderful thing is that a people who played so great a part for several ages should have wholly passed away. The Goths have not for many ages existed anywhere as a distinct nation, nor have they given an abiding name to any part of Europe. Franks, Angles, Saxons, Burgundians, Frisians, Thuringians, Lombards, Bavarians, perhaps Vandals, are all visible on the modern map. So several parts of Europe have at different times been known as *Gothia;* but the name was never borne by any large country, and it has nowhere lasted down to modern times.

The chief ancient authority for the early history of the Goths is their national historian Jordanis, who chiefly followed the Gothic history of Cassiodorus the minister of Theodoric, and the lost history of Ablavius. (On the value of Jordanis's writings see Pallmann, *Geschichte der Völkerwanderung*, i. 23.) But he is careless and uncritical, and, like other national historians, is full of mythical elements in the early part. He has to be tested throughout by the contemporary Roman and Greek writers from the 3d century to the 6th. Among these, perhaps the first place is due to Ammianus in the 4th century and to Procopius in the 6th.

The first certain historical appearance of the Goths is in the lands north of the lower Danube in the 3d century of our era. For any earlier account of them we have to go either to mythical stories or to ingenious guesses and inferences. There are a remarkable number of national and legendary names which have more or less of likeness to the name *Goth;* and this likeness has naturally led to an unusual number of theories. The Goths first appear in history in the ancient land of the *Getæ;* and this geographical fact, combined with the likeness of the names, has naturally caused *Getæ* and *Goths* to be looked on as the same people. The identification is as old as our first historical mention of the Goths (Ælius Spartianus, *Ant. Car.*, 10). Claudian always speaks of the Goths as *Getæ*. So does the national historian Jordanis (cap. v.). The identity is mentioned doubtingly by Procopius (*Bell. Vand.*, i. 2; *cf. Bell. Goth.*, v. 4). It is strongly maintained by Jacob Grimm (*Geschichte der Deutschen Sprache*, capp. ix., xviii.), but is rejected by nearly all later writers. A more famous legend, which has derived its chief currency from Jordanis, brings the Goths first of all from Scandinavia (see Gibbon, c. x.; Geijer's *History of Sweden*, c. x.). There is a so-called East and West Gothland in Sweden, but the connection of these lands with the Goths of Roman history is more than doubtful. Ptolemy (ii. 11, 35) places the Γοῦται in Scandia, and Procopius (*Bell. Goth.*, ii. 15) knew the Γαυτοί among the inhabitants of Thoule; but he clearly did not look on them as Goths (see Zeuss, *Die Deutschen*, 500, 511; Grimm, p. 312). Then there is the god *Geát* (see Kemble's *Saxons in England*, i. 370), and the *Geátas*, who figure in Beowulf, and elsewhere in Old-English writings. The Traveller's Song (34, 115, 177) distinctly distinguishes *Goths* and *Geátas*, and couples the latter with the Swedes. Pliny (*Nat. Hist.*, iv. 11) places *Getæ* and *Gaudæ* together on the lower Danube. His *Gaudæ* may possibly be Goths; if so, they are distinguished from the *Getæ*. Then there are the *Jutes* of Old-English history, the *Guttones, Gothones, Gothini* (see Latham, *Germania*, Epilegomena xxxviii. *et seqq.*). Pytheas, according to Pliny (*Nat. Hist.*, xxxvii. 7; *cf.* iv. 14) placed the *Guttones* on the south coast of the Baltic (that seems to be his meaning), and rules them to be a German people. This carries the name back to the time of Alexander. Ptolemy also (iii. 5, 20) has Γύθωνες in Sarmatia on the Vistula. Tacitus (*Germania*, 43) distinguishes the German *Gothones* in the same region from the Celtic *Gothini*, whom he places seemingly nearer to the Carpathians. Tacitus moreover not only speaks of the *Gothones* or *Gotones* as a people, but mentions (*Ann.*, ii. 62) a particular man of the nation, Catualda by name, as having restored the independence of his people after it had been overthrown by Maroboduus. With this hint, it is perhaps not too much to infer with Aschbach (*Westgothen*, 2d ed.) and Zeuss (136) that for Βούτονες in Strabo (vii. 1), who are mentioned among the nations subject to Maroboduus, we should read Γούτονες. And there is no doubt that names like *Getæ, Gethæ, Guddæ*, even *Gothi*, lived on almost to modern times, first as national names, then as names of contempt, in Poland, Lithuania, and Prussia (see Latham, and Zeuss, 672). Latham asserts the identity of the names *Getæ, Gothi*, and *Gothones*, but he holds (see especially p. 42 of his Epilegomena) that both *Gothones* and *Getæ* were Lithuanian, and that the Teutonic Goths took the name of the people whom they had conquered. They would, on this view, be Goths only in the sense in which Englishmen are Britons.

On the whole, it seems that there is no trustworthy evidence for a migration of the Goths from Scandinavia, and that the idea was suggested only by the likeness of name between the true Goths and the *Gauts* or *Geátas* of Swedish history. The application of the name *Gothland* to the island *Gotland*, as well as to the continental *Gauthiod*, is a further mistake. Nor does there seem to be any reason for making *Goths* and *Getæ* the same. But the identification of the Goths with the *Gothones*, Γούτονες, *Guttones*, on the south coast of the Baltic (which is accepted by Pallmann and Dahn) has much more to be said for it. *Gothi* and *Gothones* are strictly the same name; the double form is usual in the Latin shapes of Teutonic names. But the whole history of the Goths in their northern seats is summed up in the personal history of Catualda, who, after delivering his people from Maroboduus, was himself overthrown by the Hermunduri. The continuous and certain history of the Gothic nation begins in the Roman Dacia.

The question now comes, Which of the nations which are historically connected with the Goths had any closer connection with them than that of common Teutonic origin? Setting aside Getæ and other doubtful theories, the real Gothic name is used by the Greek and Latin writers in a wider and in a narrower sense. We must also bear in mind the vague way in which the ancient writers used national names, and their fondness for using obsolete names. Thus the Goths and other Teutonic nations are spoken of as Scythians and Samaritans. Procopius, in an evidently well-considered passage (*Bell. Vand.*, i. 2), speaks of the Goths as having been formerly called Σαυρομάται καὶ Μελάγχλαινοι, names which come out of Herodotus's description of the regions where the Goths first appear. But he gives it as the definite result of his own observations that Goths,—by this name he always means specially the East-Goths,—Vandals, West-Goths, and Gepidæ (Γήπαιδες, with an evident intention to give the word a Greek meaning) were originally one nation, speaking one Gothic language. The only question is about the Vandals. The Gepidæ are commonly acknowledged as a branch of the Goths, and Jordanis (17) has a legend which implies their kindred. The Taifalæ (Ammianus, xxxi. 19), the Bastarnæ, Peucini, and other tribes are also reckoned among the Gothic races. In other passages Procopius speaks of several other nations, as the Alans, Rogi, and Scirri, as Gothic, but he does not seem to be in the same way pronouncing a definite judgment. Among all these, the historical Goths, who play a part in European history by that name, consist of the East and West Goths, and of the small division called Tetraxitæ. The division into East and West Goths does not appear in the earlier writers, as Ammianus and Zosimus, but we find it both in Procopius and in Jordanis. Instead of East-Goths and West-Goths, we read in Ammianus, Zosimus, and Claudian of *Greuthungi* and *Tervingi*. These seem to be (see Aschbach, 21; Zeuss, 406; Köpke, 103) the strictly national names of the two divisions, which took the names of East and West Goths from their geographical position in the lands which they entered. There is an exact parallel in England, where the national name of the *Gewissas* gives way to the geographical name of *West-Saxons*. Jordanis indeed doubts whether the East-Goths were so called from their eastern position, or from a king Ostrogotha. Strange to say, this Ostrogotha seems to be a real person, and not a mere mythical eponym. Οὐστριγότθος (Procop., *Bell. Goth.*, iv. 27) is an historical person at a later date, and the name is borne in a feminine shape by one of the daughters of Theodoric. The history of the East and West Goths, as far as the empire is concerned, falls naturally into three periods. In the 3d century they are still settled outside the empire, and appear as invaders and ravagers of the Roman territory from outside. After an interval in which they almost sink out of notice, they appear again within the bounds of the empire, in various relations of alliance and enmity, marching to and fro, but not making any lasting settlement. It is not till the 5th century that they begin to form settled powers. During their wandering stage they appear mainly in the Eastern empire. But neither they nor any other Teutonic people founded any permanent settlement within its borders. The historical settlements of the Goths are the short and brilliant dominion of the East-Goths in Italy, and the more lasting dominion of the West-Goths in Gaul and Spain.

After the first vague mention of the Goths under Antoninus Caracalla, they begin to play a distinct part in the reign of Alexander Severus. They were then in Dacia, and received a tribute or subsidy of some kind (Petrus Patricius, 124, ed. Bonn). The next emperor, Maximin, is claimed by Jordanis (15) as himself of Gothic birth, but we may suspect the usual confusion with the *Getæ*. The narrative of Jordanis begins from this point to put on a more historical character, and his account is helped out by various notices in the Augustan History. In the reign of Philip (244–248 A. D.) they passed the Danube and ravaged Mœsia, and in 251 the emperor Decius fell in battle against them (see Zosimus, i. 19 *et seqq.*). From this time they ravished eastern Europe and western Asia far and wide (251–268). They carried on their warfare by sea, and reached as far east as Trebizond. And it seems to have been now that the first permanent Gothic settlement was made, though not strictly within the lands of the empire. This was in the Tauric Chersonesos or Crim. Here their settlement lasted for many ages, and they became allies rather than subjects of the empire in the reign of Justinian. Within the empire the Gothic inroads met with repulses at several points, especially from the local forces of Athens under the historian Dexippus (Trebellius, Gallienus 13, and the fragment of Dexippus himself). At last, in 269, the Goths suffered a decisive defeat from the emperor Claudius at Naissus in Dardania, which formed an epoch in Gothic history. It answers to the repulse of the Saxons from Britain by the elder Theodosius. The first attempt at Gothic settlement south of the Danube had been premature. It had to be repeated at a later time with greater success.

Further victories over the Goths are attributed to Aurelian. But the chief event of his reign was one which amounted to a legal acknowledgment of Gothic occupation north of the Danube. The Roman legions were withdrawn from Dacia, and the name of Trajan's great conquest was transferred to the land south of the Danube (274). That is, the great river was established as the boundary between the Roman and Gothic dominions. The wisdom of this cession is shown by its being followed by a period of ninety years in which the peace between the Goths and the empire was seldom seriously broken. The chief interruption was during the reign of Constantine, when the Gothic king Araric invaded the empire, and after some momentary successes, was driven back. In the middle of the 4th century a great power arose under the East-Gothic king Ermanaric (less correctly *Hermanric:* the name is the same as *Eormenric*, in the royal line of Kent), of the house of the Amali, which was reckoned to be the noblest among the Goths. Ermanaric has become a great figure in Teutonic legend, and it is not easy to say how far legend has built upon history, and how far so-called history has drawn from legend. But that Ermanaric was a real man, and the founder of a great dominion, is plain from the few words of Ammianus (xxxi. 3). Yet there is something unsatisfactory in the way in which we read vague accounts of the greatness of his power, with hardly a glimpse of himself personally. The period assigned to his reign is full of stirring events, in which we get a clear conception of much lesser Gothic chiefs, but none of Ermanaric himself. Jordanis (23) claims for him a vast dominion stretching from the Danube to the Baltic, and he is specially emphatic on the subjection of the Slavonic nations to the rule of the Gothic overlord. With regard to the Gothic nations, we can see that the rule of Ermanaric was a mere overlordship. The West-Goths appear as a distinct people, with the power of making war and peace on their own account. But they had no kings; their great chief Athanaric appears only as "judge" (Ammianus, xxvii. 5; xxxi. 3), answering to our *ealdorman* or *heretoga* (*cf.* Jordanis, 26); and along with him are other West-Gothic chiefs, specially his rival Frithigern. We hear of a civil war between these two rivals (Socrates, iv. 33), and it is more certain that Athanaric made war within the Roman border as an ally of the usurper of Procopius in 365, and afterwards made peace with the emperor Valens. By this time Christianity was making swift advances among the Goths. According to the view of some modern writers (Köpke, 123; Pallmann, ii. 63), the outlying Gothic settlement in Crim had been Christian and Catholic from the beginning; but now Christianity in its Arian form began to be gradually accepted by the great mass of the Gothic nation. This was mainly the work of the teaching of Ulfila (see ULFILA), the Gothic apostle and translator of the Scriptures into the Gothic tongue (Sozomen, iv. 24). According to some accounts (Pallmann, i. 71), he had, to avoid persecution, led a Christian colony south of the Danube (348), who settled peaceably at Nicopolis, and are hence known as Mœsogoths (seemingly the *Gothi Minores* of Jordanis, 51). Later, in 370, there was another great persecution, in which Athanaric, the special enemy of everything Roman, appears also as the enemy of the Christians, while Frithigern is their friend (Sozomen, vi. 37; Socrates, iv. 33). The distinction between Christian and heathen Goths remains of political importance for some time. But both East and West Goths had fully embraced Arianism long before the end of the 5th century, while the Goths of Crim seem to have remained Catholic, and received Catholic bishops from Saint John Chrysostom, and afterwards from Justinian.

Towards the end of the reign of Ermanaric several causes joined together to break his great dominion asunder. There were clearly signs of division between East and West Goths, between Christians and heathens, as well as discontents among the subject nations. These causes of division were now strengthened by pressure from without. Now began the first of those movements of the Turanian races into the lands north of the Danube, which have had such an effect on the history of south-eastern Europe down to our own time. The Huns pressed on the new dominion of the Goths, which was already beginning to break in pieces. Ermanaric died at the age, it is said, of 110, by the hands of subject princes stirred to wrath by his cruelties (Jordanis, 24). All thought of a lasting Gothic dominion north of the Danube died with him. With his fall the movements south of that river begin again on a great scale.

From this time the history of the East and West Goths parts asunder, to be joined together again only incidentally and for a season. The great mass of the East-Goths stayed north of the Danube, and passed under the overlordship of the Hun. They do not for the present play any important part in the affairs of the empire. The great mass of the West-Goths crossed the Danube into the Roman provinces, and there played a most important part in various characters of alliance and enmity. The great migration was in 376, when they were allowed to pass as peaceful settlers under their chief Frithigern. His rival Athanaric seems to have tried to maintain his party for a while north of the Danube in defiance of the Huns; but he had presently to follow the example of the great mass of the nation. The peaceful designs of Frithigern were meanwhile thwarted by the ill-treatment which the Goths suffered from the Roman officials, which led first to disputes and then to open war. In 378 the Goths won the great battle of Adrianople, in which the emperor Valens was killed. His successor Theodosius the Great made terms with them in 381, and the mass of the Gothic warriors entered the Roman service as *fœderati*. Many of their chiefs were in high favor; but it seems that the orthodox Theodosius showed more favor to the still remaining heathen party among the Goths than to the larger part of them who had embraced Arian Christianity. Athanaric himself came to Constantinople in 381; he was received with high honors, and had a solemn funeral when he died. His saying is worth recording, as an example of the effect which Roman civilization had on the Teutonic mind. "The emperor," he said, "was a god upon earth, and he who resisted him would have his blood on his own head."

The death of Theodosius in 395 broke up the union between the West-Goths and the empire. Dissensions arose between them and the ministers of Arcadius; the Goths threw off their allegiance, and chose Alaric as their king. This was a restoration alike of national unity and of national independence. The royal title had not been borne by their leaders in the Roman service. Alaric's position is quite different from that of several Goths in the Roman service, who appear as simple rebels (see Köpke, 128). He was of the great West-Gothic house of the Balti (bold), a house second in nobility only to that of the Amali. His whole career was taken up with marchings to and fro within the lands, first of the Eastern, then of the Western empire. The Goths are under him an independent people under a national king; their independence is in no way interfered with if the Gothic king, in a moment of peace, accepts the office and titles of a Roman general. But under Alaric the Goths make no lasting settlement. In the long tale of intrigue and warfare between the Goths and the two imperial courts which fills up this whole time, cessions of territory are offered to the Goths, provinces are occupied by them, but as yet they do not take root anywhere; no Western land as yet becomes *Gothia*. Alaric's designs of settlement seem in his first stage to have still kept east of the Adriatic, in Illyricum, possibly in Greece. Towards the end of his career his eyes seem fixed on Africa (see Köpke, 128).

Greece was the scene of his great campaign in 396, the second Gothic invasion of that country. In this campaign the religious position of the Goths is strongly marked. The Arian appeared as an enemy alike to the pagan majority and the Catholic minority; but he came surrounded by monks, and his chief wrath was directed against the heathen temples (Hertzberg, *Geschichte Griechenlands*, iii. 391). His Italian campaigns fall into two great divisions, that of 402–3, when he was driven back by Stilicho, and that of 408–10, after Stilicho's death. In this second war he thrice besieged Rome (408, 409, 410). The second time it suited a momentary policy to set up a puppet emperor of his own, and even to accept a military commission from him. The third time he sacked the city, the first time since Brennus that Rome had been taken by an army of utter foreigners. The intricate political and military details of these campaigns are of less importance in the history of the Gothic nation than the stage which Alaric's reign marks in the history of that nation. It stands between two periods of settlement within the empire and of service under the empire. Under Alaric there is no settlement, and service is quite secondary and precarious; after his death in 410 the two begin again in new shapes.

Contemporary with the campaigns of Alaric was a barbarian invasion of Italy, which, according to one view, again brings the East and West Goths together. The great mass of the East-Goths, as has been already said, became one of the many nations which were under vassalage to the Huns; but their relation was one merely of vassalage. They remained a distinct people under kings of their own, kings of the house of the Amali and of the kindred of Ermanaric (Jordanis, 48). They had to follow the lead of the Huns in war, but they were also able to carry on wars of their own; and it has been held (see Köpke, 139; Pallmann, ii. 173, 277) that among these separate East-Gothic enterprises we are to place the invasion of Italy in 405 by Radagaisus (whom Pallmann writes Ratiger, and takes him for the chief of the heathen part of the East-Goths). One chronicler, Prosper, makes this invasion preceded by another in 400, in which Alaric and Radagaisus appear as partners. The paganism of Radagaisus is certain. The presence of Goths in his army is certain, but it seems dangerous to infer that his invasion was a national Gothic enterprise.

Under Ataulf, the brother-in-law and successor of Alaric, another era opens, the beginning of enterprises which did in the end lead to the establishment of a settled Gothic monarchy in the West. The position of Ataulf is well marked by the speech put into his mouth by Orosius. He had at one time dreamed of destroying the Roman power, of turning *Romania* into *Gothia*, and putting Ataulf in the stead of Augustus; but he had learned that the world could be governed only by the laws of Rome, and he had determined to use the Gothic arms for the support of the Roman power. And in the confused and contradictory accounts of his actions (for the story in Jordanis cannot be reconciled with the accounts in Olympiodorus and the chroniclers), we can see something of this principle at work throughout. Gaul and Spain were overrun both by barbarian invaders and by rival emperors. The sword of the Goth was to win back the lost lands for Rome. And, amid many shiftings of allegiance, Ataulf seems never to have wholly given up the position of an ally of the empire. His marriage with Placidia, the daughter of the great Theodosius, was taken as the seal of the union between Goth and Roman, and, had their son Theodosius lived, a dynasty might have arisen uniting both claims. But the career of Ataulf was cut short at Barcelona in 415, by his murder at the hands of another faction of the Goths. The reign of Sigeric was momentary. Under Wallia in 418 a more settled state of things was established. The empire received again, as the prize of Gothic victories, the Tarraconensis in Spain, and Novempopulana and the Narbonensis in Gaul. The "second Aquitaine," with the sea-coast from the mouth of the Garonne to the mouth of the Loire, became the West-Gothic kingdom of Toulouse. The dominion of the Goths was now strictly Gaulish; their lasting Spanish dominion does not yet begin.

The reign of the first West-Gothic Theodoric (418–451) shows a shifting state of relations between the Roman and Gothic powers; but, after defeats and successes both ways, the older relation of alliance against common enemies was again established. At last Goth and Roman had to join together against the common enemy of Europe and Christendom, Attila the Hun. But they met Gothic warriors in his army. By the terms of their subjection to the Huns, the East-Goths came to fight for Attila against Christendom at Châlons, just as the Servians came to fight for Bajazet against Christendom at Nicopolis. Theodoric fell in the battle (451). After this momentary meeting, the history of the East and West Goths again separates for a while. The kingdom of Toulouse grew within Gaul at the expense of the empire, and in Spain at the expense of the Suevi. Under Euric (466–488) the West-Gothic power again became largely a Spanish power. The kingdom of Toulouse took in nearly all Gaul south of the Loire and west of the Rhone, with all Spain, except the north-west corner, which was still held by the Suevi. Provence alone remained to the empire. The West-Gothic kings largely adopted Roman manners and culture; but, as they still kept to their original Arian creed, their rule never became thoroughly acceptable to their Catholic subjects. They stood therefore at a great disadvantage when a new and aggressive Catholic power appeared in Gaul through the conversion of the Frank Chlodwig. Toulouse was, as in days long after, the seat of an heretical power, against which the forces of northern Gaul marched as on a crusade. In 507 the West-Gothic king Alaric fell before the Frankish arms at Bouglé, near Poitiers, and his kingdom, as a great power north of the Alps, fell with him. That Spain and a fragment of Gaul still remained to form a West-Gothic kingdom was owing to the intervention of the East-Goths under the rule of the greatest man in Gothic history.

When the Hunnish power broke in pieces on the death of Attila, the East-Goths recovered their full independence. They now entered into relations with the empire, and were settled on lands in Pannonia. During the greater part of the latter half of the 5th century, the East-Goths play in south-eastern Europe nearly the same part which the West-Goths played in the century before. They are seen going to and fro, in every conceivable relation of friendship and enmity with the eastern Roman power, till, just as the West-Goths had done before them, they pass from the East to the West. They are still ruled by kings of the house of the Amali, and from that house there now steps forward a great figure, famous alike in history and in romance, in the person of Theodoric son of Theodemir. Born about 454, his childhood was spent at Constantinople as a hostage, where he was carefully educated. The former part of his life is taken up with various disputes, intrigues, and wars within the Eastern empire, in which he has as his rival another Theodoric, son of Triarius, and surnamed Strabo. This older but lesser Theodoric seems to have been the chief (not king) of that branch of the East-Goths which had settled within the empire at an earlier time. Theodoric the Great, as he is sometimes distinguished, is sometimes the friend, sometimes the enemy, of the empire. In the former case he is clothed with various Roman titles and offices, as patrician and consul; but in all cases alike he remains the national East-Gothic king. It was in both characters together that he set out in 488, by commission from the emperor Zeno, to recover Italy from Odoacer. By 493 Ravenna was taken; Odoacer was killed by Theodoric's own hand; and the East-Gothic power was fully established over Italy, Sicily, Dalmatia, and the lands to the north of Italy. In this war the history of the East and West Goths begins again to unite, if we may accept the witness of one writer (Anon. Vales. 728) that Theodoric was helped by West-Gothic auxiliaries. The two branches of the nation were soon brought much more closely together, when, through the overthrow of the West-Gothic kingdom of Toulouse, the power of Theodoric was practically extended over a large part of Gaul and over nearly the whole of Spain. A time of confusion followed the fall of Alaric, and, as that prince was the son-in-law of Theodoric, the East-Gothic king stepped in as the guardian of his grandson Amalaric, and preserved for him all his Spanish and a fragment of his Gaulish dominion. Toulouse passed away to the Frank; but the Goth kept Narbonne and its district, the land of Septimania—the land which, as the last part of Gaul held by the Goths, kept the name of *Gothia* for many ages. While Theodoric lived, the West-Gothic kingdom was practically united to his own dominion. He seems also to have claimed a kind of protectorate over the Teutonic powers generally, and indeed to have practically exercised it, except in the case of the Franks.

The East-Gothic dominion was now again as great in extent, and far more splendid, than it could have been in the time of Ermanaric. But it was now of a wholly different character. The dominion of Theodoric was not a barbarian but a civilized power. His twofold position ran through everything. He was at once national king of the Goths, and successor, though without any imperial titles, of the Roman emperors of the West. The two nations, differing in manners, language, and religion, lived side by side on the soil of Italy; each was ruled according to its own law, by the prince who was, in his two separate characters, the common sovereign of both. The picture of Theodoric's rule is drawn for us in the state papers drawn up in his name and in the names of his successors by his Roman minister Cassiodorus. The Goths seem to have been thick on the ground in northern Italy; in the south they formed little more than garrisons. In Theodoric's theory the Goth was the armed protector of the peaceful Roman; the Gothic king had the toil of government, while the Roman consul had the honor. All the forms of the Roman administration went on, and the Roman polity and Roman culture had great influence on the Goths themselves. The rule of the prince over two distinct nations in the same land was necessarily despotic; the old Teutonic freedom was necessarily lost. Such a system as that which Theodoric established needed a Theodoric to carry it on. It broke in pieces after his death.

On the death of Theodoric (526) the East and West Goths were again separated. The few instances in which they are found acting together after this time are as scattered and incidental as they were before. Amalaric succeeded to the West-Gothic kingdom in Spain and Septimania. Provence was added to the dominion of the new East-Gothic king Athalaric, the grandson of Theodoric through his daughter Amalasontha. The weakness of the East-Gothic position in Italy now showed itself. The long wars of Justinian's reign (535–555) recovered Italy for the empire, and the Gothic name died out on Italian soil. The chance of forming a national state in Italy by the union of Roman and Teutonic elements, such as those which arose in Gaul, in Spain, and in parts of Italy under Lombard rule, was thus lost. The East-Gothic kingdom was destroyed before Goths and Italians had at all mingled together. The war of course made the distinction stronger; under the kings who were chosen for the purposes of the war national Gothic feeling had revived. The Goths were now again, if not a wandering people, yet an armed host, no longer the protectors but the enemies of the Roman people of Italy. The East-Gothic dominion and the East-Gothic name wholly passed away. The nation had followed Theodoric. It is only once or twice after his expedition that we hear of Goths, or even of Gothic leaders, in the eastern provinces. From the soil of Italy the nation passed away almost without a trace, while the next Teutonic conquerors stamped their name on the two ends of the land, one of which keeps it to this day.

The West-Gothic kingdom lasted much longer, and came much nearer to establishing itself as a national power in the lands which it took in. But the difference of race and faith between the Arian Goths and the Catholic Romans of Gaul and Spain influenced the history of the West-Gothic kingdom for a long time. The Arian Goths ruled over Catholic subjects, and were surrounded by Catholic neighbors. The Franks were Catholics from their first conversion; the Suevi became Catholics much earlier than the Goths. The African conquests of Belisarius gave the Goths of Spain, instead of the Arian Vandals, another Catholic neighbor in the form of the restored Roman power. The Catholics everywhere preferred either Roman, Suevian, or Frankish rule to that of the heretical Goths; even the unconquerable mountaineers of Cantabria seem for a while to have received a Frankish governor. In some other mountain districts the Roman inhabitants long maintained their independence, and in 534 a large part of the south of Spain, including the great cities of Cadiz, Cordova, Seville, and New Carthage, was, with the good will of its Roman inhabitants, reunited to the empire, which kept some points on the coast as late as 624. That is to say, the same work which the empire was carrying on in Italy against the East-Goths was at the same moment carried on in Spain against the West-Goths. But in Italy the whole land was for a while won back, and the Gothic power passed away for ever. In Spain the Gothic power outlived the Roman power, but it outlived it only by itself becoming in some measure Roman. The greatest period of the Gothic power as such was in the reign of Leovigild (567–586). He reunited the Gaulish and Spanish parts of the kingdom which had been parted for a moment; he united the Suevian dominion to his own; he overcame some of the independent districts, and won back part of the recovered Roman province in southern Spain. He further established the power of the crown over the Gothic nobles, who were beginning to grow into territorial lords. The next reign, that of his son Recared (586–601), was marked by a change which took away the great hindrance which had thus far stood in the way of any national union between Goths and Romans. The king and the greater part of the Gothic people embraced the Catholic faith. A vast degree of influence now fell into the hands of the Catholic bishops; the two nations began to unite; the Goths were gradually Romanized, and the Gothic language began to go out of use. In short, the Romance nation and the Romance speech of Spain began to be formed. The Goths supplied the Teutonic infusion into the Roman mass. The kingdom, however, still remained a Gothic kingdom. "Gothic," not "Roman" or "Spanish," is its formal title; only a single late instance of the use of the formula, "regnum Hispaniæ" is known. In the first half of the 7th century that name became for the first time geographically applicable by the conquest of the still Roman coast of southern Spain. The empire was then engaged in the great struggle with the Avars and Persians, and now that the Gothic kings were Catholic, the great objection to their rule on the part of the Roman inhabitants was taken away. The Gothic nobility still remained a distinct class, and held, along with the Catholic prelacy, the right of choosing the king. Union with the Catholic Church was accompanied by the introduction of the ecclesiastical ceremony of anointing, a change decidedly favorable to elective rule. The growth of those later ideas which tended again to favor the hereditary doctrine had not time to grow up in Spain before the Mahometan conquest (711). The West-Gothic crown therefore remained elective till the end. The modern Spanish nation is the growth of the long struggle with the Mussulmans; but it has a direct connection with the West-Gothic kingdom. We see at once that the Goths hold altogether a different place in Spanish memory from that which they hold in Italian memory. In Italy the Goth was but a momentary invader and ruler; the Teutonic element in Italy comes from other sources. In Spain the Goth supplies an important element in the modern nation. And that element has been neither forgotten nor despised. Part of the unconquered region of northern Spain, the land of Asturia, kept for a while the name of Gothia, as did the Gothic possessions in Gaul and in Crim. The name of the people who played so great a part in all southern Europe, and who actually ruled over so large a part of it, has now wholly passed away; but it is in Spain that its historical impress is to be looked for.

Of Gothic literature in the Gothic language we have the Bible of Ulfila, and some other religious writings and fragments (see notice of Gothic Language below). Of Gothic legislation in Latin, we have the edict of Theodoric of the year 500, lately edited by Bluhme in the *Monumenta Germaniæ Historica;* and the books of *Variæ* of Cassiodorus may pass as a collection of the state papers of Theodoric and his immediate successors. Among the West-Goths written laws had already been put forth by Euric (466–484). The second Alaric (484–507) put forth a *Breviarium* of Roman law for his Roman subjects; but the great collection of West-Gothic laws dates from the later days of the monarchy, being put forth by King Rekisvinth about 654. This code gave occasion to some well-known comments by Montesquieu and Gibbon, and have been discussed by Savigny (*Geschichte des Römischen Rechts,* ii. 65) and various other writers. They are printed in the old collections of Lindenbrog and Heineccius. They do not seem to have been yet reprinted in the *Monumenta Germaniæ.* Of special Gothic histories, besides that of Jordanis, already so often quoted, there is the Gothic history of Isidore, archbishop of Seville, a special source of the history of the West-Gothic kings down to Siunthala (621–631). But all the Latin and Greek writers contemporary with the days of Gothic predominance make their constant contributions. Not for special facts, but for a general estimate, no writer is more instructive than Salvian of Marseilles in the 5th century, whose work, *De Gubernatione Dei*, is full of passages contrasting the vices of the Romans with the virtues of the barbarians, especially of the Goths. In all such pictures we must allow a good deal for exaggeration both ways, but there must be a ground-work of truth. The chief virtues which the Catholic presbyter praises in the Arian Goths are their chastity, their piety according to their own creed, their tolerance towards the Catholics under their rule, and their general good treatment of their Roman subjects. He even ventures to hope that such good people may be saved, notwithstanding their heresy. All this must have had some ground-work of truth in the 5th century, but it is not very wonderful if the later West-Goths of Spain had a good deal fallen away from the doubtless somewhat ideal picture of Salvian.

Of modern writers dealing specially with Gothic history may be mentioned Manso (*Geschichte des Ost-Gothischen Reiches in Italien*, Breslau, 1824); Aschbach (*Geschichte der Westgothen*, Frankfort, 1827); Köpke (*Die Anfänge des Königsthums bei den Gothen*, Berlin, 1854); Dahn (*Die Könige der Germanen*, Munich and Würzburg, 1861–1871); Pallmann (*Geschichte der Völkerwanderung*, Gotha and Weimar, 1863–64). It is hard to find any work in English dealing specially with Gothic history, though much may be learned from writers like Gibbon and Milman, who deal with the Goths simply as part of some larger subject. Several chapters in the third book of Milman's *History of Latin Christianity* are of special importance in this way.

(E. A. F.)

GOTHIC LANGUAGE.

By this name, which may be taken generally as denoting the idoms of the various divisions of the Gothic nation, is more particularly meant the language exhibited in certain fragments of a translation of the Bible and other minor documents, which, although preserved in manuscripts not dating farther back than perhaps the 5th century, and clearly written in Italy during the rule of the East-Goths, are commonly assumed to have originated among the West-Goths at the time when they were seated in Mœsia, and to be therefore older by at least a century than the manuscripts themselves. It is chiefly due to this assumption that the more distinctive name of *Mœsogothic language* is often used, in England and elsewhere, as well as the simpler *Gothic*. The latter name, however, seems to be more appropriate, in spite of the great probability of the assumption referred to,—since it is, for obvious reasons, utterly impossible to prove that the language of the West-Goths at that time differed from that of the East-Goths, or, even if there was any difference, to show that our manuscripts represent the original forms of the speech of their supposed West-Gothic author. Indeed, according to a fragment of a Gothic calendar preserved in one of the Milan manuscripts, which gives the name of the Gothic people as *Gut-thiuda*[1] (*thiuda*, "people"), the most correct form of the name would be *Gotic*. This spelling at least has obviously greater claims to authenticity than *Gothi*, *Gotthi*, or Γότθοι, and other similar forms most commonly (although not exclusively) used by Latin and Greek writers, whose want of familiarity with the sounds of the Gothic language is often abundantly manifest. From *Gut-thiuda* we may infer with certainty that the Goths called themselves *Gutôs*, the corresponding adjective being *gutisks*.

We have no direct evidence of the character of the Gothic language until the time of the above-mentioned manuscripts; but some conclusions regarding a more archaic state of the language may be drawn from a careful examination of the numerous words borrowed from Gothic at a much earlier period by some of the Finnish tribes originaily dwelling in the interior of Russia.[2] It may be safely assumed that some at least of these words still retain forms of the Gothic language from as early a period as perhaps the 1st or 2d century B. C. By the same date the Goths, as well as the other Teutonic nations, were no doubt already in possession of the Runic alphabet, an adaptation of a particular form of the Latin characters to their special wants and uses.[3] No traces of this alphabet, however, have been left, except the already mentioned short inscription of the Bucharest ring, a list of the Gothic names of these runes, preserved in a Vienna manuscript of the 9th century,[4] and some letters in Ulfila's Gothic alphabet, which soon supplanted the less convenient Runic characters, and so helped to inaugurate the short literary period of the Gothic language so closely connected with the name of that prelate.

Ulfila, or rather Vulfila (310–380 A. D., see ULFILA), was a man of the most profound learning. He not only invented, as has been said, a new alphabet for his literary purposes, but was also able to preach and to write in Latin and Greek as well as in his native Gothic language, and he is reported to have left behind him a great number of tracts and translations in these three idioms. The principal work of his life, however, was his translation of the Bible, parts of which seem to have reached us in the famous *Codex Argenteus*, now at Upsala, and in several minor fragments at Wolfenbüttel (*Codex Carolinus*) and Milan (*Codices Ambrosiani*, including some leaves now kept at Rome and Turin). In this way we possess the greater part of the gospels, considerable portions of the epistles, and a few fragments of the Old Testament; there is also a fragment of a commentary on St. John's gospel, commonly called *Skeireins* (or "explanation"), and the fragment of a calendar which has been already mentioned as containing the original form of the name of the Gothic people.[5] As to the authorship of the last two fragments nothing can be said with certainty; and certain differences in language and manner of translation make it doubtful even whether the fragments of the Old Testament can be traced to the same origin as those of the New. The bulk of the whole, however, may safely be ascribed to Ulfila, for it can hardly be assumed that the same work would have been done twice over in so short a space of time as that lying between the days of Ulfila and the date of our manuscripts. The whole character of the translation too seems to indicate a man of Ulfila's mental power and theological learning. Although it cannot be denied that several alterations of the original have been introduced into our texts at a later time, it is certain both that the author carefully interpreted the Greek text (which was of course the fundamental source of his work), and also that he consulted, and in not a few places followed, the old Latin versions where his own ideas seemed to differ from those of his Greek authorities.[6]

As a specimen of the language, and of Ulfila's mode of translation, we may insert here his version of the Lord's prayer:—

Atta unsar thu in himinam. Weihnai namo thein. Qimai thiudinassus theins. Wair'hai wilja theins swe in himina jah ana airthai. Hlaif unsarana thana sinteinan gif uns himma daga. Jah aflet uns thatei skulans sijaima swaswe jah weis afletam thaim skulam unsaraim. Jah ni briggais uns in fraistubnjai, ak lausais uns af thamma ubilin.

The Gothic language did not very long survive the times of Ulfila. From Mœsia, where it had gained its highest literary culture, it disappeared together with the Goths, when they were driven from these parts by later migrations. In the western portions of Europe, that is, in Italy, France, and Spain, whither it had been carried by the emigrants, the Gothic language seems to have died out even sooner than the Gothic nationality, giving way to the overpowering influence of Latin, and leaving behind it only a few indistinct relics in some proper names and other words that had been received into that victorious language. It was only in a remote spot of the Crimea that it continued to exist until the 16th century, when the last remains of a Gothic people were detected, and a few specimens of their language were gathered by Augerius de Busbeck, a

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[1] The same form of the name seems to occur a second time in the Runic inscription of the Bucharest ring *Gut-annôm hailag*, "dedicated to the Goth's treasure." *Cf.* H. F. Massmann, in Pfeiffer's *Germania* (Vienna, 1857), ii.p. 209 *sq.*; and Ludv. Wimmer, *Aarböger for nordisk Oldkyndighed og Historie* (Copenhagen, 1867), p. 45.

[2] See Dr. Wilh. Thomsen, *Ueber den Einfluss der Germanischen Sprachen auf die Finnisch-Lappischen* (Halle, 1870).

[3] See especially Dr. Ludv. Wimmer, *Runeskriftens Oprindelse og Udvikling i Norden*, Copenhagen, 1874.

[4] J. Zacher, *Das Gothische Alphabet Vulfilas und das Runenalphabet*, Leipsic, 1855.

[5] A few Gothic words and names occur among the subscriptions to two Latin charters, one of which is now preserved at Naples; the other, formerly kept at Arezzo, is now lost.

[6] For fuller particulars see the two principal editions of the Gothic texts by V. d. Gabelentz und Loebe (3 vols. Altenburg and Leipsic, 1843–76), and by E. Bernhardt (Halle, 1875).

Dutch traveller, who visited the eastern parts of Europe in the years 1554–1564.[1]

It is well known that the literary remains of Gothic are (with the exception, perhaps, of a few Runic inscriptions belonging to the Scandinavian languages) by several centuries the oldest specimens of Teutonic speech, and therefore have a particular value for the student of the history of that family of languages. Notwithstanding this fact, it would be altogether wrong to regard Gothic as common source of the more modern stages of these idioms. Although very archaic in many of its forms and sounds, it is in these still far removed from the original features of the common language, as that was spoken before any separation of Teutonic tribes had taken place. Most nearly related to it seem to have been the Scandinavian languages, which are now generally assumed to have formed, together with Gothic, the so-called eastern branch[2] of the Teutonic family, while English, Frisian, and Low and High German belonged to a western division. The latter is chiefly marked by the introduction of a considerable number of forms and sounds of a less archaic stamp, while the eastern idioms are found to have adhered more closely to the original forms. Thus, almost the only distinct innovation in the sound-system of the eastern branch is the insertion of a *g* sound into the groups *iuw, auw, uw* in accented syllables, as in Gothic *triggws*, Old Norse *tryggr*, compared with Old High German and Old Saxon *triuwi*, Old English *treowe, trywe*, "true;" or Old Norse *höggva*, to hew, Old High German and Old Saxon *hauwan*, Old English *heawan*. Western Teutonic, on the other hand, is at once discernible by its doubling all single consonants ending a short root-syllable before *y* (*w, r, l*); thus Old English *theccan*, Old Saxon *thekkian*, Old High German *decken*, to cover (literally "to thatch"), but Gothic *thakjan*, Old Norse *thekja*; or Old English *sellan*, Old Saxon *sellian*, Old High German *sellen*, to sell, but Gothic *saljan*, Old Norse *selja*. As to the inflexional system, the accusative plural of nouns has in Western Teutonic been replaced by the nominative form, as in Old English *dagas*, Old Saxon *dagōs*, Old High German *tagā*, days; Gothic still has *dagōs* for the nominative, and *dagans* for the accusative, the Old Norse forms being *dagar* and *daga* respectively. The same change is found in the adjectives, as Old English and Old Saxon *blinde*, Old High German *blinte*, blind (*cæci*), corresponding to both Gothic *blindai* and *blindans*, Old Norse *blindir* and *blinda*. On the other hand, the formation of the plural of certain neutral substantives by adding an *r*, as in Old English *lombru*, lambs, Old High German *lembir* (still extant in the English plural *children*), is entirely lost in Eastern Teutonic (Gothic *lamba*, Old Norse *lömb*). Another instance of change is to be seen in the loss of the dative case of the reflective pronoun (Gothic *sis*, Old Norse *sér*) in Western Teutonic, the corresponding forms of the personal pronoun of the 3d person being used instead (Old English *him, hire*, etc.). Western Teutonic has also introduced the use of the genitive forms of the same personal pronoun instead of the possessive pronoun (Gothic *seins*, Old Norse *sinn*) when the possessor is denoted by a feminine or a plural (Old English has gone even farther by dropping the possessive pronoun altogether). In the verb, Western Teutonic has replaced the original form of the 2d person singular of the past indicative ending in *-t* (as in Gothic and Old Norse *wast, gaft*, thou wert, gavest) by the corresponding form of the subjunctive (Old English *wǽre, geáfe*, Old Saxon and Old High German *wāri, gābi*). Western Teutonic has also lost the faculty of deriving passive or intransitive verbs from active verbs or adjectives by adding the syllable *-na-* after the root-syllable, as in Gothic *fullnan*, Old Norse *fullna*, to be filled, as compared with Gothic *fulls*, Old Norse *fullr*, full; or Gothic *fulljan*, Old Norse *fylla*, to fill. Only a very few instances of this formation are left in Western Teutonic, such as Old English *wæcnan*, to awaken [intrans.], or *leornian*, German *lernen*, to learn (*cf.* Old English *weccan*, German *wecken*, to awaken [trans.], and German *lehren*, to teach). As to the vocabulary, we may mention the loss of the verb *dón*, to do, in Gothic and Scandinavian. The most conspicuous peculiarity in the syntax is the frequent use of the dative (or perhaps originally the instrumental case) instead of the accusative in Eastern Teutonic.

Among the Teutonic languages Gothic holds by far the foremost rank as regards the regularity of its sound-system and its inflexions. The vowel system is remarkable for the absence of the short *e* and *o* sounds, except in a few places where *ĕ* and *ŏ* (spelt *ai* and *au*) occur under certain consonantal influences. *Umlaut*, or assimilation of root-vowels to a following *a-*, *i-*, or *u-* sound, is not discernible in Gothic. Thus we find only five short vowels, *a*, (*ai*), *i*, (*au*), *u*; five long vowels *ā*, *ē*, *ī* (spelt *ei*), *ō*, *ū*; and three diphthongs *ai*, *au*, and *iu*. There may have been other distinctions of vowel-qualities besides those expressed in spelling, but we have no means of definitely settling this question; so much, however, can be said, that the long vowels, and especially *ē* and *ō*, probably had the close sounds, since these are often interchanged with *ei* and *u* in our manuscripts. The spelling of the consonantal system is also very simple. Besides *y*, *w*, *r*, *l* and three nasal sounds (the guttural nasal being expressed by *g* after the Greek fashion), we find three voiceless stops, *p*, *t*, *k* (*q* being only a combination of *kw*); three voiced stops, *b*, *d*, *g*; four voiceless spirants, *f*, *s*, *th*, *h*; and only one distinct sign for a voiced spirant, *z*. This system of spelling, however, is obviously insufficient to express all the sounds of the language,—an insufficiency partly due to the fact that the transcription of the Gothic speech-sounds was chiefly an imitation of the Greek graphic system, which, at least in Ulfila's time, had become rather imperfect, inasmuch as different sounds developed out of one sound of an earlier period were still often expressed by the same sign (just as in the English orthography of the present day). It is highly probable, for instance, that the signs of *b*, *d*, *g* of the Gothic alphabet not only expressed the sounds of voiced stop consonants (*mediæ*), but also represented the sounds of voiced spirants, such as English *v* and soft *th*, or North German *g* after a vowel (these values being the only ones left to the Modern Greek signs β, γ, δ). Hence the regular change of *b*, *d* final after a vowel into *f*, *th*, as in *gaf*, I gave, from *giban*, to give; or *bath*, I bade, from *bidjan*, to bid.[3]

Great regularity prevails also in the inflexional system. In the substantival and adjectival declensions the instrumental case has become extinct by an early confusion with the dative (the case commonly called dative being, in fact, a mixture of forms of the original dative and the instrumental and local cases), while in the Western branch of Teutonic it was still in frequent use. At the same time, Gothic is the only Teutonic idiom that has still preserved, in a few cases, the vocative in a form distinct from that of the nominative (*fisks*, fish, for instance, has *fisk* in the voc.). The adjectival declension is remarkable for the retention of special forms of the *i-* and *u-* stems, which in all other Teutonic languages have been transferred to the inflexion of the *ja-* stems. In the pronominal inflexion the instrumental case has been kept distinct in a few instances, such as *thē*, *hvē* (the latter form being the same as English *why*). There are also some relics of the dual number left in the 1st and 2d personal pronouns. As for the verb, Gothic is quite unique in retaining the old formation of the passive voice by means of simple derivation (as in *bairada*, *bairanda*, he is, they are borne, Greek φέρεται, φέρονται), the dual number of the 1st and 2d persons throughout the whole active voice (*bairōs*, *bairats*, we, you two bear, in the indicative, or *bairaiva*, *bairaits* in the subjunctive, or *bēru*, *bēruts*, we, you two bore [ind.], and *bēreiva*, *bereits* [subj.] along with the plural forms *bairam*, *bairith*, etc.), and the 3d person of the imperative (as *bairadau*, *bairandau*, he, they shall bear, Greek φερέτω, φερόντων). The different verbal classes are of course the same as in the other cognate idioms; but they are kept more completely distinct in Gothic, for it is only there that the reduplication has been preserved intact in the past of the reduplicative verbs, Gothic *haihald*, I held, for instance, corresponding to such shortened forms as Old Norse *helt*, Old English *heold*, Old Saxon *held*, and Old High German *hēlt*, *healt*, *hielt*. Gothic again is the only language that seems to give us a clue to the explanation of the formation of the past in weak verbs. There we find such plural forms as *hausi-dēdum*, we heard, while in Old Norse we have simple *heyr-ðum*, in Old English *hier-don*, etc. Now, this *-dēdum* would be exactly the corresponding form of the verb *dōn*, to do (lost in Gothic, as mentioned above), so that *hausi-dēdum* must once have meant "we did hear."

Notwithstanding all these instances of great antiquity we must be on our guard against the assumption that Gothic in all its features bears the same archaic stamp. In fact, it often goes further than the other cognate idioms in dropping short final vowels. There are no traces left of the short vowels originally ending *a-* or *i-* stems in declension; thus, *dags* from *daga-*, day; *haurn* from *horna-*, horn; *gasts* from *gasti-*, guest; *hugs* from *hugi-*, mind; but there are many instances of the preservation of these vowels in the other languages, such as *dagar*, *horna*, *gastir* in Old Scandinavian Runic inscriptions, or *hyge* in Old English, or *hugi* in Old Saxon and Old High German.[4] Even the regularity of the inflexional system is often not archaic, but due to later assimilations of forms originally more distant than in Gothic. The most striking instance of this is perhaps the loss, in the verbal system, of the so-called grammatical change, that is, the transferring of a voiceless spirant into a voiced spirant after a syllable unaccented in the earliest time before the general Teutonic rule of fixing the accent on the root-syllables had come into use.[1] This change (still discernible in such English forms as *I was, we were*) was fully developed in all other cognate idioms, as for instance in Old English, *cf. ic wæs, we wǽron*, or *ceosan*, to choose, *ic ceás, we curon, gecoren*, etc., these forms standing for *wás, wēzúm*, etc. Gothic has given up the voiced sound altogether, forming simply *was, wēzum*, or *kiusan, kaus, kusum, gakusans*. It is only in some isolated words (such as *fadar* and *brōthar*, corresponding to Sanskrit *pitár* and *bhrā́tar*), and some derivatives that even traces of this fundamental rule are now to be found in the Gothic language. (E. SI.)

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[1] See his report and word-lists, reprinted by Massmann, in *Zeitschrift für Deutsches Alterthum*, i. p. 345 *seq.* The words contained in these lists are not all intelligible, and some of them are clearly of Slavonic or Iranian origin, but others are decidedly Gothic as regards their form, thus *schlipen*, to sleep; *criten*, to weep; *fyder*, four; the correct Gothic forms being *slēpan*, *grētan*, *fidvōr*.

[2] H. Zimmer, "Ostgermanen und Westgermanen," in *Zeitschrift für Deutsches Alterthum*, xix. p. 393 *sq.*

[3] See W. Weingaertner, *Die Aussprache des Gothischen* (Leipsic, 1658); F. Dietrich, *Ueber die Aussprache des Gothischen* (Marburg, 1862); H. Paul, "Zur Lautverschiebung," in *Beiträge zur Geschichte der Deutschen Sprache und Literatur*, i. 147 *sq.* (Halle, 1874).

[4] E. Sievers, in *Beiträge zur Geschichte der Deutschen Sprache und Literatur*, v. 101 *sq.* (Halle, 1878).

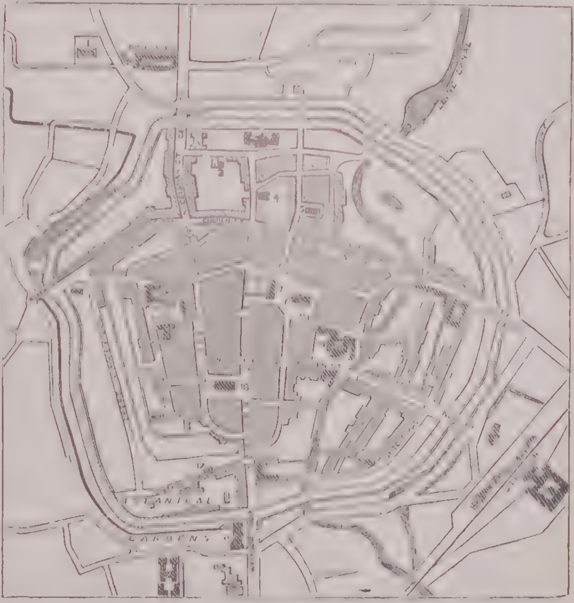
GOTTFRIED. Meister Gottfried of Strasburg, the most brilliant German poet of the Middle Ages, flourished about the end of the 12th and beginning of the 13th century. Of his life and position we have no certain information, for he has told us next to nothing about himself, and contemporary records are dubious and confusing. It would seem, however, that he was a man of good birth and position, who filled an important municipal office in his native town of Strasburg. His chief work was written about 1210, and we may confidently place his death between 1210 and 1220. We know from his writings that he was a man of high culture, but it is almost certain that he was not a priest. Of this his occasional sneers at the clergy are perhaps a better proof than the dubious morality of much of his work. Gottfried wrote one great poem, *Tristan und Isolt*. The story is of Celtic origin; it came first from Britain and Ireland, thence was carried to France, and thence to Germany. Few stories have been so often treated or have had so wide an influence upon literature. A very few words will suffice to give Gottfried's version of it. King Mark of Cornwall has a nephew named Tristan, whom he sends to woo vicariously, and bring home as queen of Cornwall, the beautiful Isolt, princess of Ireland. The young man goes on his mission, is successful, and sets out with Isolt on the homeward journey. Before they reach Cornwall, however, they unfortunately drink a love potion which Isolt's mother had intended to be given to her daughter by the king of Cornwall. The consequence of the mistake is that the young people fall madly and hopelessly in love with one another. The wild force of their passion soon causes them to disregard morality and prudence alike, and the bulk of the poem is devoted to an account of the numerous complications which in time arose. Of course the king soon becomes suspicious, and at last his suspicions become certainties. Tristan withdraws to Normandy, and enters into an alliance with a princess of the land, whose very name—Isolt, the white-handed—has a strange charm for him. But he finds that he really cares nothing for this new Isolt; the memory of his old love rises powerfully in his soul; and he gives utterances to his doubts and perplexities in a soliloquy, with which the poem abruptly concludes.

Tristan is thus an unfinished work; still it is a tolerably long one, as it consists of 19,552 short rhymed lines. The style is highly finished. There is an artistic choice of fit words, a frequent use of antithesis and word-play, and a skilful management of the versification. But these are, of course, only side matters. The permanent interest of the poem consists in its representation of human passion, and in the knowledge it shows of the human heart. The plain, rude story, when told by Gottfried, takes a depth and pathos that are hardly its own. All is described, too, with such clear, bright touches, and such vivid force, that the poem seems somehow a tale of our own time. Its morality indeed is not high; but this objection did not probably occur to those who first read it. If we judge it by a purely art standard, we must pronounce it worthy of an important place in the literature of Europe. *Tristan* was not allowed to remain a fragment. Ulrich von Türheim (about 1236) and Heinrich von Freiberg (about 1270) both wrote continuations and conclusions of the work, which certainly fell far short of the original.

Of Gottfried's other writings, only some lyrics in the ordinary style of the minnesingers remain to us. Two longer poems, entitled *Lobgesang auf die Jungfrau Maria* and *Gedicht von der Armuth*, were long attributed to him, but recent criticism has conclusively proved that they are the work of others. Gottfried's influence on German literature was very great, and a proof of this is the number of poets who treated the same subject after the plan he had laid down. All these, from Hans Sachs (1494–1576) to Immermann (1796–1840), may fairly be claimed as his followers.

The chief editions of Gottfried's *Tristan* are those of Fr. Heinrich v. d. Hagen (a complete edition, with the continuations, Bresl., 1823), Groote (Berlin, 1821), Massmann (Leip., 1843), and Bechstein (containing a very able and complete introduction, 2d ed., 2 vols., Leip., 1873). See also the translations into modern German, with continuations, etc., by Herm. Kurz (Stuttg., 1844, 3d ed., 1877), and Karl Simrock (2d ed., Leip., 1875). For what is known of the life of Gottfried see Kurz's "Zum Leben Gottfried von Strassburg" (in the *Augsburg Allgemeine Zeitung* for 1868, and *Germania*, 15 Jahrgang); and as to the sources of the story, Franck's *Tristan et Isoult* (Paris, 1865), and F. Compart, *Die Sagenüberlieferungen in den Tristan-Epen Eilharts von Oberge und Gottfrieds von Strassburg* (Güstrow, 1876).

GÖTTINGEN, the chief town of a circle of the same name in the land-drostei of Hildesheim and province of Hanover, Prussia, is pleasantly situated at the foot of the Hainberg in the fertile valley of the Leine, about 67 miles to the south of Hanover, on the Hanover and Cassel railway. It is traversed by the Leine, which separates the Altstadt from the Neustadt and Masch; and it is surrounded by ramparts which are planted with lime trees and form an agreeable promenade. The streets in the older part of the town are for the most part crooked and narrow, but the newer portions are spaciously and regularly built. Apart from the churches and the numerous university buildings, it has few structures of any public importance. There are several thriving industries, including, besides the various branches of the publishing trade, the manufacture of woollen and cotton goods, and of physical and mathematical instruments. The university, the famous Georgia Augusta, founded by George II. in 1734, and opened in 1737, rapidly attained a leading position, and in the year 1823 its students numbered 1547. Political disturbances, in which both professors and students were implicated, lowered the attendance to 860 in 1834; and the expulsion of the famous seven professors (Albrecht, Dahlmann, Ewald, Gervinus, Weber, and the brothers Grimm) in 1837 still further reduced its prosperity. The events of 1848, on the



Plan of Göttingen.

1. Observatory.
2. Chemical Laboratory.
3. Reading Room.
4. Catholic Church.
5. University Church.
6. St. John's Church.
7. Townhouse.
8. Gymnasium.
9. University.
10. St. James's Church.
11. Lecture Rooms.
12. Reformed Church.
13. Synagogue.
14. Library and Museum.

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[1] W. Braune, "Ueber den grammatischen Wechsel," in *Beiträge* etc., i. 513 *sq.*; K. Verner, "Ueber eine Ausnahme der ersten Lautverschiebung," in *Zeitschrift für vergleichende Sprachwissenschaft*, xxiii. 97 *sq.* (Berlin, 1877).

other hand, told somewhat in its favor; and since the annexation of Hanover in 1866, it has been carefully cherished by the Prussian Government. In the winter session 1877–1878, its students numbered 909, and the teaching staff 124, —its numerical strength thus entitling it to rank as the eighth on the list of German universities. The present professoriate includes, among other distinguished names, those of Benfey, Lagarde, Lotze, Ritschl, and Weber. Amongst those who have been teachers within its walls may be mentioned, besides the seven already named, Haller, Gesner, Gatterer, Sprengel, Heyne, Blumenbach, Herbart, Heeren, O. Müller, K. F. Hermann, and Eichhorn. Neander, Ewald, and the distinguished chemist Bunsen, it may be added, were natives of Göttingen. The university library contains upwards of 500,000 printed volumes and 5000 manuscripts. There is a good chemical laboratory, as well as adequate zoological, ethnographical, and mineralogical collections, the most remarkable being Blumenbach's famous collection of skulls. The other establishments more or less connected with the university, such as the observatory, botanical garden, and various hospitals, do not call for special notice. The Gesellschaft der Wissenschaften publishes the long-established and well known *Göttingische Gelehrte Anzeigen.* The population in 1875 numbered 17,057.

The earliest mention of a village of Goding or Gutingi occurs in documents of about 950 A. D. The place received municipal rights from the emperor Otho IV. about 1210, and from 1286 to 1463 it was the seat of the princely house of Braunschweig-Göttingen. During this period it held a high place among the towns of the Hanseatic League. In 1531 it joined the Reformation movement, and in the following century it suffered considerably by the Thirty Years' War, having been taken by Tilly in 1626, after a siege of 25 days, and recaptured by the Swedes in 1632. After a century of decay, it was anew brought into importance by the establishment of its university; and a marked increase in its industrial and commercial prosperity has again taken place in recent years.

See Schmidt, *Urkundenbuch der Stadt Göttingen 1400–1500* (1867); Pütter, *Versuch einer akademischen Gelehrtengeschichte der Universität Göttingen* (1765–88), continued by Saalfeld (1820) and by Oesterley (1838); Unger, *Göttingen und die Georgia Augusta*, 1872.

GOTTSCHALK, or **GOTESCHALCUS**, surnamed **FULGENTIUS**, a prominent figure in one of the most important theological controversies of the 9th century, was the son of Berno, a Saxon count, and, having been devoted (oblatus) from infancy by his parents to the monastic life, was trained at the monastery of Fulda, during the abbacy of Hrabanus Maurus, and while Walafridus Strabus was a member of the fraternity. At the approach of manhood he made strenuous efforts to be released from his vows; and he actually succeeded in obtaining from a synod held at Mainz in 829 the necessary dispensation; but through the hostile influence of his abbot this was afterwards cancelled by Louis the Pious, though as a slight mitigation of the harshness of this treatment he was permitted to remove to the monastery of Orbais, in the diocese of Soissons. Here he devoted himself to ardent study of the writings of Augustine, with the result that he became an enthusiastic believer in the doctrine of absolute predestination, in one point going even beyond his master, Gottschalk believing in a predestination to condemnation as well as in a predestination to salvation, while Augustine had contented himself with a doctrine of preterition as complementary to his doctrine of election. While returning from a pilgrimage to Rome in the year 847, Gottschalk, happening to pass a night at a hospice in Friuli, came into contact with Notting, the newly elected bishop of Verona, and expounded to him his peculiar views. The bishop, apparently without saying much at the time, carried word to Hrabanus Maurus, who, meanwhile, had become archbishop of Mainz; the latter lost no time in issuing two letters, one to his informant and another to Count Eberhard of Friuli, in both which he denounced the opinions of Gottschalk with some recklessness and great violence. On the one hand he accused his adversary of neglecting the distinction between foreknowledge and foreordination; on the other hand, he himself refused to recognize any difference between predestination to punishment and predestination to sin. At a synod held in Mainz in presence of the emperor, in 848, Gottschalk presented himself with a written explanation and defence of his views; he was, however, very summarily found guilty of heresy, and handed over to his ecclesiastical superior, Hincmar of Rheims, to be dealt with as his crime might deserve. Having again assumed the defensive in an assembly at Chiersy in 849, he was once more condemned,—on this occasion not only as a heretic, but also as a despiser of authority, and as a disturber of the church's peace,—and sentenced to be whipped severely and rigorously imprisoned (durissimis verberibus castigari et secundum ecclesiasticas regulas ergastulo retrudi). The place selected for his captivity was the monastery of Hautvilliers in the diocese of Rheims, and here he languished throughout the remainder of his life, a period of twenty years, notwithstanding the efforts of influential friends and his own pitiful appeals. Prudentius of Troyes, Wenilo of Sens, and Florus of Lyons successively expressed opinions more or less in favor of his views; nor did Hincmar derive much real aid from the dialectical skill of Erigena, whom he had called in as an authority on the other side. Various synods met, reached widely discrepant opinions on the burning question, and ultimately postponed its settlement to a future council in less troubled times. The summons of Pope Nicholas I., in 863, calling Hincmar to account for his harsh conduct, unfortunately never took effect; and the result was that, after many renewed attempts at conviction and persuasion on the part of Gottschalk—he even proposed to settle the question by ordeal of fire—he was suffered to die unheeded in 868, and, by orders of his inhuman adversary, was buried in unconsecrated ground. It may be added that Gottschalk had attempted to establish a counter charge of heresy against Hincmar, on account of the latter's substitution of "Sancta Deitas" for "Trina Deitas" in a current hymn. This was thought to savor of Sabellianism; but the orthodox archbishop succeeded at once in purging himself from such an imputation of heretical pravity.

The story of Gottschalk has been told with great fulness by Neander and Gieseler. See also Gfrörer's *Untersuchung über Alter, Ursprung, und Zweck der Dekretalen des falschen Isidorus*, 1848.

GOTTSCHED, JOHANN CHRISTOPH (1700–1766), a German author and critic of considerable influence in his own time, was born, 2d February, 1700, at Judithenkirch, near Königsberg. He studied philosophy and literature at Königsberg, was appointed professor, first of poetry (1730), afterwards of logic and metaphysics (1734), at Leipsic, filled various other important offices in connection with the university, and died 12th December, 1766. His chief works were a tragedy entitled *Der sterbende Cato* (Leipsic, 1732) —poor enough rubbish, though it had great but short-lived popularity; *Deutsche Schaubühne* (1740–45), a collection of plays, some of which were written by himself, his wife, J. C. Schlegel, and their friends, whilst others were translated from the French classical dramatists; *Nöthiger Vorrath zur Gesichte der deutschen dramatischen Dichtkunzt* (1757–1765), intended to contain an account of all previous German plays. Though not complete, the last is a very valuable and important work. Besides these, Gottsched wrote a number of educational works, and edited several journals devoted to literary criticism. He was a pedant, but there is no doubt that he did good and lasting service to German literature. When he began to write, the stage was occupied by plays in which extravagant rant did duty for eloquence, coarse vulgarity for wit, and the wildest improbabilities for inventive incident. In the writings of the second Silesian school the utmost extent of absurdity was reached. Gottsched set his face against such productions. He enunciated rules by which the playwright must be bound; he insisted on the observance of the dramatic unities, and pointed to the French drama as the best possible model for the German stage; moreover, his criticism did much to regulate and purify the German language. Unfortunately he went too far. He placed himself in opposition to the Swiss writers Bodmer and Breitinger, who were bringing before the German public several of the great English writers, more especially Milton; he refused to recognize the rising genius of Klopstock and Lessing, and still went on enunciating rules when the time for that was past, and praising mediocre writers as if they had been great geniuses. So it came to pass that his influence speedily declined, and that before his death his name became almost proverbial for pedantic folly. Of all lots his was the hardest, for he outlived his own reputation. His wife, Luise Adelgunde Victorie Kulmus (1713–1762), was his faithful helper in his literary labors, and herself an authoress of reputation. Among other works she translated the *Spectator* (9 vols., 1739–43) and Pope's

Rape of the Lock (1744, new ed. 1772). After her death her husband edited her *Gedichte*, with a memoir (1763). See Danzel's *Gottsched und seine Zeit*, Leipsic, 1848.

GÖTZ, Johann Nikolaus (1721–1781), a minor German poet, born at Worms, 9th July, 1721, studied theology at Halle (1739–1742), where he became intimate with Gleim and Uz, acted for some years as military chaplain, and afterwards filled various other ecclesiastical offices. He died at Winterberg, 4th November, 1781. The writings of Götz consist of a number of short lyrics and several translations, of which the best is a rendering of Anacreon. His original compositions are light, lively, and sparkling, and are animated rather by French wit than by German depth of sentiment. They give easy expression to some unexpected whim or conceit, and, though utterly destitute of depth or force, are yet very pretty specimens of elegant trifling. Of that sort of work it would be difficult to find more favorable examples than *Thamire an die Rosen* and *An eine Romansleserin*. See Götz's collected works, with biography by Ramler (Mannheim, 1785, new ed., 1807); also J. H. Voss, *Briefe über Götz und Ramler* (Mannheim, 1809).

END OF VOLUME TENTH.

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